Chapter 5. Project-Based Activities

Coordinating Lead Authors
Sandra Brown (USA), Omar Masera (Mexico), and Jayant Sathaye (USA)

Lead Authors
Kenneth Andrasko (USA), Paige Brown (USA), Peter Frumhoff (USA), Rodel Lasco (Philippines), Gerald Leach (UK), **Pedro Moura-Costa (Brazil)**, Stephen Mwakifwamba (Tanzania), Gareth Phillips (UK), Peter Read (New Zealand), P. Sudha (India), Richard Tipper (UK)

Contributing Authors
Arthur Riedacker (France), Michelle Pinard (USA), Charles Wilson (UK).

Review Editor
Mark Trexler (USA)

Contents

Executive Summary

Land use, land-use change, and forestry (LULUCF) activities aimed at mitigating GHG emissions are often organized as projects. A LULUCF project may integrate one or more activities aimed at reducing GHG emissions or enhancing GHG sinks in terrestrial ecosystems and related sectors. LULUCF projects are confined to a specific geographic location, time period, and institutional framework such as to allow GHG benefits to be monitored and verified. Three broad types of LULUCF projects are: avoiding emissions via conservation of existing carbon stocks, increasing carbon storage by sequestration, and substituting carbon for fossil fuel and energy intensive products. Each type has a variety of sub-types. Integrated multi-component projects may combine many of these sub-types.

LULUCF projects have raised specific concerns regarding duration, additionality, leakage, risks, accounting, measuring and monitoring, and verification of GHG benefits. These concerns include the ability to construct reasonable, empirically-based, without-project baselines, to quantify and reduce potential leakage of GHGs across project borders to other areas or markets, and to cope with natural or human induced risks that may reduce or eliminate accrued GHG benefits. Many of these issues are also applicable to climate mitigation projects in other sectors. There are further questions about the degree to which projects can be designed to contribute to sustainable development and improved rural livelihoods. This chapter addresses each of these concerns.

Assessment of the experience of LULUCF projects is constrained by the small number, limited activity and geographic scope, and the short period of field operations since the first GHG mitigation project began in 1988. About 3.5 million ha of land are currently included in 27 LULUCF GHG mitigation projects, which are beginning to be implemented in 19 countries. And, to date, LULUCF project experience has focussed only on mitigating carbon (as carbon dioxide) emissions.

As no internationally agreed set of guidelines or methods yet exists to quantify carbon benefits, costs, and carbon and financial efficiency of project activities, projects have estimated carbon benefits and financial indicators using a wide range of methods. Few of the results of these projects have been independently verified that makes comparative assessments difficult. Using the data as reported by the projects reviewed, average carbon sequestration or emissions avoidance per unit area ranges from about 14 t C/ha to 330 t C/ha and has wide variations across regions and specific project types. The cost of GHG benefits in these projects ranges from $0.16 to $28 /t C based on dividing the total financial commitment by the estimated long-term carbon benefit. (Table 5-3).

A fundamental component of project assessment is to determine whether the GHG benefits of a project are "additional" to business as usual. The first step in determining *additionality* has been to develop a without-project (baseline) scenario against which carbon stocks in the project can be compared. To date, a number of approaches have been used for developing and applying baselines: (1) they may be *project specific*, established through a case-by-case exercise, or (2) *generic*, based on regional, national, or sectoral aggregated data. These baselines may remain fixed throughout the duration of a project, or be periodically adjusted, in light of new data or evidence. Methods to quantify (or estimate) carbon stock in the baseline scenario include the use of models to project the fate of land in the project area in combination with data on carbon stocks from proxy or control areas, or from the literature, to estimate the amount of carbon that would have been stored in the site in the absence of the project. (Table 5-6).

Experience shows that reducing access to food or fiber resources without offering alternatives or substituting for the activity leading to GHG emissions may result in project leakage as people move elsewhere to find needed supplies. A few pilot projects to date are designed to reduce leakage by explicitly incorporating components that supply resource needs of local communities (e.g., planting fuelwood plantations to reduce pressures on other forests), and that provide socio-economic benefits that create incentives to maintain the project. (Table 5-5)

Project accounting and monitoring methods can be matched with project conditions to address leakage issues. For example, if flows of LULUCF products or people across project boundaries are negligible, leakage is likely to be small, and the monitoring area can be set roughly equal to the project area. Conversely, where there are significant flows and leakage is likely to be large, the monitoring area will need to be expanded beyond the project area to account for the leakage. Alternative approaches for accounting and monitoring leakage may be required where monitoring and project areas cannot be easily matched. Potential options include: (a) national or regional LULUCF sectoral benchmarks (empirically derived values that relate leakage levels to activities and/or regions) that could capture and report leakage outside the project area, and (b) standard risk coefficients developed by project or activity type and region, and adjusting project GHG benefits accordingly.

Implementation of projects in countries without assigned amounts for national emissions present specific concerns regarding baselines, GHG accounting, leakage and monitoring. Unlike Annex I countries, non-Annex I countries are not required to account for emissions on a national level. Therefore leakage and emissions arising after the project has been completed will not be detected.

Several approaches have been used to account for the GHG benefits over the lifetimes of LULUCF projects. One method is based on calculating the difference in carbon stocks between a project and its baseline at a given point in time, and is referred to as the *carbon stock method*. The resulting values provided by this method vary depending on the decision of when to account for the project's benefits. To account for dynamic systems, e.g., in which planting, harvesting and replanting operations take place, the *average storage method* has been used. The advantage of this method is that it accounts for the dynamics of carbon storage over the whole project duration, not only at the times chosen for accounting. Another approach is to credit only a fraction of the total greenhouse gas benefit for each year that the project is maintained (i.e. *tonne-year* method). A variety of methods have been proposed for establishing an equivalency factor by analogy to Global Warming Potentials. Depending on the accounting method used, different amounts of carbon benefits accrue to the project at different times (Table 5-9).

The Kyoto Protocol says that LULUCF projects must result in long-term impacts on CO_2 concentrations in the atmosphere. The definition of "long-term", however, varies, and there is no consensus on minimum timeframes for project duration. Different approaches have been proposed to define the duration of projects. (1) The GHG benefits have to be maintained in perpetuity. This argument is based on the assumption that the "reversal" of GHG benefits of a project at any point in time would totally invalidate a project. (2) The GHG benefits have to be maintained for a period of 100 years to be consistent with the timeframes adopted in the Kyoto Protocols for the calculation of

Absolute Global Warming Potential values. (3) The GHG benefits have to be maintained until they counteract the effect of an equivalent amount of GHGs emitted to the atmosphere. (4) The GHG benefits may vary over different timeframes, acknowledging that different projects may have different operational timeframes (this has been the approach adopted during the AIJ Pilot Phase). Eventually guidelines will be needed on how to calculate the GHG benefits of projects that are conducted for periods of time shorter than some agreed-on minimum timeframe.

Quantification of GHG emissions or removals in LULUCF projects is subject to a variety of risks and uncertainties. Some of these (such as fires, pest and disease, storms) are inherent to certain land-use activities, particularly forestry, while others (such as political and economic) may be generic and applicable to any GHG mitigation project in LULUCF and other sectors. These risks and uncertainties can be estimated and greenhouse gas benefits adjusted, or mitigated through project design, diversification of project portfolios, or insurance methods.

The GHG benefits associated with individual LULUCF projects are likely to be more readily quantified and monitored to desired precision levels than national inventories of GHG emissions and removals because of clearly defined boundaries for project activities, ease of stratification of project area, sampling efficiency, and measurement of only a selection of carbon pools. Techniques and methods for measuring carbon in vegetation and soils in LULUCF projects exist, and are based on commonly accepted and peer reviewed principles of forest inventory, soil sampling, and ecological surveys. However, they have not been universally applied to all projects and methods for accounting of the carbon benefits have not been standardized. A selective accounting system can be used to choose which carbon pools to measure: the choice must include all pools anticipated to decrease and a selection of pools anticipated to increase as a result of the project. The requirements for verifiability in the Protocol suggests that only carbon pools that can be measured and monitored could potentially be claimed as a GHG benefit (Table 5-7).

The costs of measuring and monitoring carbon pools in LULUCF projects are mainly related to the desired precision level, which varies by project type, size of the project, distribution of the project lands (contiguous or dispersed), and the natural variation within the various carbon pools. Different levels of intensity of sampling can be used to balance the costs of estimating, monitoring, and verifying the value of carbon benefits. **I**n a few forestry projects in tropical countries, project developers have, in the early stages of project implementation, measured and monitored relevant above and below ground carbon pools to precision levels of about 10% of the mean at a cost of about US$1-5 per ha and US$0.10 - 0.50 per ton. The accuracy and precision of carbon measurements and monitoring is likely to be similar among LULUCF project types, but differing measuring and monitoring costs result from decisions about which particular carbon pools are to be measured and monitored and their variability. (Figure 5-6)

Qualified independent third-party verification plays an essential role in ensuring unbiased monitoring. While there is growing experience in verification of baseline and project design, there is no experience with verification of monitored data. Guidelines are needed to help establish a procedure and institutional structure for verification.

LULUCF projects may provide significant socio-economic and environmental benefits to host countries and local communities, though some types of projects do pose significant risk of negative impacts. Experience from many pilot project to date indicates that the involvement of local stakeholders in the design and management of the project activities is often a critical requirement for success. Critical factors affecting the capacity of projects to provide GHG and other benefits include: consistency with nationally-defined sustainable development goals; institutional and technical capacity to develop and implement project guidelines and safeguards; and extent and effectiveness of local community participation in project development and implementation.

5.1 Introduction

5.1.1 Scope of the chapter

Projects that are based on land use, land-use change, and forestry (LULUCF projects) are an important means of mitigating GHG emissions. They are the required approach for putting some parts of the Kyoto Protocol into practice. In this context they have special features and raise issues which differ sharply from those found with GHG accounting at the national level (see Chapters 2 to 4).

Although experience has shown that many types of LULUCF project can provide GHG benefits in a cost-effective, measurable and verifiable manner, there have been questions about the practicality of including LULUCF projects generally within the Kyoto Protocol. These concerns center on the permanence, additionality, leakage, measuring and monitoring, and risks of project-based GHG benefits. There are also questions about the degree to which LULUCF projects can meet tests for sustainable development and compatibility with national development priorities.

This chapter reviews these project-related issues with two aims in mind. The first is to provided policy makers and others with broad guidance about the nature of LULUCF projects. What is their potential for meeting national emission reductions commitments and with what costs? Are some types of projects more or less efficient in producing GHG and other socioeconomic and environmental benefits? How accurately can carbon be measured and monitored and with what tradeoffs between accuracy and cost? Will the compliance costs of LULUCF projects deter potential investors or create biases for large projects at the expense of small ones? How do LULUCF projects differ from project in other sectors, such as energy, with respect to key issues such as additionality, leakage, duration, and risks of GHG benefits?

Answers to many of the aforementioned questions depend on rules and guidelines that remain to be agreed. The second aim of the chapter is therefore to provide information to help policy makers develop internationally agreed rules or guidelines concerning a number of challenging project-specific issues. The chapter presents and discusses these issues together with relevant scientific information, alternative options and the implications of these.

5.1.2 Characteristics of projects

A LUCF project can be defined as a planned set of activities within a specific geographic location that is implemented by a specific set of sub-national or, occasionally, national institutions. These activities may relate to Articles 3.3, 3.4 and 6 of the Kyoto Protocol and possibly to Article 12, should LUCF activities be included for certified emissions reductions in the Clean Development Mechanism. However, there are important differences between the status of LUCF projects, activities and enabling policies under these Articles and hence between countries with and without assigned amounts (Figure 5-1). In particular:

- Annex I Parties have taken on commitments to reach assigned amounts of GHG emissions by the end of the first commitment period, and thus will have national GHG inventories and accounting systems in place to meet these commitments. Limitations are imposed by Articles 3.3 and 3.4 on which LULUCF activities are eligible (see Chapters 2 - 4), and a project-based approach is possible under Article 3.4 (Chapter 4). The national assigned-amount commitment may allow Annex I Parties to account for emissions reduction or sequestration across Articles 3.3, 3.4, and 6, as lands or activities move among the Articles, potentially minimizing the risk of leakage of GHGs (see section 5.3.3).
- Some policies by governments, the private sector, or NGOs can facilitate or hinder the socio-economic and policy conditions likely to encourage the diffusion of LULUCF activities or projects. For example, land tenure, agricultural subsidy, and timber concession or taxation policies have a strong impact on the financial and practical feasibility of many forest or agricultural activities that could generate GHG benefits, such as rates of deforestation or afforestation (e.g., Repetto and Gillis, 1988). These policies are not likely to directly produce emissions reductions or sequestration under Article 3.3, 3.4, 6, or 12, but may produce enabling conditions.
- Under Article 6, in Annex I Parties, emissions reduction units can be generated only by LULUCF activities that are organized as projects, and under Article 12, certified emissions reductions can be generated only by projects, which may include LULUCF activities.
- Thus LULUCF activities not implemented as projects are likely to be excluded under Articles 6 and 12. The dispersed, individual actions of land users and beneficial policy changes, which are not instituted as projects, and that may have dispersed GHG impacts but cannot be readily measured and verified, are not likely to be included in these Articles unless specifically organized as projects.

[insert Figure 5-1 here]

There are many potential LULUCF project activities which, taken together, can reduce net emissions of a wide range of greenhouse gases (GHG). However, project experience to date has been limited mostly to reductions in carbon emissions and enhancement of carbon stocks , and to forestry operations. This chapter therefore concentrates on carbon and forestry, although it refers to other gases and types of LULUCF projects where this is pertinent and where information is available.

There are three broad categories of LULUCF projects, each with a variety of sub-types:

- *emission reduction by the conservation of existing carbon stocks*:
  for example, avoidance of deforestation, improved forest management -including alternative harvest practices such as reduced-impact logging, fire and pest protection;

- *carbon sequestration by the increase of carbon stocks*:
  for example, afforestation, reforestation, agroforestry, enhanced natural regeneration, revegetation of degraded lands, reduced soil tillage and other agricultural practices to increase soil carbon, extend lifetimes of wood products; the use is in next bullet

- *carbon substitution*:
  for example, the use of sustainably-grown biofuels to replace fossil fuels, or biomass to replace energy-intensive materials such as bricks, cement, steel and plastic).

The eligibility under the Kyoto Protocol of these different types of LULUCF project and many of the rules which apply to them have still to be decided and formulated. The outcome of this policy-making process will have a large bearing on the potential – and costs – of LULUCF projects as a means of mitigating GHG emissions while contributing to sustainable development.

The very concepts of LULUCF mitigation projects generally, and joint implementation (JI) projects specifically, (projects that mitigate GHG emissions by Annex I countries in non-Annex I countries, established under the UNFCCC Climate Convention) have been challenged in a growing literature. Critics raise three general sets of questions (e.g., Maya and Gupta, 1996; Smith et al., 1999; Mulongoy et al., 1998; Lashof and Hare, 1999). First, do LULUCF projects provide measurable, verifiable, long-term GHG emissions avoidance or reductions? This concern includes projects' ability to construct reasonable, empirically-based, without-project baselines, and to quantify leakage of GHGs across project borders to other areas or markets. Second, can LULUCF projects meet tests for sustainable development, and be compatible with national sustainable development priorities? Should other policy tests be required for their use under Articles 6 and 12? And third, under what policy circumstances might LULUCF projects be used in the Kyoto protocol to provide Annex B certified emissions reductions? Should they be limited to foster energy sector emissions reductions? The technical issues raised are addressed in the following sections.

5.2 Magnitude and Experience of Project-Based Activities

This section reviews the experience of LULUCF projects that generate GHG as well as other benefits, and are at least partially being implemented on the ground. It summarizes estimated GHG benefits for 27 such projects and several portfolios of projects, reviews estimated project costs, and assesses the limited estimates of the potential magnitude of project activities under Articles 6 and possibly 12 of the Kyoto Protocol.

Some of the key questions addressed by this section are:

- What is the experience of the voluntary, non-credit Activities Implemented Jointly (AIIJ) Pilot phase established by the UNFCCC in terms of the number, type, and technical issues surrounding LULUCF projects?
- What are the cost estimates of such projects, and how do they vary by project type and location?;
- What is the likely supply and cost of projects that might help Annex I countries meet their emissions reduction commitments, under Articles 6 and 12?
- Are such projects likely to be implemented at significant scales by 2012?

5.2.1 Quantifying project activities: issues and methods

By far, the majority of LULUCF projects being implemented within countries or funded internationally are designed to promote economic and social development, without regards for their potential GHG benefits. Instead, they provide timber or fuelwood supply, community woodlots, agroforestry crops, soil conservation, biodiversity or watershed protection, and socioeconomic development. The GHG implications of these projects generally have not been estimated or reported.

Six representative case studies of LULUCF projects being implemented illustrate the diversity of project types, locations, and estimated GHG benefits and costs (Box 5-1). These cases provide an introduction to the kinds of activities, projected socioeconomic benefits, and environmental impacts associated with LULUCF projects described throughout this chapter. The cases are representative of two major categories of LULUCF projects stated in section 5.1: carbon sequestration by the increase in carbon stocks, and emissions avoidance by the conservation of existing carbon stocks.

[insert Box 5-1 here]

About 3.5 million ha of land are currently included in LULUCF GHG mitigation projects beginning to be implemented in 19 countries (see Section 5.2.2 below). Assessment of the experience of LULUCF mitigation projects is constrained by the small number, limited range of project types and uneven geographic distribution, and the short period of field operations to date. The first publicized LULUCF mitigation or carbon offset project began in 1988--the CARE-AES Guatemala community forestry project (Trexler et al., 1989; Faeth et al., 1994).

Most reviews of LULUCF climate change mitigation project experience to date are simply summaries of information reported by individual projects or AIJ programs (e.g., Dixon et al., 1993; Stuart and Moura-Costa, 1998; UNFCCC, 1998; FACE, 1998; EPA/USIJI, 1998. A few studies review or analyze several project case studies (e.g., Witthoeft-Muehlmann, 1999; Brown et al., 1997; Brown et al., 1996; Imaz et al.,1998; Goldberg, 1998; Faeth et al., 1994). Several projects have been well documented. The Rio Bravo conservation and alternative forest management project in Belize, for example, has produced a set of Operational Protocols (Programme for Belize, 1997b). These protocols include descriptions of its reference case, leakage assessment, sustainable forest management strategy (including boundary security and fire management), estimate of GHG benefits, baseline, and monitoring plan, and have been filed with the U.S. Initiative for Joint Implementation program along with other project documents (EPA/USIJI, 1998).

No internationally agreed set of guidelines and methods (e.g., comparable to the OECD/IPCC Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories) exists to quantify GHG emissions and sequestration, baselines, socioeconomic and environmental impact assessment, and reporting of project activities (Swisher, 1997; Andrasko et al, 1996). The development of such guidelines and methods is an urgent need, if projects are to be reported consistently and credibly under several articles of the Kyoto Protocol (see Chapter 6).

The project data reported in the literature use a wide range of methods, and, for the most part, have not been independently verified. Thus, it is difficult to compare data across projects. At present, evaluations of project GHG accounting by different analysts are likely to produce estimated GHG benefits different from the estimates of project developers, since GHG accounting methods have not yet been standardized. Analysts and project developers are building on early experience to alter the design of projects, and beginning to produce data-driven baselines in some cases, and to revise project estimates of sequestration or avoided emissions.

Table 5-1 compares the initial baseline and net GHG benefits made by project developers during the planning phase and reported to the USIJI program (see 5.2.2 below) for two large projects, with later evaluations by other entities. These projects were conceived in the voluntary, non-credit exploratory AIJ phase, where steep learning curves were experienced. As illustrated here, estimated GHG benefits have tended to go down over time as methods and initial assumptions have been refined and applied to a given project (e.g., Busch et al., 1999; Brown et al, 2000). If standardized methods are introduced, estimates should tend to vary mainly as changes occur in project conditions or land uses, or the availability of new data. Over the next five years or so, early projects will begin measuring and monitoring their performance, replacing earlier estimates of project baselines and GHG benefits with field data collected for the purpose of monitoring. Reported GHG benefits potential could change as well if verification of GHG reductions occurs, and the results are significantly different from previous estimates.

[[insert Table 5.1 here]]

This review surveys projects that are in early or later stages of implementation by 1999 (i.e., projects have been at least partially funded and have begun activities on the ground that will generate GHG benefits). It focuses on the LULUCF projects formally reported to the UNFCCC Activities Implemented Jointly Pilot Phase program (17, as of late 1998), and over a dozen other projects (UNFCCC, 1999b; Trexler et al., 1999). The AIJ program was established in 1995 by Decision 5/CP.1 of the Conference of the Parties to the UNFCCC as a voluntary program to experiment with the concepts of joint implementation that evolved during the negotiation of the UNFCCC (UNFCCC, 1995). Many projects have not been reported to the voluntary AIJ program, which precludes transfer of emissions reduction or avoidance credits to Parties. Unreported projects often began prior to the AIJ program, and faced reluctance by host countries to grant formal acceptance, and the lack of incentives for investors or developers to report. One review identified 18 offset projects underway in 14 countries that have not been reported to the AIJ program (Trexler et al.,1999).

5.2.2 Experience in LULUCF project-based activities: estimates of sequestration, emissions avoidance, and substitution, and land areas involved.

A representative set of LULUCF projects currently underway that have been reported to provide carbon sequestration or emissions reduction benefits are summarized in Table 5-2. The projects are divided in six subcategories: carbon sequestration by the increase in carbon stocks, e.g., (1) reforestation, afforestation, and restoration; and (2) soil carbon management, and emissions avoidance by the conservation of existing carbon stocks, e.g., (3) forest conservation; (4) forest management and alternative harvest practices, (5) agroforestry, and (6) multi-component or community forestry projects that combine several of these activities. The projects reported in Table 5-2 are predominately forestry projects because the experience to date has been most influenced by electric utility companies and conservation NGOs seeking projects likely to produce credible GHG benefits at costs lower than their emissions reduction options in their home territories, as well as conservation, biodiversity, and community development benefits. Many soil management, bioenergy, and other LULUCF management projects exist, but few have estimated and reported GHG benefits, and thus are underrepresented in Table 5-2.

The 3.5 million ha of projects currently being implemented could eventually total 6.4 million ha if fully funded. The majority of the 3.5 million hectares (2.9 million ha, or 83%) are in forest land protection or conservation, potentially avoiding emissions or sequestering about 40 to 108 million t C, if the projects are fully financed and implemented (Table 5-2). Another 100,000 ha (3%) are in projects primarily undertaking afforestation, reforestation, or forest restoration, potentially generating an estimated 12 million t C. Projects involving forest management, and alternative silvicultural or harvesting practices occupy about 60,000 ha (less than 2%) and may generate about 5.3 million t C. Multi-component community forestry or agroforestry system projects cover at least 530,000 ha (15%) and may provide 20-49 million t C in benefits. Only a few very small projects currently exist for soil carbon management (see Chapter 4 also).

Carbon sequestration or emissions avoidance per unit area over the reported lifetime of the projects varies by project type: from an average of about 120 t C/ha for afforestation and reforestation projects, to 88 t C/ha for forest management projects, to 14-38 t C/ha for community forestry projects, to a low of 14 t C/ha for forest protection projects (from avoided logging mainly), with very large ranges both within and across project types (Table 5-2). These averages reflect project design to date, and vary across design, site condition, and implementation conditions.

The emissions avoidance per hectare of forest protection projects, in particular, is highly sensitive to the total project area involved, and the activity avoided --avoided deforestation or avoided logging. These projects generally conserve a large area of forest considered under threat of deforestation at rates of about 1-5% of total forest area per year. In the Noel Kempff project, for example, areas where deforestation is anticipated to be avoided are estimated to generate about 143 t C/ha over the life of the project, areas where logging is avoided about 12 t C/ha, and the project overall about 7 t C/ha (because the total project area is large) (Brown et al, 2000). For project components designed solely to avoid deforestation, typical emissions avoidance values are likely to range from 28-80 t C/ha for boreal forest, about 30-140 t C/ha for temperate, and 100-175 t C/ha for tropical forests (Brown et al., 1996).

[insert Table 5.2 here]

Several models for the design and funding of projects are already being used in many of the projects reviewed in Box 5-1 and Table 5-2:

- Project funding is provided by investors who are committed to offsetting their carbon emissions, irrespective of the status of the international climate change negotiations. Monies are provided to a central office which seeks out, designs, and implements projects meeting investor criteria;
- Entities, e.g., electric utilities, who consider themselves likely to face emissions reduction mandates in the future are implementing their own projects;
- Project proponents identify and design projects on the basis of expected GHG and non-GHG benefits, then seek funding from donor sources. These projects are developed primarily to mobilize resources for non-climate services (e.g., biodiversity protection by a land management NGO), and to gain experience in project implementation (often reporting under the AIJ pilot program).

Other models are likely to develop as entities seeking certified emissions reductions organize their investments to spread liabilities and risks. One potential evolution may be the emergence of flexible derivatives involving brokers, traders and insurers, who trade various attributes of the potential emissions reductions of bundles of projects. Experience using the models above in the early stages of pilot project implementation has helped produce a number of advances. These include quantifying and monitoring the GHG benefits of a range of project types using the Winrock estimation and monitoring methodology (MacDicken, 1997a); reviewing and refining without-project baseline assumptions in an independent review of the Costa Rica PAP project (Busch et al., 1999); and addressing ways to minimize leakage in the design and implementation of the Noel Kempff project (Brown et al., 2000).

Several portfolios of projects have been assembled by national, NGO or private joint implementation (JI) or AIJ pilot programs. For example, the FACE Foundation, founded in 1990 by the Dutch Electricity Generating Board, has targeted 150,000 ha of new forest planting in five projects in six countries, to absorb the lifetime CO2 emissions of a coal-fired 600 MW power station. About 40,000 ha have been planted by 1999. The projected carbon benefits are 75 million t C over the lifetime of the projects. Total estimated, undiscounted costs are $100 million, of which $30 million has been committed, with an estimated unit cost of $8/tC (FACE Foundation, 1998; Verweij and Emmer, 1998).

The US Initiative on Joint Implementation (USIJI) began in 1993. It has accepted 14 forestry and one soil carbon management project as of February, 2000. Estimated total carbon benefits over the lifetimes of eight projects in at least initial implementation stages are about 13 million t C, rising to 25.5 million t C if fully funded and implemented, on 1.27 million ha. Total funding committed to date is about $17 million, at an estimated carbon cost of $3.90/tC (EPA/USIJI, 1998; Table 5-2).

Some projects have been designed that could potentially expand across whole regions. The Scolel Te project in southern Mexico has initiated agroforestry activities on about 150 small farms. If an incentive rate of US$15/t C was available, it potentially could supply 150-200 million t C over 40 years (de Jong et al, 1997; Tipper et al., 1998).

Projects offer varying rates of supplying carbon benefits over time. Projects summarized in Table 5-2 have reported project lifetimes ranging from 16-99 years, and average 41 years. Forest conservation projects designed to slow deforestation are highly sensitive to the estimated baseline assumptions about non-project forest loss rates (see section 5.3; Busch et al., 1999). However, these projects appear to deliver carbon benefits quickly relative to other project types, by annually avoiding the loss of high carbon stocks per hectare of mature forest. Conversely, soil carbon management and afforestation or reforestation projects in boreal forest deliver carbon benefits slowly, because carbon sequestration rates in both systems are generally less than 1 t C $ha^{-1}y^{-1}$.

5.2.3 Financial Analysis of LULUCF Project Activities

Financial analysis of GHG reductions by projects are rarely comparable, as no standard method of evaluation has emerged and been widely used. Financial analysis of direct, indirect, initial, and recurring costs, and the stream of revenues, varies across projects. Available cost estimates for LULUCF projects often include those direct costs incurred by the project developers: e.g., land purchase or rental costs, if necessary; land clearing and site preparation; initial planting or other activity costs; annual recurring costs of project maintenance and management, including, for example, periodic thinning or other stand improvement, or weed control in agricultural soil management; and sometimes the establishment of monitoring data collection and evaluation systems.

Opportunity costs of land (i.e., the present value of alternative opportunities or uses of the land, at the margin) are often not included in financial analyses of projects. Other costs often overlooked are infrastructure costs (e.g., road development), monitoring data collection and interpretation costs, and maintenance or other recurring costs that will be incurred in the future (Witthoeft-Muehlmann, 1998; Mulongoy et al., 1998). The stream of revenues is not widely reported for projects to date, in part because few revenues have accrued in their early stages of implementation. Revenues may include: sale of logs or value-added products from timber harvest, sale of fuelwood or non-timber products like medicinal plants, usage fees for access, government or NGO grants for subsidies, in-kind contributions, and sale of emissions reductions.

Project-level financial analysis methods are widely used and fairly standardized in development assistance and private investment projects. But they have yet to be consistently applied to, and reported for, LULUCF projects, in part because of the highly varied expertise of early actors in such projects (Mulongoy et al., 1998). A standard approach for comparing the economic attractiveness of different projects would compare the time flow of revenues, including the sales of emissions reductions and the crediting rules applying to them, with the time flow of expenditures, applying appropriate discount rates. However, detailed financial data are not available for most LULUCF projects, so many times the economic indicators are obtained simply by dividing a project's total carbon sequestration or emissions avoidance over time by total expenditures (e.g., Witthoeft-Muehlmann, 1998). A further complication is how emissions reductions are allocated between the sellers and investors. The unit cost of reduction will vary directly with the percentage of total reductions that accrue to the investor.

Cost and investment estimates are available for virtually all the projects in Table 5-2, but because of the different methods used in the estimates, only summary ranges are reported in Table 5-3. The costs of GHG benefits in these projects range from \$0.1 to \$28 /t C, simply dividing project costs by their total reported carbon benefits. Most of the cost estimates are in the range of \$1-15, with a higher range for reforestation and afforestation projects (reflecting inclusion of temperate and boreal projects). A recent study reviewed cost estimates for LULUCF carbon projects and found that most estimates for the tropics fall in the range of \$2-25/tC (Mulgonoy et al., 1998). Two other reviews reported costs of sets of projects in the temperate and tropical biomes ranging from \$4-26 (Swisher and Masters, 1992), and \$2-12 (Witthoeft-Muehlmann, 1998). Other studies are consistent with these results (Dixon et al., 1993; Brown et al., 1996; Stuart and Moura-Costa, 1998).

[INSERT TABLE 5.3 HERE]

Other methodological issues include the absence of discounting in most of the available cost estimates, to reflect the time value of the investment and the production of GHG benefits. The choice of accounting approach is important,also. If the ton-year approach (section 5.4.2.) were used, these costs would tend to rise from about 50% to several times, since fewer GHG benefits could be credited over a similar timeframe.

Estimated total investment committed to date in projects in Table 5-3 is about \$160 million, and could grow to about \$330 million if fully funded and implemented, although these estimates are provisional (Stuart and Moura Costa, 1998; EPA/USIJI, 1998; Witthoeft-Muehlmann, 1998). Project costs per t C to developers are likely to change over time from these initial estimates. The price and supply of certified emissions reductions will be revealed if a market for them develops, and as the eventual eligibility and requirements for various articles of the Kyoto Protocol become known. Costs may tend to decrease if economies of scale and technology transfer become widely available, potentially via development of portfolios of projects by entities transferring common, state-of-the-art methods to countries and projects. The Costa Rican Government's Protected Area Project, for example, undertook land-use data collection, baseline development, and the establishment of monitoring systems for virtually all public lands in the country. The parallel Private Forest Program provided some of the same services for private forest lands, in both cases to reduce barriers to investment for carbon benefits (Tattenbach, 1996; Subak, 1999).

5.2.4 Potential Magnitude of LULUCF Projects

The form and magnitude of the eventual markets for emissions reduction units (ERUs) under Article 6 (i.e., Annex I Joint Implementation), and certified emissions reductions (CERs) under Article 12 (the Clean Development Mechanism (CDM) emissions reductions are difficult to estimate. Key policy decisions have not been made by the Parties. This discussion of the potential for LULUCF activity in the CDM makes no judgment about the policy issue of whether or not CDM includes specific LULUCF activities.

No credible, detailed estimates of the magnitude of the potential for LULUCF activities in Annex I and in non-Annex I countries are available for the first commitment period, 2008-2012 (see Chapter 4). To date, the macroeconomic model assessments of the supply and demand for emissions reductions by Annex I countries using the Kyoto Protocol flexible mechanisms (e.g., emissions trading, JI, or CDM) have not separated out LULUCF activities or projects. Generally these analyses do not reflect the policy or technical tests and guidance likely to be included in the operationalization of Articles 6 and 12. Analyses are needed of the potential supply, cost, and demand for LULUCF project-based activities, especially at the national level, under realistic scenarios for operating conditions under Articles 6 and 12.

The best approximations of Annex I project-level activity would be some small fraction, as yet unknown, of estimated country-level Article 3.3 and possibly 3.4 activities (depending on what, if any, additional activities the Parties decide to include under Article 3.4). Prospective activity levels under these two articles are reviewed in Chapter 3 and 4, and in one survey (Nabuurs et al., 1999). Project-level activities under Article 6 likely would be a small subset of these activities, which otherwise have been widely assumed to be reported nationally under the two articles, not as projects. No estimates of the demand for LULUCF project ERUs under Article 6 have been widely reviewed and reported for individual countries, or for Annex I as a whole.

Global economic general equilibrium models have been used to project GHG target levels for 2010 for Annex I countries, to estimate the percentage of emissions reductions, and total financial flows, that might occur under Annex I JI, or the CDM. The results of four independent modeling teams have been summarized (Austin and Faeth, 2000). These models have been used to estimate where emissions reductions could occur at least cost, largely based on fossil fuel CO2 emissions. Modeling results project estimated emissions reductions by Annex I countries in the year 2010 (for that year) predominately would come from domestic reductions (15-45%), Annex I trading (6-10%), and "hot air" (8-41%). (Hot air is the term used to describe ERUs predicted to be generated by country emissions during the first commitment period below countries' assigned amounts, as an artifact of macroeconomic and political changes in economies in transition, like the Russian Federation, Ukraine, and Poland.) Some limited set of JI projects under Article 6 might be developed, although such projects would compete directly with these emissions reduction alternatives. Reductions in developing countries were estimated at 33-55% (another estimate is 19-57%; Vrolijk, 1999) of the demand for reductions by Annex I countries.

These models are not designed to assess LULUCF activities, nor JI or the CDM. Project-oriented mechanisms are not likely to deliver the same stream of least-cost GHG abatement activities as an efficient emissions trading system, carbon tax, or other economic instrument (Austin and Faeth, 2000). Projects under Articles 6 and 12 may require certification and reporting costs, and under Article 12 may also include charges for an adaptation fund and administration expenses of the CDM mechanism, and sustainable development considerations. These constraints may reduce the economic efficiency of JI and of the CDM relative to emissions trading, according to reviews by some economists (e.g., Manne and Richels, 1999).

5.2.5 Factors that may affect the realized magnitude of projects

Studies and pilot project experience indicate that the net costs per ton of carbon of LULUCF mitigation activities in developing countries can be relatively modest, or even negative (i.e., profitable), in some projects and conditions (e.g., Wangwacharakul and Bowonwiwat, 1995; Makundi and Okiting'ati, 1995; Xu, 1995; Masera et al 1995; Ravindranath and Somashekhar, 1995). Annex I country estimates of LULUCF activities are generally found to be relatively higher per ton of carbon, but a substantial supply of sequestration or GHG reductions may be available at less than $20/t C (Brown et al, 1996).

Only a limited number of potential projects are likely to be funded and implemented, however, as a result of community, investor and national government priorities, and cost effectiveness (Smith et al., 1999; Mulongoy et al., 1998). The cost-effectiveness of LULUCF project activities will compete with the costs of achieving emissions reductions in other sectors, domestically within each country and internationally, under continual technological innovation in the energy sector, and the development of the GHG emissions reduction market.

Pilot projects in both Annex I and non-Annex I countries commonly face high transaction costs (e.g., for implementing, monitoring and reporting project activities) (World Bank, 1997; UNFCCC, 1999a). One key uncertainty is how transaction costs will be affected by the implementation of any eventual standardized guidelines for monitoring and verifying project emissions reductions and associated impacts on sustainable development. Transaction costs and risk may decline as carbon markets develop and standard financial techniques to spread risk and reduce uncertainty evolve, e.g., diversified portfolios, futures options contracts, and project performance insurance (Smith et al., 1999; Frumhoff et al., 1998).

The types of projects financed may not reflect patterns to date, as economies of scale may favor larger-scale activities with low costs (Smith et al, 1999). Investors with substantial near-term carbon liabilities may have a strong incentive to invest in projects that could have the potential to provide carbon credits quickly but at a net cost, such as forest conservation. By contrast, those with relatively modest near-term liabilities may have a strong incentive to invest in projects that provide carbon credits relatively slowly, but at a net profit, such as managed plantations (Frumhoff et al., 1998; Smith et al., 1999).

An example of how mixed incentives for LULUCF activities could occur has been raised by critics of the Kyoto Protocol. Non-Annex I countries would not have commitments to meet assigned amounts of GHG emissions, and hence would not have emissions from deforestation or forest degradation counted against their assigned amounts. Financial incentives might exist to harvest or degrade forest lands to receive revenues from both the timber products produced, and the CERs generated if such lands were eligible for reforestation as project-based activities (Greenpeace, 1998; Chomitz, 2000.). This situation could produce tensions for Parties between objectives of the Climate Convention and the Biodiversity Convention. At least two options exist to address this concern. First, the definition of reforestation activities selected by the Parties could limit reforestation to lands deforested prior to the commencement of the non-Annex I project-based activities (this approach is discussed for Article 3.3 reforestation in Chapter3). Second, individual Parties could use the sustainable development conditionality of Article 12 to preclude eligibility of projects reforesting recently deforested lands, on biological diversity conservation or other grounds. The economic benefits to the host country of large-scale projects could be a disincentive for countries to limit LULUCF investments in any way, however, eroding their ability to manage these investments and their associated socioeconomic and environmental impacts (Smith et al, 1999).

Integrated projects or portfolios may offer potential synergies addressing several technical issues. A sequestration component could provide sustainably managed forest products and reduce leakage from a conservation component, and a bioenergy component could provide jobs and low-cost power important to sustainable development priorities of host countries, and enhanced profitability for investors (Niles and Schwartz, 2000). This approach has not been widely experimented with yet.

The public policy environment for the agriculture, forestry, and industrial sectors varies across countries and may facilitate or inhibit the penetration rate of LULUCF projects. Examples of such policies could include ones that address: tax incentives or subsides for afforestation, reforestation or deforestation; land conversion to agriculture or alternative agricultural practices; land tenure; agrarian reform; and sustainable development more generally (Repetto and Gillis, 1988; Smith et al, 1999). A review of the feasibility of significant levels of project-based LULUCF activity in non-Annex I countries under the Kyoto Protocol argues that the removal of distortionary national policies that promote forest degradation and land use change may be a prerequisite for projects in some developing countries (Smith et al, 1999).

A major potential limitation on LULUCF project penetration into the market for CERs and ERUs is the perception that LULUCF projects are less likely to produce credible, real and additional reductions. Two major perceptions are often advanced: the perceived difficulty of establishing the additionality of project benefits vs. baselines, and the claim that LULUCF projects are more difficult to measure and monitor, and have greater leakage of GHG benefits, than energy sector projects (Greenpeace, 1998; Trexler and Associates, 1998). A recent review of projects in both the energy and LULUCF sectors (Chomitz, 2000) assessed five critical technical issues--additionality, baseline and systems boundary issues (including leakage), measurement, duration, and local social and environmental impacts. It found that LULUCF and energy projects face parallel, comparable issues in measurement and in assuring social and environmental benefits. In general, it is not possible to assert that energy projects are superior as a class to LULUCF projects on these grounds. The one significant difference identified between the two sets is the issue of project duration, as LULUCF activities can be halted or their emissions reductions emitted. Similarly, a review of eight commonly raised technical issues in 12 CDM-like projects or activities in Brazil, India, Mexico and South Africa (including seven LULUCF projects) found that about half of the concerns were minor or well managed by the project developers. Mainly additionality, host country institution capacity, and baselines and leakage needed more effort to be adequately addressed (Sathaye et al., 1999).

5.3. Issues Arising from the Implementation of Projects

5.3.1. Project Boundary

Adequate determination of the physical and conceptual project boundaries is one of the critical steps in project design and implementation. The choice of accounting boundary influences the carbon credit that can be assigned to a project. It can also raise carbon accounting problems, particularly with regards to the relationship between project and national accounting.

Estimates of project impacts on carbon stocks may at one extreme be limited to above-ground vegetation within the geographical area of the project. At the other extreme, "total carbon" accounting may be used to include not only below-ground vegetation and soils on the project site but also the effects of wood products, fossil fuel substitution and other changes at the national or even the international level. Because of these accounting problems, assessments of project impact should provide explicit details about the spatial, temporal and conceptual boundaries used. Examples of carbon stocks and emission sources that may not always be captured within project boundaries include:

- Emissions associated with preparation of land prior to the official start of a project;
- Emissions or removals of GHGs associated with the use of harvested timber;
- Emissions associated with project development (e.g. car and air transport, machinery use, etc.); and
- Fossil fuel emissions avoided from the use of biomass fuels as substitutes for energy production.

Decisions will need to be made as to the level of standardization required for boundary setting in projects. The cost implications of extending project boundaries to include many secondary effects could be significant.

5.3.2. Baselines and additionality

A fundamental component of project assessment under the Program for AIJ has been the determination of the extent to which project interventions lead to GHG benefits that are "additional" to *business as usual* (UNFCCC, 1995; UNCCCS, 1997, Baumert 1998). The concern for additionality also appears in Articles 6 and 12 of the Kyoto Protocol. While additionality arguments have several different components and are based on multiple sources of information, most additionality problems apply equally to projects in the energy sector as they do to those in LULUCF (Chomitz, 2000).

The first step in determining the additional greenhouse gas benefits (its *greenhouse gas emissions additionality*) of a project is the elaboration of a without-project baseline scenario against which the changes of carbon stocks occurring in the project can be compared (discussed in Section 5.3.2.1 below). It is then necessary to demonstrate that purported GHG benefits are truly additional, and not simply the result of incidental or non-project factors, such as new legislation, market changes or environmental change (Section 5.3.2.2).

Establishing the baseline scenario thus requires knowledge of historical series of conventional practices in the affected area, the local socio-economic situation, wider (national, regional or even global) economic trends which may affect the conventional outputs of a project, and other relevant policy parameters. The baseline, however, is established by projecting these past trends and current situations into the future. Consequently, baseline scenarios are necessarily based on a range of assumptions.

Currently, there is no standard method for determining baselines and additionality (Matsuo, 1999; Puhl, 1998). This section describes the approaches used or proposed, to date.

53.2.1. Alternative Approaches Proposed for Establishing Baselines

The main choices to be considered when deciding on how to establish a baseline are:

- Project specific versus generic ? — should baselines be developed by a case-by-case project specific exercise, or could it based on generic data aggregated in a “top-down” approach ? Should baselines be developed by project proponents or by independent bodies (regional, national or international institutions) ?
- Fixed or adjustable? — should baselines established at the start of the project be maintained for the it lifetime, or be periodically adjusted?
- Simple or complex models — should baselines be derived by simple extrapolation of past trends in the use of land, or should they be derived from models that attempt to simulate the driving forces of change?

These options are discussed below, and Table 5-4 provides examples of how baselines of different pilot projects have been constructed.

[insert Table 5-4 here]]

Project specific versus generic

Most projects developed under the AIJ Pilot Phase have used project-specific, bottom-up baselines determined by project developers (Moura-Costa *et al*., 2000; see also Table 5-4). The attraction of this approach is that analysis is focused on the specific areas and activities relating to the project, and developers may have a better knowledge of local conditions. Because land-use practices and change processes are often spatially and temporally variable, it can argued that a detailed project specific study is likely to yield a more accurate prediction of emissions than a broader, regional or sectoral assessment. However, it may also be argued that giving project developers the task of developing baselines introduces the risk that they may choose scenarios that maximize their perceived benefits (Tipper and de Jong, 1998). Moreover, if many baselines are developed by different teams it may be difficult to ensure consistency between assessments. Allowing ad hoc project baselines may lead to inconsistent approaches among similar projects and increase the risk that project baselines would be set strategically to maximize the potential to generate credits.

Generic methods proposed, but not yet tested, include benchmarking models, similar to those being assessed for the industrial and energy sectors (Baumert, 1998; Center for Clean Air Policy, 1998; Ellis and Bosi, 1999; Friedman, 1999; Hargrave *et al*., 1998; Jepma, 1999; Michaelowa, 1999). For example, certain practices could be considered “standard management practice,” and baselines might be set to reflect the level of carbon sequestration or emission avoidance that would occur if these practices were universally applied. Credit would then be available only to the extent that a project improved upon the results that would be obtained by simply applying these standard practices.

Since the development of credible baseline scenarios represents a significant capital cost, there could be economies of scale by using generic baselines for sectors, technologies or regions (Baumert, 1998). If set by an organization independent from project developers, it could also provide transparency and reduce the potential for discrepancies between projects. The applicability of this approach to the LULUCF sector is unclear, and no project yet has used a benchmarking approach. Generic baselines set by a coordinating body have been used in a few cases (e.g., the Protected Areas Project in Costa Rica, SGS, 1998; the Profafor project in Ecuador, Face Foundation 1998).

Another approach proposed is that of minimum performance benchmarks (Brown, 1998). Minimum baselines or benchmarks could help avoid rewarding countries or investors with poor practices or policies by paying for improvements over an exceedingly low baseline (Brown, 1998). If countries hosting LULUCF projects have policies encouraging carbon-emitting activities, such as subsidies for deforestation, then LULUCF projects may only be mitigating the impact of poor policies. For instance, if project baselines are influenced by the threat that a particular area will be deforested in the absence of the project, this could create a incentive to “demonstrate” threat of deforestation by, for example, building roads through isolated areas.

Approaches for determining baselines

Most projects to date have adopted a two step approach to determining baselines. First, the likely fate of terrestrial ecosystems within the project boundary is predicted. Second, the changes in carbon stocks that would occur as a result of this scenario are estimated.

Specification of the “without-project” scenario for the project area have usually been based on projections of past trends of land use into the future. These predictions have taken into consideration events that are expected to alter current behavior (e.g., changes in legislation related to land use and tenure, changes in market preferences or prices, changes in environmental awareness, etc.). However, even a thoroughly investigated without-project baseline is prone to the risk that unexpected social or policy changes will confound predictions over the longer time frame. For example, the baseline for a reduced impact logging project could change radically if national policy dictated adoption of this practice in all forest concessions. Key factors used in projecting the baselines have included: (1) planned land-use decisions of the landowners/stakeholders; (2) the designation of the land by the national authorities and; (3) historical patterns of land-use change in the local area.

It is likely, however, that different approaches would be required for different types of projects, operating in different circumstances:

- Afforestation projects might use simple models predicting zero uptake /emissions without intervention;
- Projects to conserve forests used by small farmers are likely to need models that reflect local demands for agricultural land, firewood and timber;
- Projects aiming to reduce emissions through better forest management may need models that compare technological alternatives.

Different approaches for data collection have been used, from compilations of national/regional statistics, use of satellite imagery, as well as interviews with relevant authorities and key stakeholders. There is debate as to the level of detail required and the weight given to different criteria (historical trends, available technology, population pressure, etc) (Busch *et al*., 1999).

A number of approaches have been proposed and/or used during the AIJ Pilot Phase for deciding on how to carry out the baseline projections, which vary on data requirements and treatment:

- Simple logical arguments – that do not use quantitative methods for predicting changes in current trends (or use simple ones). Examples include: “without intervention, the forest concerned will be sold for agricultural development” (Rio Bravo project [Program for Belize, 1997a]); or “without intervention, loss of above-ground carbon stocks within the area will continue at approximately 1.5% per year” (Scolel Té pilot project [Tipper et al., 1998]; see also Box 5.2). Variations of this approach have been used by most projects during the AIJ Pilot Phase (e.g., Noel Kempf Project in Bolivia, [Brown et al. 2000]; Reduced

Impact Logging Project in Sabah, Malaysia [Pinard and Putz, 1997]; the Protected Areas Project in Costa Rica [SGS, 1998]).

- Use of spatial or social-economic models – that simulate land use change processes based on factors such as proximity of towns, roads and agricultural frontiers, population growth, food requirements and the productivity of local agricultural technology (e.g., LUCS model [Faeth *et al*. 1994]; Jepma,1995; Ludeke, 1990). This approach is being used in The Nature Conservancy's project in Guaraqueçaba, Brazil (Brown et al., 1999ab).
- Utilization of econometric models - that give an econometric treatment to data factors such as historical series of productivity, price, costs, etc. This approach has not been used in the AIJ pilot phase, but it has been discussed in a few publications (e.g., Chomitz, 1998).

[insert Box 5.2 here]

Simple logical arguments are not necessarily less accurate, in terms of predictive ability. However, their applicability will probably be limited to specific areas and contexts. Increasing model complexity is likely to be required to attempt credible predictions across a range of land uses. Such models, however, generally require large amounts of input data and may still be poor predictors of specific local changes. Requirements for complex baseline models could represent a serious barrier to small-scale projects or initiatives in poorer countries unless "umbrella" approaches are adopted (Bass et al., 2000). Procedures for selection or approval of models, and a program for model testing and improvement to ensure some degree of consistency and quality would need to be considered.

Once a baseline scenario for land-use and ecosystem changes has been developed, the changes in carbon stocks associated with this scenario must be estimated. Different approaches have been used and/or proposed during the AIJ Pilot Phase (see examples in Table 5.4), and include:

- Quantification of carbon in proxy areas (e.g., Noel Kempf Climate Action Project, Brown et al., 2000);
- Control plots where the project activities are not applied, which are set aside for mensuration of carbon stocks in the absence of the project intervention (e.g., as used in the Reduced Impact Logging Project in Sabah, Malaysia, Pinard and Putz, 1997);
- Modeling (e.g., the Protected Areas Project in Costa Rica, SGS 1998);
- Combinations of the above.

Fixed or adjustable baselines?

Baselines could be fixed for the lifetime of the project, or adjusted following periodic reviews or the occurrence of unexpected events. A preliminary report to the Secretariat to the Convention (UNCCCS, 1997) argued that baselines for AIJ projects should not be revised because this would increase the uncertainty associated with any investment and entail significant additional costs. The central argument for revising the baseline over the length of the project is that this may ensure more realistic offsets. A key counter argument is that if baselines are revised continuously this could have a significant impact on the economic value of the project, introducing another source of risk to the project. It is also difficult to disassociate the changes observed after the implementation of the project with the impact of the project itself. Detailed discussion of the methods for adjusting baselines and their implications is found in Michaelowa (1998, 1999) and Ellis and Bosi (1999).

5.3.2.2. Additionality Tests

After determination of a project baseline, it may then be necessary to demonstrate that the purported GHG benefits of the project are truly additional (environmental additionality). Several *additionality tests* have been devised to assess the eligibility of projects to enter the AIJ program. Tests applied by the USIJI (USIJI, 1997a) included:

- *Technological tests* – where activities have resulted from the introduction of new technologies or through the removal of technological barriers. Evidence would include comparison of current practices and technologies with those to be adopted by the project (Carter, 1997b).
- *Institutional or program tests* - where activities go beyond the scope of the programs of the institutions involved in the development of the project. Evidence would include the removal of institutional constraints, or the implementation of measures in excess of current activities and regulatory requirements.
- *Financial tests*– demonstration that the project incurred higher costs (or has higher risks) compared with those of comparable baseline activities. Evidence could include an assessment of the potential for commercial finance, and cost-benefit analysis.

Projects may demonstrate additionality using one or more (but not necessarily all) of the above tests. According to the USIJI experience, additionality criteria are difficult to evaluate objectively on a project-by-project basis (Carter, 1997a). As with other screening programs, two types of errors exist: the *approval of non-additional projects,* and the *exclusion of valid ones* (Chomitz, 1998). The concept itself is complicated because it requires assessment of hypothetical future scenarios in the absence of the project.

It should be noted that, for projects implemented under the AIJ modality, additionality has not only been required in terms of the expected GHG benefits, but also regarding their funding. The first Conference of the Parties of the UNFCCC ruled that "the financing of AIJ shall be additional to the financial obligations of Parties included in Annex II to the Convention within the framework of the financial mechanism as well as to current international development assistance flows." This applies to country level Official Development Assistance (ODA) transfers, funding mechanisms under the Framework Convention on Climate Change, and the various multilateral development bank and development agency activities

5.3.3. Leakage

Leakage is defined as the unanticipated decrease or increase in GHG benefits outside of the project's accounting boundary (the boundary defined for the purposes of estimating the project's net GHG impact) as a result of the project activities. For example, conserving forests that would have otherwise been deforested for agricultural land may displace the farmers to an area outside of the project's boundaries. There, the displaced farmers may deforest and the resulting carbon emissions is referred to as leakage.

Projects may also yield greater GHG benefits than anticipated; referred to as positive leakage or "spillover." For example, if a project introduced a new land management approach or technology, such as increased use of agroforestry, cover crops, or increased saw mill efficiency, and this technology was more widely adopted outside the project's boundaries, the net GHG benefits would be larger than initially estimated.

5.3.3.1 Assessing Leakage

Leakage has been divided into various effects. The following leakage effects are most relevant to forest and land-use projects: Market effects occur when project activities change supply and demand equilibrium, such as if demand is unmet because a project reduces supply or because it unexpectedly increases demand. For example, large-scale plantation projects may depress the local price of wood products, causing nearby plantations to be replaced with pasture or other low-biomass land uses (Fearnside 1995). Activity shifting occurs when the activity causing carbon loss in the project area is displaced outside project boundary. For example, preventing deforestation in the project area may displace the greenhouse gas emitting activity.

Although project experience to date is limited, case studies have indicated that landscape dynamics may signal if the project has no/low potential for leakage or a moderate/high risk for leakage.

No/Low Leakage Potential: Experience to date indicates that projects implemented on land that has few, or no, competing uses are unlikely to impact areas outside of project activities, and leakage potential is minimal. For example, the Krkonose project in the Czech Republic (see Table 5-2 and Box 5-1), is situated in a protected area with virtually no danger of encroachment or displacement because the park had protected status for many years (Brown et al., 1997).

Moderate/High Leakage Potential: Where land has competing uses, or in dynamic settings where factors such as population growth, logging or agricultural production for export, subsistence agriculture, fuelwood needs, and concerns about deforestation interact, a project's impact may extend beyond the area of direct project activities (Brown, 1998). If the net greenhouse gas benefits estimated and monitored fails to account for emissions that arise because of the project outside of the area of direct activities, then leakage is an issue. For example, a project that stopped conversion of forest to agricultural land or ended timber harvest, by effectively "putting a fence around the forest," will face leakage problems because if economic activity in the forest is stopped, with no alternative taking its place, then people will shift the activity to a surrounding area.

Changes in national or international policies can lead to leakage. For example, when a government changes policy to lower their country’s overall emissions, the emissions may be displaced to other countries (see Chapter 2, section 2.1.1).

5.3.3.2 Methods for Monitoring Leakage

To date, two approaches have been used and proposed to monitor leakage. One approach involves determining the appropriate spatial area of monitoring project effects; the other involves identifying the key indicators of leakage based on the demand driving land-use change and management.

Monitoring by Area: Leakage may be monitored by expanding the project’s boundary. The monitoring area may be larger than the area on which project activities are implemented (Trexler, 1998, Brown, 1997). Potential monitoring boundaries for leakage are at the project, the local/regional level, or the global level:

- *Project activity boundaries*. Projects implemented on land that has few, or no, competing uses may need to only consider the area of direct project activities because the project's impact is unlikely to extend beyond its immediate boundaries. For example, the RUSAFOR project (see Table 5-2) has no competing land uses and the timber will not be harvested.
- *Regional/local boundaries*. Where land has competing uses, or in dynamic settings where factors such as emigration, population growth, and fuelwood gathering are important, a project's impact is likely to extend beyond it immediate boundary and may extend to the local area or region (Brown, 1998). For example, monitoring can be expanded to include the local cattle/timber/or food market (Chomitz, 2000).
- *Global market boundaries*. Still other projects, notably those involving timber harvesting or agricultural production for export may be operating in a global market. In these cases, if the project causes a restriction on the goods produced, leakage may occur because the project will be unable to affect global market demand. For example, a logging project where the timber is for a global market, could monitor regional wood product production surveys, regional or national wood product flows, or survey mill (Brown et al., 2000).

Monitoring by Key Indicators: Alternately, it has been proposed that leakage be monitored by determining key indicators for the demand driving land-use patterns or management that leads to carbon emissions (such as demand for timber, fuelwood, or agricultural land) (Brown et al. 1997). The key indicator is the output of the product demanded. A project that reduces output or access to resources without offering alternatives is likely to result in leakage as people within the project area will move elsewhere to find other sources of resource supply. A review at the project level has suggested that leakage indicators can be developed by determining whether the project has displaced activities leading to carbon emissions, rather than replacing or substituting for them (Brown et al., 1997). For example, to monitor leakage potential for a project that seeks to replace conventional logging with reduced-impact logging, timber output would be the key indicator that would be monitored. If timber output from the project area decreases, while prices and demand for wood products remain the same, then the project could have leakage. The assumption would be that additional areas would be logged to compensate for the timber loss (Brown et al., 1997). Under this method, it would be unnecessary to track global markets or the harvest intensity of nearby timber concessions, instead, the key indicator of output would be used to monitor the leakage potential. Similarly, where demand for agricultural land is driving land-use change, if conversion of forest to agricultural land is halted, but agricultural productivity is not increased on existing lands, then the project is likely to result in leakage.

Several projects have developed leakage indicators. For example, the Noel Kempff Mercado project in Bolivia involved the Government of Bolivia using carbon mitigation funds to compensate forest concessionaires for giving up logging rights on government-owned forest lands and expand the park boundaries (see Box 5-3). A legally binding “leakage agreement” was signed by the logging companies obliging them not to invest the funds received in logging elsewhere. The key indicators are the use of received carbon funds and the harvesting rates in the concessions. The concessionaires will be monitored to ensure that they do not increase production elsewhere because of the project funding (Brown et al., 2000).

Table 5.5 presents indicators of leakage for LULUCF project activities based on whether the project has addressed demands driving carbon emissions from the project area (Brown et al., 1997). The underlying concept is that decreasing output or access to needed resources will prevent a project from meeting its carbon benefit goals. The extent of the unmet demand determines the potential magnitude of leakage caused by project activities. Multicomponent projects are missing from the table, but potential management strategies point to adding activities, particularly to conservation projects (Chomitz, 2000)

[Insert Table 5.5 here]

5.3.3.3 Options for Responding to Leakage

Two approaches to date have been used and proposed to address leakage; they may be employed either independently or simultaneously. One approach involves addressing leakage at the project level by either project design or re-estimating net GHG benefits. However, some question whether project level approaches can adequately ensure that leakage will be addressed. As a response, macro-level approaches to address leakage have been proposed involving developing regional or national baselines, or establishing risk coefficients by project type or characteristic.

Project level approaches: Leakage potential may be identified at the front-end of project design and additional activities incorporated if the project appears vulnerable to leakage. Should evidence of leakage emerge after project implementation has begun, project implementers may undertake additional activities to mitigate leakage or to monitor and subsequently revise net GHG estimates.

Project design elements incorporated in projects to date: Although experience to date is limited, several elements have emerged that may help avoid leakage, depending on the socioeconomic and physical context of the project. Project design strategies that have been used to avoid leakage include: (a) providing socio-economic benefits to local people, that create incentives to maintain the project and its GHG benefits because of these associated benefits and (b) using replicable or transferable technologies that can help avoid leakage because it allows project benefits to be duplicated outside project boundaries, thus avoiding restricting social benefits to a limited area. Incorporating these can help avoid leakage.

Multicomponent projects may also help avoid leakage because they can combine project activities to fully address demands driving land use change (Chomitz, 2000). For example, the Costa Rican Protected Areas Project (PAP) generated carbon offsets by avoiding carbon emissions and carbon sequestration. The PAP is consolidating approximately 570,000 ha of primary, secondary and pasture lands within the National Parks and Biological Reserves of Costa Rica (Stuart and Moura-Costa 1998; Tattenbach 1996). The PAP plans to reduce deforestation of primary forest, thereby reducing carbon emissions resulting from deforestation. The PAP also plans to allow secondary forest and pasture to regenerate, thereby sequestering carbon through tree growth and accumulation of woody biomass. Concurrently, Costa Rica has also developed a parallel program called Private Forests Project (PFP) that provides financial incentives for land-owners outside the PAP area to opt for forestry-related land uses as opposed to agriculture, thus generating a series of environmental services such as CO_2 fixation, maintenance of water quality, biodiversity, and landscape beauty (Forestry Law N. 7575, April 1996) (Stuart and Moura-Costa 1998). It is expected that the PFP will also offset the effects of decreasing timber harvest in the project area, reducing possible leakage effects.

Another example of a multi-component project is the CARE/Guatemala project that increased fuelwood availability and agricultural productivity by encouraging agroforestry. The project also protected some forest areas, thus allowing degraded areas to regenerate. The CARE/Guatemala project began in 1988 and persisted through years of political strife and high demand for agricultural land because the project combined elements of forest protection and agricultural extension that provided social benefits which gave local people a stake in the project's success (Brown et al., 1997)

Re-estimate net GHG benefits: Leakage cannot always be avoided at the outset or mitigated with additional activities. In some cases, GHG estimates can be recalculated. If project implementers can quantify the shortfall in output from the project, then they can quantify the amount of leakage (Brown et al., 1997). To recalculate the original net GHG benefits, the project evaluator needs to determine approximately how much area must be logged, or converted to agriculture to compensate for the decrease in output. For example, the Reduced-Impact Logging (RIL) project in Malaysia (Table 5-2) was originally estimated to avoid 38,700 tons of carbon emissions. However, the project may have resulted in carbon leakage because on 450 hectares of the 1,400 hectare project, timber production was decreased by approximately 49 m^3 per hectare relative to conventional logging. Total timber shortfall was: 450 hectares* 49 m^3 per hectare or 22,050 m^3 of reduced timber output. To quantify the amount of potential leakage, it is possible to estimate the additional area that must be logged to make up for the deficit. The leakage potential could be roughly determined by estimating the amount of emissions resulting from logging to compensate for the 22,050 m^3 of reduced output. Assuming that the shortfall is made up for by RIL, leakage could be estimated as follows:

> RIL emits 108 tons of carbon per hectare and yields 103 m^3 of timber per hectare, (Pinard and Putz 1997), therefore harvesting 214 hectares using RIL methods would make up for the reduced output. Leakage is then equals 23,112 tons of carbon emitted (214 hectares * 108 tons of carbon per hectare). Thus the net carbon benefit is the original tons of carbon, 38,700, minus the leakage, 23,112, to give an estimate of: 15,558 tons carbon.

These estimates are approximate, represent one harvest cycle, and serve to illustrate one means of quantifying leakage. In this example, RIL still results in a net carbon gain, which may or may not be the case for all projects. Also, RIL projects are designed to increase output over time because there is less damage to young trees. In the long run, it is possible that reduced impact logging sites may produce greater output than conventionally logged ones.

Macro level approaches: Alternatives to project-based approaches have been proposed, including, (a) estimation of empirically-based sectoral, national, or regional baselines that can potentially capture leakage, (b) develop adjustment coefficients for leakage risk and adjust net greenhouse gas estimates accordingly.

- *National and regional baselines:* Adopting sectoral or regional baselines on LULUCF emissions and sequestration is one alternative to the project-based approach. If a project attempted to reduce the rate or area of deforestation, then the project-level effect would need to be demonstrated in subsequent monitoring, and baseline estimates improved. By encompassing a large geographic area, leakage could potentially be internalized. One proposal involves developing national, regional, or sectoral baselines on land-use change and management and is based on the concept of tradable development rights. As above, a regional baseline deforestation rate would be determined using land-use trends. A certain percentage of the forest would be protected, while the remaining forest would be allowed to be developed (Chomitz, 2000). Allowance or development rights to the forest would be distributed, the owners of these development allowances could then in turn sell the development rights. In areas where development was allowed, the carbon sequestration services of the forest could be sold instead of developing the forest (Chomitz, 2000).

- *Risk premiums and adjustment coeffiecients:* To overcome the complexity of quantifying leakage, another approach suggested is to assign specific leakage coefficients (Trexler & Kosloff, 1998). Project estimates could then be adjusted by this coefficient (Gustavsson et al, 1999). These coefficients could be developed at a regional or national level for different project types. The effect of risk premiums or adjustment coefficients is that the projects can only claim a portion of the estimated GHG benefits. A percentage of the net GHG benefit is retained in a buffer to cover the risk of leakage, the goal being to protect the atmosphere from added carbon emissions. For example, the PAP project in Costa Rica has a reserve or buffer of carbon sequestered to insure against various risks, including leakage. The PAP project assumes that some of the subsistence-based farmers who move from the forest may squat on new land, thus resulting in leakage. The PAP estimates a low risk of leakage as only 22,223 ha of the total of 530,498 ha is currently in private hands. Therefore, if 25% of all private owners choose to buy or occupy new areas of land and deforest them, this would negate the carbon offsets arising from just over 1% of the total project area. As a response, in its first year, the PAP will offer only half of the estimated emission reductions for sale, with the rest serving as an insurance buffer for this and other estimated risks (Chomitz et al., 1999).

5.3.4 Project duration

5.3.4.1 How long do projects have to be run for ?

A requirement of the Kyoto Protocol is that LULUCF projects must result in long-term changes in terrestrial carbon storage and CO_2 concentrations in the atmosphere. The definition of “long-term”, however, varies substantially, and there is no consensus regarding a minimum timeframe for project duration.

During the AIJ Pilot Phase, projects have been conducted for a variety of timeframes, from 20 years (e.g., the Protected Areas Project in Costa Rica, Trines, 1998a) to 99 years (e.g., the Face Foundation’s projects, Verweij and Emmer, 1998). Most projects state that their GHG benefits are expected to be maintained beyond the project timeframe (see list of AIJ projects in UNFCCC website (UNFCCC, 1999b) although their contractual arrangements are finite. This lack of definition has caused uncertainty to all parties involved, from regulatory bodies to project developers and investors.

There is a need, therefore, to agree on what timeframe should be used as the basis for quantification of GHG benefits of a project. Different timeframes or approaches have been proposed to define the duration of projects:

a) Perpetuity - the environmental benefits of projects have to be maintained forever. This argument is based on the assumption that the “reversal” of GHG benefits of a project at any point in time would totally invalidate a project (Maclaren, 1999; Carbon Storage Trust, 1998), and that only maintenance of carbon stocks in perpetuity could counter the environmental effects of GHG emissions from fossil fuel sources. It is also argued that this is the only approach which is compatible with the stock change method currently used by the IPCC for National GHG Inventories (Houghton et al., 1997). Criticism of this approach includes: 1) it is impossible to guarantee that a project will be run in perpetuity; 2) maintenance of projects in perpetuity may create conflicts with other land uses in the long term; 3) because of the decay pattern of GHGs in the atmosphere, there is no need for mitigation effects to be perpetual (see ***c)*** below);

b) 100 years – the GHG benefits of a project have to be maintained for a period of 100 years to be consistent with the Kyoto Protocol’s adoption of the IPCC’s GWPs (Article 5.3) and of a 100-year reference timeframe (Addendum to the Protocol, Decision 2/CP.3, para. 3) for calculation of the Absolute Global Warming Potential (AGWP) for CO_2. While this concept has limitations (IPCC, 1996), it has been adopted for use in the Kyoto Protocol to account for total emissions of the greenhouse gases on a CO_2-equivalent basis.

c) Equivalence based - the GHG benefits of LULUCF mitigation projects have to be maintained until they counteract the effect of an equivalent amount of GHGs emitted to the atmosphere, estimated based on the cumulative radiative forcing effect of a pulse emission of CO_2 during its residence in the atmosphere (its AGWP; IPCC, 1992). Variations of this concept have been developed, proposing minimum timeframes of 55 years (Moura-Costa and Wilson, 2000) or 100 years (Fearnside et al., 2000) (see Chapter 2).

d) Variable - acknowledging that different projects may have different operational timeframes. Given the wide range of timeframes of projects carried out to, it can be implied that this has been the approach adopted during the AIJ Pilot Phase.

The adoption of a standard definition of the minimum required timeframe for project duration would greatly facilitate consistency in accounting for GHG benefits of different projects. It would also reduce the uncertainty of all parties involved in project development (project developers, investors, certifiers, regulatory bodies, and the general public).

5.3.4.2. How should projects with shorter timeframes be treated?

Once the minimum project duration has been defined, it is also important to decide how to treat projects that have a shorter duration than the minimum required timeframe. The options can be divided into two main approaches:

a) Full liability – in the event of 'reversal' of GHG benefits, projects should return an amount of credits equal to the total amount of GHGs released. This approach is consistent with the stock change method, which consists of giving credits to projects as carbon is fixed, and removing credits if stocks of carbon diminish. In essence, this approach does not recognize the temporal value of carbon storage. This is the only method possible if it is decided that projects have to be run in perpetuity.

b) Proportional liability - projects should be debited an amount of credits proportional to the difference between the minimum required timeframe and the actual project duration (the "period of non-compliance'). This method is only applicable if a finite minimum project duration is adopted. If, for instance, a minimum timeframe of 100 years is adopted, a plantation project which is harvested at 60 years (assuming that all carbon is released to the atmosphere), would be liable for not maintaining carbon stocks for the last 40 years of the required timeframe. Different methods have been proposed for calculating this proportional liability, such as:

- Linearly – dividing the 'period of non-compliance' by the required timeframe. In the example above, the project would have to return 40% of the credits that it earned/claimed.
- Ton-year based – calculating the liability based on the ton-year approach (see Section 3 and, Fearnside et al., 2000; Moura-Costa and Wilson, 2000).
- Adjusted for time preference – using any of the methods described above, but applying discount rates to reflect time preference (see Chapter 2).

The choice of method for dealing with liability is linked with methods chosen for accounting for GHG benefits, and when credits are given to projects (see Section 5.4).

5.3.5. Risks

Quantification of GHG emissions or removals in LUCF projects is subjected to a variety of risks and uncertainties. Some of these are inherent to certain land-use activities, particularly forestry, while others may be generic and applicable to any GHG mitigation project in both energy and LUCF sectors.

Risks refer to events that negatively affect the expected GHG benefits of the project. Land-use projects are exposed to a series of risks, such as: natural (e.g., rainfall, sunlight, pests and diseases, reductions in growth rates, fire, climate change); anthropogenic factors (e.g., encroachment, fires, theft); political (such as the non-enforcement of legally binding contracts between project partners, the non-compliance with guarantees, expropriation, uncertain property rights, policy changes)*;* economic (such as exchange rate and interest rate fluctuations; Shapiro, 1996), changes in prices of the relevant factor and product markets (Janssen, 1997), changes in opportunity costs of land; financial; institutional (land tenure); and market risks. Not all the risks listed above are exclusive to land-use activities. However, because of their strong social implications, their reliance on a land base, their dependence on natural factors such as rainfall, sunlight, pollinators, and exposure to natural and anthropogenic factors, land-use activities are particularly exposed to these risks.

Risks of project failure due to factors such as fire, climatic variations (drought, storms), and pests also entail potential negative environmental and social impacts associated with failed projects. Implementation of large-scale teak plantation projects in India, for instance, may have led to cultivation of monocultures, which are susceptible to pest infestation, loss of timber affecting local timber markets and associated release of sequestered carbon (Ravindranath *et al*., 1998). Since carbon mitigation projects have to also address issues of sustainable forest management, the risks associated with these new endeavors where there is less experience and infrastructure to draw upon, may not realize the full potential of co-benefits. In the Salicornia project (Box 5.1), for instance, a new concept is being tested to evaluate cultivation possibilities and commercial uses of a previously uncultivated crop. The entry of Salicornia straw to wood markets could lower the price of wood, reducing the incentive for forest plantations locally (Imaz *et al*., 1998). Project developers will have to establish procedures to deal with extra costs in an event of such impacts. For example, the Costa Rican government has committed to find replacement farmers if targets are not met in the PFP project. Another example includes the contractual obligations required by the Face Foundation, that require project implementers to replant any forests which are lost during the project's timeframe (Verweij and Emmer, 1998). Alternatively, in the context of a growing trend in trading in carbon credits, it is to be expected that management would seek to lay these risks off in conventional insurance and reinsurance markets.

Risk mitigation can be done through a variety of internal and external mechanisms to the project. *Internal* methods include:

- Introduction of good practice management systems to control occurrence of damaging events;
- Project design, aiming at diversification of activities within a project, and spreading of projects in different areas, reducing risks of damage spreading (e.g., fire, pests and diseases, flood.);
- Self insurance reserves or keeping a portion of the project's benefits as a reserve to ensure for any shortfalls. This reserve could be financial or in kind (GHG benefits). This approach was used by the national program of the Costa Rican Office for Joint Implementation, which placed about 40% of the credits derived from this project in a self insurance buffer reserve (SGS, 1998). In case of non-occurrence of damage, this reserve can be used at the end of the project life time;
- Diversification of sources of funding, reducing financial dependency on a single source;
- Involvement of a wide range of stakeholders, through a consultation and participatory management approach;
- Creation of positive local side effects of hosting the project, such as the transfer of needed *technologies*, the fostering of local social developments, e.g. by job creation, or the creation of positive side effects on other local or regional environmental goals in the host country (Janssen, 1997);
- Project auditing and external verification, which may serve as a way to highlight project risks early on;
- Timed allocation of GHG benefits – if GHG benefits are only credited to project partners after they are fully realized, there will be less need for long term guarantees, and a lower perception of risk. This could be done by staggering sequestration and crediting, or by only allowing crediting according to a ton-year factor calculated according to an equivalence factor between CO_2 sequestration and emissions (Moura-Costa and Wilson, 2000).

External methods include:

- Cross-project insurance – through direct arrangements in which projects would guarantee each other;
- Regional carbon pools – a similar approach, but through the establishment of "carbon banks", with contributions from a diversified pool of projects to insure contributing projects;
- Financial insurance - some insurance companies are already offering services related to risk mitigation for carbon offset projects. It is important to note that a series of project risks are common to non-GHG specific activities, and have been traditionally been covered by standard insurance schemes, (such as crop or timber insurance).
- Portfolio diversification in terms of different projects in different locations (the Face Foundation's portfolio is an example [Verweij and Emmer, 1998]).

There are still issues related to liability, such as allocation of responsibilities for ensuring compliance and deliverables. The UNCTAD's Emissions Trading Forum has raised issues of responsibility, such as buyer beware, in which buyers are responsible to ensure that offsets are valid, or seller beware, in which an exporting country would have all the transaction invalidated if projects do not deliver (Tietenberg et al., 1998). This has different implications in the case of countries with and without an emissions limitation cap. Issues raised during the meetings of the Ad Hoc Working Group on CDM also included allocation of liabilities between nations, individuals and certifiers (Stewart et al., 1999; Stuart, 1998).

5.4. Measuring, Accounting, Monitoring, and Verifying GHG Benefits

Many pilot projects have been developed (see Tables 5-1 and 5-2), and much experience has been gained particularly at the early stages of project implementation. Based on this experience, an assessment of the nature of measuring, monitoring, accounting, verifying and reporting GHG benefits is presented in this section. Some key questions that guide this section are: With what accuracy and precision can GHG benefits be measured and monitored in LULUCF projects? Does accuracy and precision of measuring and monitoring GHG benefits vary across project types? What are the tradeoffs between cost and precision of measuring and monitoring GHG benefits? What effects do different accounting methods have on the GHG benefits accruing to a project? How long should monitoring, verification and reporting be pursued? How can verification costs be managed? And, what alternative formats are available for reporting project-level GHG benefits?

5.4.1. Methods for quantification of project GHG benefits

A key aspect of implementing LULUCF projects for mitigating GHG emissions and trading is the accurate and precise quantification of project-level GHG benefits. In LULUCF projects, the main focus is on carbon (as carbon dioxide) benefits, but the other gases need to be included as appropriate. Table 5-6 presents typical examples of generic projects, some of which could include carbon only or both carbon and non-CO_2 GHG benefits (see also Chapter 4). For instance, a project designed to stop deforestation typically would include the carbon benefits, but it could also include the nitrous oxide and carbon monoxide benefits that would result from stopping the burning of biomass during forest clearing. Soil and agricultural projects could include non-CO_2 GHG such as nitrous oxide and methane as well. However, whereas carbon benefits are generally measured as changes in carbon pools, the non-CO_2 GHG are measured as fluxes, and the methods are less well developed (See Chapter 1 and 2, and Houghton et al. 1997); thus in the following discussion we focus on carbon (as CO_2). Moreover, the example projects in Table 5-6 could vary in size and distribution; for example, they could be contiguous extending over hundreds to thousands of hectares or a “bundle” of small scattered landowners whose total area could be hundreds of hectares.

[Insert Table 5-6 here]

In this section which pools need to be quantified, how they can be accurately measured to a known level of precision, and the techniques to monitor the carbon benefits over the length of the project are discussed. The initial carbon inventory is distinguished from subsequent monitoring: in the initial inventory the relevant major pools or fluxes are quantified, but in subsequent monitoring only selected pools or fluxes may be measured and even indicators could be used depending upon the type of LULUCF project.

5.4.1.1 Identification of carbon pools

Possible criteria affecting the selection of carbon pools to inventory and monitor are: type of project; size of the pool, its rate of change, and its direction of change; availability of appropriate methods; cost to measure; and attainable accuracy and precision (MacDicken, 1997a,b). A selective or partial accounting system can be used that must include all pools anticipated to decrease and a choice of pools anticipated to increase as a result of the project (Hamburg, 2000). Only measured (or estimated from a measured parameter) and monitored pools are incorporated into the calculation of GHG benefits. Carbon benefits are calculated as the net differences between selected pools for the with- and without-project baseline conditions on the same piece of land over a specified time period.

The major carbon pools in LULUCF projects are: live biomass, dead biomass, soil, and wood products, and each of these can be subdivided further (e.g., , live biomass may include leaves, twigs, branches, stems, coarse and fine roots of trees, herbaceous plants, shrubs, and vines—see Chapter 2 for further details). Table 5-7 illustrates how decisions about which pools to chose for quantification and monitoring may be made for different types of LULUCF projects. Accurately and precisely measuring soil carbon pools present several challenges; however, it should be noted that, of the projects given in Table 5-7, in only two cases need the soil carbon pool be measured (Y).

A selection of projects and their measured or estimated carbon pools is shown in Table 5-8 (for other project details see Table 5-1 and Box 5-1.). Although soil carbon is measured in two of the emission avoidance projects, using these data for calculating the carbon benefits could be problematic. For example, in the Noel Kempff project, the soil carbon benefits from averted deforestation could be calculated as the difference between the soil carbon in the project area and soil carbon in a nearby reference area. Without careful selection of the reference site, its average soil carbon could be higher or lower than the average of the project area due solely to variability in soil characteristics and not to human management. Thus simply subtracting the forest soil carbon from the agriculture soil carbon would give erroneous carbon offsets.

[Insert Table 5-7 here]

[Insert Table 5-8 here]

5.4.1.2. Measurement of carbon benefits

Land use and forestry projects generally are easier to quantify and monitor than national inventories due to clearly defined boundaries for project activities, relative ease of stratification of project area, and choice of carbon pools to measure (Section 5.4.1.1). Techniques and methods for sampling design and for accurately and precisely measuring individual carbon pools in LULUCF projects exist and are based on commonly accepted principles of forest inventory, soil sampling, and ecological surveys (MacDicken, 1997a,b; Pinard and Putz, 1996, 1997; Post et al., 1999; Winrock International, 1999; Hamburg, 2000). For example, there is a wealth of experience in inventorying forests for merchantable volume and growth and the methods are well developed and accepted; these methods can be and are being readily adopted for inventorying forest biomass carbon. Likewise for measuring soil carbon, where standardized techniques are well established. Further descriptions of the methods for estimating the carbon pool in live tree biomass, understory and herbaceous plants, roots, fine and coarse litter, and soil are described in Chapter 2. However, standard methods have not been universally applied to all projects, and methods for accounting for the carbon benefits have not been standardized, resulting in some difficulties in comparing results across different LULUCF projects.

For most LULUCF projects, it would be necessary also to measure non-project reference or control sites. These sites must be sufficiently similar to the project area to serve as a valid proxy under the assumption that the project was not implemented (Vine et al., 1999). To help overcome the difficulty of establishing proxy areas, non-project reference sites could be identified during the project design phase. The location of proxy sites as close as possible to the project would be the most desirable situation. For example, in projects composed of many small landowners converting to no-till agriculture, proxy areas would be those farmers in the area not practicing no till. A description of the Noel Kempff Climate Action Project is presented in Box 5-3 to illustrate the types of measurements being taken to estimate the with- and without-project cases and the resulting carbon benefits.

The total carbon stock has been measured to <10% of the mean with 95% confidence in several pilot LULUCF projects (e.g., Programme for Belize, 1997a; Hamburg, 2000; the Noel Kempff project—see Box 5-3). Although techniques and tools exist to measure carbon stocks in project areas to a high degree of precision, this does not necessarily result in the same level of precision for the carbon benefits. The carbon benefit per unit area of land is the difference between the carbon stocks in the with-project case—which is high if, e.g., the project is conserving carbon in existing forests through an avoided deforestation project—and the carbon pools in the without-project case—which is low if the baseline is agricultural or degraded lands. In this case, the estimated carbon benefit is likely to be high (a small carbon stock subtracted from a large carbon stock), and the error estimate, expressed as a percent of the mean difference, likely to be small and similar to that obtained for the carbon stocks in the forests. However, as the difference between the with- and without-project cases decreases as e.g., in reduced impact logging projects, the percentage error of the carbon benefit increases. To reduce this error, monitoring can be designed to measure the carbon benefit directly as in the NKCAP (see Box 5-3).

START BOX 5-3 HERE_____________

Box 5-3: Carbon inventorying and monitoring of the Noel Kempff Climate Action Project (NKCAP), Department of Santa Cruz, Bolivia

The project area of approximately 634,000 ha is located within the newly expanded western region of the Noel Kempff Mercado National Park. Prior to the initiation of the NKCAP, much of the forest in the expansion area had been high-graded over a period of about 15 years. In addition to logging, this area was also under pressure for conversion to agriculture. For further details see Brown et al. (2000). The forests in the expansion area were divided into six strata for sampling: tall evergreen, liana, tall inundated, short inundated, mixed liana, and burned forest.

The project design for inventorying and monitoring the C pools in the with-project case is based on the methodology and protocols in MacDicken (1997a). The C inventory of the area was based on data collected from a network of 625 permanent plots, with the number of plots sampled in a given strata based on the variance of an initial sample of plots in each strata and the desired precision level (±10%) with 95% confidence. A fixed area, nested plot design was used and carbon stocks were measured or calculated for each of the following pools in each plot: all trees with diameter at breast height ≥ 5cm, understory, fine litter standing stock, standing dead wood, and soil to 30 cm depth. Root biomass was estimated from root-to-shoot ratios given in Cairns et al. (1997). The total amount of C in the park expansion area was about 115 million t C, most of which was in aboveground biomass of trees (60%), followed by soil to 30 cm depth (18%), roots (12%); dead wood (7%); the understory and fine litter accounted for about 3% of the total. The 95% confidence interval of the total carbon stock was ± 4 %, based on sampling error only; regression and measurement error were not included.

Averted logging: The carbon benefits from this activity result from halting removal of commercial timber and eliminating damage to the residual stand. Estimates of the changes in major C pools due to logging and projections of timber extraction if logging had been allowed to continue over the project life were assessed to generate the without-project baseline. The main C pools considered in this activity are aboveground tree biomass, dead biomass, and wood products. Bolivia recently enacted a new forestry law, and developed new regulations for forest harvesting. This information is used to predict how much forest area in the project area would have been harvested in a given year for each year over the length of the project. From data provided by logging concessionaires, an analysis of concessionaire management plans in areas nearby, and the likely quantity of wood (in cubic meters per hectare) extracted per year is also estimated.

The change in C stocks from logging activities is measured in a nearby proxy forest concession. Permanent plots are established to measure the amount of dead biomass produced during the felling of a tree and associated activities as well as the rate of regrowth after harvesting. Dead biomass results from the crown and stump of the felled timber tree and damage to other trees. Total production of dead biomass C per unit of harvested biomass C is determined from these plots.

C benefits from averted logging = Δlive biomass C + Δdead biomass C + Δwood product C
where Δ is the difference in C stocks between the with- and the without-project case. The annual benefits are calculated from a C accounting model that tracks all the changes in these pools from a scenario based on the annual area logged, log extraction rates, and logging damage.

Δlive biomass C = (biomass C from logging damage + C in timber extracted) x growth factor
To estimate the change in live biomass, one could measure the live biomass in the proxy concession before an area was logged and then again after it was logged; the difference would give the change in the live biomass C. However, one main problem with this approach is that two large C stocks are being subtracted, and although the

error on each stock could be small, the error on the difference, expressed as a percent, will be much larger. To overcome this problem, the change in live biomass was measured directly. The change in live biomass between the with- and without-project cases is a result of the extraction of timber and damage of residual trees from the logging activities (the quantity in parenthesis). The quantity in parenthesis, expressed on an area basis, multiplied by the area logged per year gives the total change in live biomass without adjustment for logging effects on growth of the residual stand (the growth factor in the above expression). It is not clear if harvesting stimulates or reduces regrowth in recently logged areas. The logging of large trees and the damage to residual trees may be enough to actually reduce net biomass growth of the stand per unit area for a number of years after logging rather than stimulate it. For projects that prevent or modify logging, this effect of logging on growth of the residual trees must be determined. Monitoring of paired permanent plots in logged and unlogged areas of the proxy concession is underway to establish the sign and magnitude of the growth factor over the length of the project.

<u>Δdead biomass C</u> = (dead biomass from logging damage x decomposition factor)
In projects related to preventing or reducing logging, dead wood cannot be ignored because it is a long-lived pool and logging increases the size of this pool. Thus stopping logging has the effect of reducing the dead biomass C stock, and the dead biomass C in the with-project is less than without-project case. However, the change in the dead biomass pool has to be corrected for decomposition. At present, estimates of the decomposition correction factor are taken from the literature (Delaney et al.,1998), but field measurements are underway for improving this factor.

<u>Δwood products C</u> = (timber extracted x proportion converted to long-lived products)
Stopping logging reduces the long-term wood product pool because the input of new products is reduced; the change in the wood products pool is thus <u>negative</u>. The harvested timber in the Santa Cruz area is from a small number of speciality tree species and a reduction in their supply may not be supplied from elsewhere. In the NKCAP, the proportion of harvested roundwood that goes into long-term wood products was obtained from literature sources for Brazil (Winjum et al., 1998). The project assumed that wood waste generated at each stage of the conversion of timber to products (50% was converted to sawdust in the first milling stage) was oxidized in the year of harvest.

The difference between the with- and without-project case is that the with-project case has more carbon in the live biomass pool and less carbon in the dead biomass and wood product pools than the without-project case.

Averted conversion to agriculture: The carbon benefits from this activity result from elimination of loss of C in forest biomass and soil. The without-project baseline for this component was established using projected human demographics in the areas adjacent to the project area. The two factors affecting conversion of forestlands to agriculture in the area surrounding the NKCAP are increasing human populations and the resulting demand for farmland. In constructing the deforestation scenario, it was assumed that migration into the area will fuel a continued demand for agricultural land as has been seen in other areas nearby to the NKCAP.

C benefits from averted forest conversion = Δtotal biomass C + Δsoil C

Carbon loss from change in biomass is calculated as the product of the projected area cleared and the difference between C in forest biomass (sum of trees, understory, litter, dead wood, and roots) and agriculture crop biomass. Changes in soil C is estimated as the product of area cleared, weighted average forest soil C, and an average soil oxidation rate for converted tropical forest soils obtained from Detwiler (1986).

END BOX 5-3 HERE__________________

5.4.2. Accounting

5.4.2.1. Carbon accounting methods

Various methods have been used to account for the GHG mitigation effectiveness of LULUCF projects. Some are based on absolute measurements at a point in time, while others take into account the time dimension of carbon sequestration and storage. These methods are discussed below and a comparison of results using different methods is given in Table 5-9.

Stock change method. The method most commonly used for expressing carbon storage is based on calculating the difference in carbon stocks between a project and its baseline at a given point in time. This method is referred to as the *stock change method* (previously referred to as the *flow summation method,* Richards and Stokes; 1994), and measurements are usually expressed in t C ha^{-1}. However, it is limited in so far as it provides only a 'snap shot' of the carbon fixed such that resulting values will vary depending on the often arbitrary decision of when to account for the project's benefits. Furthermore, this method does not differentiate between projects that earn credits earlier rather than later. For these reasons, this method does not provide a useful tool for comparison between projects.

For example, Figure 5-2 illustrates a projection of carbon stored in two hypothetical tree plantation projects, with different growth rates. The arrows illustrates that stock change measurements carried out at time *t1* would provide different results between the two projects, but the same result would be reached if measurements were carried out at time *t2*. If measurements were carried out at time *t3*, after harvesting, a totally different result would be reached for both projects, in relation to measurements at *t2*.

[Insert Figure 5-2 here]

Average storage method. To account for dynamic systems, e.g., afforestation projects, in which planting, harvesting and replanting operations take place, an alternative approach has been used (e.g., Dixon *et al.,* 1991; 1994, Masera, 1995), called the *average storage method* (Schroeder, 1992). This method consists of averaging the amount of carbon stored in a site over the long-term according to the following equation:

[Insert Equation 5.1 here]

where *t* is time, *n* is the project time frame (years), and measurements are expressed in t C ha^{-1}. The advantage of this method is that it accounts for the dynamics of carbon storage over the whole project duration, not only at the times chosen for accounting. This method is also useful for comparing different projects with different growth patterns. As shown in Figure 5-3, the average storage over three rotations of project 1 is higher than that of project 2. However, a weakness of this method relates to the still subjective time frame, *n*, chosen for running the analysis. In the case of Figure 5-3, e.g., the average net carbon storage in either project would be equal whether the calculation was performed for one, two, or infinite rotations, as long as the denominator chosen for equation above coincided with the last year of a rotation..

[Insert Figure 5-3 here]

Alternative approaches. Alternative approaches have been proposed to better address the temporal dimension of carbon storage. Most of these are based on adopting a two-dimensional measurement unit that reflects storage and time, i.e., the ton-C year. The concept of a ton-year unit has been proposed by many authors (Moura-Costa, 1996a; Fearnside, 1997; Greenhouse Challenge Office, 1997; Chomitz, 1998; Tipper and de Jong, 1998; Dobes *et al*., 1998; Moura-Costa and Wilson, 2000; Fearnside et al., 2000). The general concept of the ton-year approach is in the application of a factor to convert the climatic effect of temporal carbon storage to an equivalent amount of avoided emissions (this factor is referred to as the *equivalence factor*, or E_f, for the rest of this Section) and vary from 0.007 to 0.02 (Dobes *et al*., 1998; Tipper and de Jong, 1998; Moura-Costa and Wilson, 2000). This factor is derived from the "*equivalence time*" concept (referred to as *Te* for the rest of this Section), i.e., the length of time that CO_2 must be stored as carbon in biomass or soil for it to prevent the cumulative radiative forcing effect exerted by a similar amount of CO_2 during its residence in the atmosphere (Moura-Costa and Wilson, 2000). The definition of the theory and methods used for determining E_f are given in Chapter 2.

Irrespective of the method used for calculating the equivalence factors , they could be useful for the accounting of GHG benefits of LULUCF projects. Different applications have been proposed (Moura-Costa and Wilson, 2000), and in practice a combination of approaches can be used, as follows:

- *Equivalence-adjusted average storage,* using T_e as the denominator of the *average storage* equation (see above). This method could be used to standardize the way in which the average storage method is currently used;
- *Stock change crediting with ton-year liability adjustment* – giving projects credits according to the stock change method, but using ton-years to calculate the amount of credits to be removed in the case of any non-compliance (in the case of occurrence of risk-related events);
- *Equivalence-factor yearly crediting (ton-years),* by which a project is credited yearly with a fraction of its total GHG benefit, determined by the amount of carbon stored each year, converted using the equivalence factor E_f (Figure 5-4). This approach would greatly discourage the implementation of LULUCF projects;
- *Equivalence-delayed full crediting,* only recognizing the full benefits of carbon sequestration after storage for a time period T_e (Figure 5-5). It is likely that this delayed crediting would discourage the implementation of LULUCF projects;
- *Ex-ante ton-year crediting* – giving projects an amount of credits at the beginning of the project, according to the planned project duration, using the ton-year approach. This would reduce the disadvantages that delayed crediting would create to project developers.

[Insert Figures 5-4 and 5-5 here]

If an *equivalence factor* ton-year approach is used, carbon storage could be credited according to the time frame over which storage takes place. Such a crediting system would reduce the need for long-term guarantees and hence the risks associated with long time frames. If the forests storing this carbon pool suffer any damage, the proportion of carbon credits lost could be easily calculated. This method also allows for comparisons between projects. The main disadvantage of this method is that that there is still much uncertainty in relation to the permanence of CO_2 in the atmosphere, and consequently the values of the equivalence parameters T_e and E_f. Depending on the manner in which ton-years accounting is used (see list above), there may also be disadvantages in relation to the timing when crediting occurs, discouraging the implementation of LULUCF GHG mitigation projects (particularly in the case of the *equivalence factor yearly crediting* and *equivalence-delayed crediting* approaches). A comparison of the GHG benefits of each method is shown in Table 5-10.

Whichever method is chosen, it would need to be made compatible with the FCCC reporting requirements (Chapter 6).

Comparison of methods. Table 5-9 shows a comparison of the GHG benefits attributed to the sequestration project illustrated in Figure 5-3. The example assumes that the project is:

- run for three rotations of 18 years each,
- that at the end of each rotation the carbon stock in the forest reach 140 t C/ha,
- that harvesting reduces carbon stocks to zero and that the baseline is zero.

Calculations were conducted assuming both a minimum required project duration of 55 years (based on the equivalence time *Te* of 55 years [Moura-Costa and Wilson, 2000]), and 100 years (based on the equivalence time of 100 years, see Chapter 2 [Fearnside et al., 2000]). It is clear from this example, that depending on the accounting method used, different amounts of carbon benefits accrue to the project, as is shown by the following results:

- According to the ***stock change method***, this project would receive 140 t C/ha during the sequestration phase of each rotation, and would need to return an equivalent amount after each harvest.
- The ***average storage*** calculated for the duration of this project is 84 t C/ha (using the traditional average storage method, without a fixed minimum project duration), that is reached before the end of the first rotation and remains the same irrespective of the duration of the project. If a set timeframe is adopted for the calculation of the average storage (i.e., with a pre-determined denominator in the average storage equation), the GHG benefits of a project would increase proportionally to the time frame under which the project is conducted.
- If a minimum project duration of 55 years was required, the ***equivalence-adjusted average storage*** of this project (which is conducted for 54 years) would be 83 t C/ha, while if the minimum time frame required was

100 years, the equivalence-adjusted average storage would be 45 t C/ha. Furthermore, if this project was conducted only for one rotation, the project's benefits would be lower (see values in parentheses in Table 5-10)

- Another accounting option (the ***stock change crediting with ton-year liability adjustment method***) is to use the stock change method for calculating the benefits of the projects during the sequestration phase, and to use ton-years to calculate the "loss" of benefits when emission take place. Using this approach, the calculated GHG benefits of the project at the end of the first rotation would be 140 t C/ha (the same as in the stock change method), but when emissions take place after harvesting the calculated GHG benefits "lost" is either 112 t C/ha (if a ton-year equivalence factor $E_f = 0.0182$ is chosen, based on Te=55) or 136 t C/ha (if a ton-year equivalence factor $E_f = 0.010$ is chosen, based on Te=100). The longer the project duration, the smaller becomes the amount of GHG benefits "lost" after harvesting.
- If the GHG benefits of the project are calculated using the ***equivalence-factor yearly crediting method (ton-year accounting)***, the GHG benefit attributed to the project would increase gradually as the project is conducted for a longer time frame. Because it is assumed that the ton-year equivalence factor reflects the GHG benefit to the atmosphere derived from temporary storage, no loss of benefits is assumed when emissions take place.

[Insert Table 5-9 here]

5.4.2.2. Accounting for Risks and Uncertainty

Projects have dealt with risks and uncertainty in different ways depending on the type of uncertainty (see also Section 5.3.4). Mensuration error can be dealt with by:

- *Error acceptance* –acknowledging that measurement error is inevitable and listing a range of acceptable errors for different pools;
- *Error minimization* – by setting acceptable errors at a low level, forcing projects to engage in more effective inventorying and monitoring exercises; more samples, larger sample size, and more frequent sampling (see section 5.4.3). This may affect the eligibility of certain types of projects that present mensuration difficulties;
- *Error deduction* – this method consists of deducting the error from a carbon estimate. This approach has the advantage that it allows the project to decide what is more cost effective: data gathering or carbon claims (see section 5.4.3). This approach was used by the international certification company SGS in the certification of the Costa Rican national carbon offset program (SGS, 1998; Moura-Costa *et al*., 2000).

Methods to account for baseline uncertainty include estimation of effect of different uncertainty assumptions on the baseline adopted and deduction of the claims. In the case of quantifiable risks, these can be accounted for by keeping a portion of the project's GHG benefits as a reserve to ensure for any shortfalls. This reserve could be financial or in kind (GHG benefits) as in the Costa Rica PAP example (SGS, 1998). In case of non-occurrence of damage, this reserve may be used at the end of the project life time.

5.4.2.3. Accounting for time (Discounting)

The timeframe of project benefits can affect their attractiveness. Projects that bring benefits at an earlier stage may be favored by some, and this raises the point of *time preference*. Time preference relates to the preference of society to benefits that accrue at an earlier rather than a later stage. In the context of climate change, time preference can be used to introduce a sense of urgency in relation to GHG emission mitigation measures. Not using it implies an endorsement of the assumption that a GHG mitigation activity can be postponed indefinitely without any effect on the overall objective of reducing the impacts of GHG concentrations in the atmosphere.

To account for the value of time and include the concept of time preference, the *discounting method* has been proposed (Richards and Stokes 1994; Fearnside 1995). It consists of using a discount rate to calculate the present value of the total amount of carbon stored over the lifetime of a project, according to the following equation:

[Insert Equation 5.2 here]

where i is the discount rate and n is the project's timeframe (usually in years).

One problem of using discounting, however, relates to the selection of an appropriate discount rate to reflect financial (interest rates), economic or social degrees of time preference attached to the carbon mitigation benefits of a project. High rates favor short term projects, discouraging long-term sustainability and forest maintenance. Too low rates discourage efficiency and approaches that promote more rapid results. Discounting, however, favors activities that prevent the release of carbon, such as conservation or reduced impact logging, instead of activities which actively remove carbon from the atmosphere over a longer period (*e.g.,* forest establishment). This is because conservation activities internalize large amounts of carbon at the beginning of the project cycle, therefore suffering less from the effects of discounting.

5.4.3 Monitoring

Monitoring relates to the periodic measurement of carbon pools in the project area and in proxy or reference non-project areas. Permanent sample plots, as often used in the initial carbon inventory (e.g., see Box 5-3), are generally considered as the statistically superior means for evaluating changes in forest carbon pools. Methods are well established and tested for determining the number, size, and distribution of permanent plots (i.e., sampling design) in several LULUCF projects for maximizing the precision for a given fixed monitoring cost (MacDicken, 1997a; Winrock International, 1999). The use of permanent plots allows for efficient assessments of changes in carbon stocks over time and for cost and time efficient verification of the project's reported carbon benefits (MacDicken, 1997a). Moreover, a random selection of the permanent plots may only be measured as part of the ongoing monitoring program. And, not all of the initial carbon pools need be measured at every interval in some projects; the judicious selection of some pools could serve as indicators that the project is following the expected trajectory. For example, projects designed to avoid emissions through arresting deforestation or logging need only establish that no trees are removed or clearings made over the course of the project. In projects designed to sequester carbon, changes in the vegetation carbon or soil carbon pools do need to be re-measured periodically.

Remote sensing can provide a useful means for monitoring LULUCF projects (see Chapter 2). A range of remote data collection technologies are now widely available, ranging from satellite imagery to aerial photographs from low flying planes. An new advance in this area couples dual-camera videography with a pulse laser profiler, data recorders and differential GPS (geographical positioning system), mounted on a single engine plane (Department of Forestry and Conservation Management, University of Massachusetts, 1999). This system is able to produce indices of crown density, number of trees per unit area, and tree height, as well as identify the extent of gaps that will be especially useful for projects related to arresting or modifying logging, as well as monitoring for small-scale human disturbance in protected forests.

In some circumstances, models (parameterized for project conditions) can be used for projecting changes in carbon pools over short time periods for which direct measurements fall below easily detectable levels, followed by direct measurements over longer time intervals to verify model projections (Post et al., 1999; Vine et al., 1999). Process-based models are particularly useful for projecting slowly occurring changes in soil carbon pools (Paustian et al., 1997; Post et al., 1999). Likewise, models exist for plantations and agroforestry systems (e.g., Mohren et al., 1999; Maclaren, 1996, Schlamadinger and Marland, 1996; ICRAF, n.d.) that could be used in conjunction with direct field measurements to estimate changes in carbon pools over shorter time frames.

5.4.4. Precision and Costs

Field methods to accurately quantify carbon pools exist, but the level of precision can vary by pool. The total error in measuring a given carbon pool is based on sampling error (the variation among sampling units, e.g., the number of plots, within the population of interest), measurement error (error in measuring the parameter of interest e.g. stem diameter and soil carbon.) and regression error when appropriate (e.g., error resulting from conversion of tree diameter to biomass based on a regression equation). Sampling error is usually the largest source of error (Phillips et al., 2000) and increased precision generally comes at increasing cost of inventorying because of the time and cost involved in establishing the appropriate number and distribution of permanent plots. Carbon inventory in forests can be more complicated than traditional forest inventories as each carbon pool will have a different variance. The sample size for each pool can be calculated individually and, based on resources available for monitoring the project and the information in Table 5-7, informed decisions can be made about which pools to measure and count. Such information can be used at the design stage to select pools to be included in the project, with significant implications for the total cost of the project and measurement and monitoring costs per ton of carbon.

The costs of measuring and monitoring carbon offsets are a function mainly of the desired level of precision, which may vary by the type of project activities, the size of the project (areal extent, contiguous, fragmented, of a bundle of small landowners), and the natural variation within the various carbon pools. Stratification of the project area into more or less homogeneous units, based on vegetation type, soil type, topography or management practice, can increase the precision of the carbon measurements without increasing the cost unduly by lowering the amount of variation around the mean, thus requiring fewer plots to be within acceptable levels of precision. For example, an increase in the coefficient of variation (a measure of the variation around the mean) within a forest stratum of about 160% would increase the cost of measurement by about 280% to maintain the same level of precision (Figure 5-6a).

A few data exist that are used here to provide some preliminary estimates of costs of measuring and monitoring carbon in LULUCF projects three tropical countries (Powell, 1999 for the Noel Kempff; Subak 1999 for Costa Rica; Box 5-4). For the first inventory of the Noel Kempff project, the total fixed operational costs (including human resource costs, project management, mapping, etc.) were estimated to be about $196,000 and variable costs per plot (including labor, equipment, transport, etc.) ranged between $230 to $281 for a total of about $154,000 (625 plots). The grand total cost was about $350,000 (Powell, 1999). The precision of the inventory, based on sampling error only, was ±4% with 95% confidence (see Box 5-3). The variable costs dropped rapidly from about $108,000 for a precision level of ±5% to $1,000 for a level of ±30%; fixed costs would be the same for all levels of precision (Fig. 5-6b). Estimates of the revised carbon benefits from this project for its duration based on additional measurements and data collection (Brown et al., 2000) and the additional cost to collect this information result in an estimate of about $0.10 per t C benefits. Estimating future monitoring costs based on the first inventory is difficult but they are likely to be less than those for the initial inventory because different sampling intensities will be used, project implementers can build on previous experience, and advances in technology will be available (e.g., Section 5.4.3). [Figure 5-6 here]

The organization responsible for monitoring carbon sequestration in Costa Rica’s Private Forestry Project (PFP) and for acquiring remote-sensing information has an annual budget of $200,000 (Subak, 1999). Additional costs associated with the PFP relate to the costs of monitoring forests and plantations. The implementing organizations do not absorb all the monitoring costs but charge landowners at a rate that varies in different regions. For example, in the Central Volcanic Range (including the upper Virilla), landowners pay the implementing organizations 10% of their annual environmental services payment for monitoring forest protection and pay slightly more for monitoring forest management but do not pay anything for monitoring plantations (Subak, 1999). The implementing agency’s unit costs will tend to be higher when monitoring smaller landholdings, and although a stated objective of the PFP is to compensate small and medium-sized landowners, larger parcels may be favored by some implementers . Monitoring of the PFP is supposed to include site visits by forest engineers and more detailed audits of some sites. The annual visits involve making a report on the size, density and health of the trees on the land and the more detailed “audits” are to assess management and the conditions of the trees and soil. The intention is to audit as few as 5% of the PFP sites. The costs in labor for auditing are estimated to be $10 per ha per year compared to $1 per ha per year for monitoring and $2 per ha per year for certification. The aggregate costs of project developing, recruiting, and auditing are significant but have not been judged to be excessive or to reverse the cost-effectiveness of the PFP as an LULUCF project.

Currently, there are no guidelines as to level of precision to which pools should be measured and monitored. Setting such a level would facilitate comparison of projects and could encourage project developers to measure projects more precisely if the price of carbon was high. For example, if the total average carbon benefit was 5 million t C with a ±30% confidence interval, this example would result in a lower bound of 3.5 million t C. If LULUCF projects could only claim benefits for a lower bound of the confidence interval and if carbon was worth $10/t C, this would represent a “loss” of carbon benefits of 1.5 million t, equivalent to $15 million, a value likely to greatly exceed the cost of monitoring to a ±5% precision level. Thus it is likely that project developers would chose high precision levels for their monitoring.

START BOX 5-4 HERE________________

Box 5-4: Cost of Monitoring and Verification of a Forest-Based Project in the Western Ghats, India

The dominant activity in this project is to reforest degraded lands. The specifics are to perform enrichment planting of trees in partially degraded forests and establish multipurpose tree plantations on fully degraded lands (Ravindranath and Bhat, 1997). The carbon benefits from this project are from: carbon conservation of biomass in native forest by substituting with wood from tree plantations; carbon sequestration in trees and soil in the enrichment planting of partially degraded forests (logging is banned in this area); and enhancing soils C in the badly degraded lands. The total area to be reforested is 42,000 ha for a total budget of US$11.7 million over a period of 6 years starting in 1991. The cost for reforesting with the dominant multi-purpose tree plantations is US$609/ha. The allocation for monitoring and research of the reforested lands (survival and growth rate) is about US$1 million, which accounts for about 9% of the total budget allocated for this project (Ravindranath and Bhat, 1997). The annual cost for monitoring of the project lands is about US$5 per ha.

END BOX 5-4. HERE_________________

5.4.5. Verification

Verification by third party institutions offers a way to provide confidence to governments, investors, project developers, NGOs and the public at large of the validity of the claimed carbon benefits by a project. Third party verification could be based on an assessment of the project’s compliance with defined eligibility criteria. A single set of internationally accepted eligibility criteria may facilitate direct comparison of projects whilst a variety of such criteria may result in projects and GHG benefits of differing quality.

Verification activities may include: (1) review of data or documentation (e.g., procedures, methodologies, analyses, reports), including interviews with project personnel; (2) inspection or calibration of measurement and analytical tools and methods; (3) repeat sampling and measurements; (4) assessment of the quality and comprehensiveness of the data used in calculating the project baseline and offsets and therefore the confidence in the final claims; (5) assessment of risks associated with the project and the carbon benefits; and (6) the presence or absence of non-GHG externalities such as environmental and social impacts. Existing programs describe alternative ways that verification could be accomplished. Notable elements of the alternative programs include periodic verification of project performance against defined criteria (EcoSecurities, 1997; Trines, 1998b; Moura Costa et al., 2000), an external evaluation panel, site visits, and third-party inspections (U.S. Initiative on Joint Implementation, 1996), and designation of verifiers by the proposer (World Business Council for a Sustainable Development, 1997).

Unlike projects in other sectors, the carbon stocks of LULUCF projects may require verification and monitoring beyond the project time horizon. The verification period will depend on the method chosen for accounting of carbon stocks (see Section 5.4.2). The carbon stock method may require verification until the end of the project, the average net carbon storage method may need verification in perpetuity. And the ton-year approach may require verification for periods ranging from the project lifetime to some specified time period beyond the lifetime, depending on the specifics of the accounting method chosen.

To date there has been little experience with third-party verification of carbon stock of projects (Moura Costa et al., 2000). However, the Forest Stewardship Council (FSC) offers a model as to how verification might be accomplished and how verifiers might be accredited by an independent accreditation body. The FSC accredits organizations that inspect forest operations, and grants labels certifying that the timber has been produced from well managed forests. It is funded by organizations other than the industries it monitors. Other institutions such as SGS are establishing certification councils with similar responsibilities.

Costs of verification by third parties can be alleviated by taking several steps:

- a single set of eligibility criteria accompanied by standardized accounting and reporting methodologies will reduce the costs of developing such services;
- definition of acceptable confidence intervals will enable project developers to maximize their sampling efficiency and verifiers minimize their costs; and
- development of “group verification programs”, successful in other sectors, can make verification available to small-scale projects.

5.4.6. Reporting

The purpose of reporting is to provide information on the project’s *measured* GHG and non-GHG benefits to government and/or inter-government entities to establish GHG credits that might be used for offsetting an Annex B country's commitments during the budget period (see also Chapter 6 of this report). Reporting guidelines for each of the Kyoto Protocol’s flexibility mechanisms are to be developed by the Conference of Parties. This section discusses what types of data may be required for reporting, and the issues about multiple reporting of project activities.

The UNFCCC’s SBSTA developed a Uniform Reporting Format (URF) for activities implemented jointly under a pilot program. The format was approved by the SBSTA as part of the implementation of the UNFCCC (Subsidiary Body for Scientific and Technological Advice, 1997). In completing the URF, project proposers are to estimate the projected emissions for their without-project baseline scenario and with-project activity scenario. They are to estimate cumulative effects for carbon dioxide, methane, nitrous oxide, and other greenhouse gases. The URF also contains a section on environmental and socioeconomic benefits. Project developers are to describe how their project is compatible with, and supportive of, national economic development and socioeconomic and environmental priorities and strategies. Furthermore, the URF requests information on the “practical experience gained or technical difficulties, effects, impacts or other obstacles encountered”. As of October 13, 1998, 95 AIJ projects had reported the above information using the URF format (UN Framework Convention on Climate Change, 1999). Other programs, such as the US IJI, have their reporting requirements as well.

Improvements to the URF format have been proposed (Vine et al., 1999) that include: basic project contact information, a description of the project, the projected and actual changes in carbon stock, net changes in carbon stock; information on the precision of the results, data collection and analysis methods used in calculating changes in carbon stock, estimates of project leakage—both negative and positive, and market transformation where calculated. Finally, information on environmental and socioeconomic impacts and an indication of whether there is consistency between environmental laws, environmental impact statements, and expected environmental impacts could be included.

Unlike projects in other sectors, the time period over which reporting needs to occur will depend on the method chosen for accounting of carbon stocks of a project. The project developer or some other organization will need to be designated to report on changes in the carbon stock, should the accounting method require continued monitoring and verification after the end of the project. Governments may need to establish a procedure and set rules for post-project reporting, if needed.

5.4.6.1 Multiple reporting

Several types of reporting might occur in forestry projects: (1) impacts of a particular project are reported at the project and / or program level (where a program consists of two or more projects); (2) impacts of a particular project are reported at the project level and at the entity level (e.g., a utility company reports on the impacts of all of its projects); and (3) impacts of a particular project are reported by two or more organizations as part of a joint venture (partnership) or two or more countries. To reduce any problems that may occur in multiple reporting, project-level reporters would need to indicate whether other entities might be reporting on the same activity and, if so, who. Establishment of a clearinghouse with an inventory of stakeholders and projects might solve this problem. For example, in their comments on an international emissions trading regime, Canada (on behalf of Australia, Iceland, Japan, New Zealand, Norway, Russian Federation, Ukraine and the United States) has proposed a national recording system to record ownership and transfers of assigned amount units (i.e., carbon offsets) at the national level (UN Framework Convention on Climate Change, 1998). A project synthesis report could confirm, at an aggregate level, that book keeping was correct, reducing the possibility of discrepancies among Parties' reports on emissions trading activity.

5.5 Associated Impacts (Benefits and Costs) of LULUCF Projects

Several authors have noted that LULUCF projects to reduce or offset GHG emissions can also provide significant environmental and socioeconomic "co-benefits" to host countries and local communities (Frumhoff *et al*., 1998; Makundi, 1997; Trexler and Associates, 1998; Losos, 1999; Brown, 1998; Reid, 2000; Lasco and Pulhin, 1999, Klooster and Masera, 2000). Because their scale is prospectively large (Section 5.1), such projects may have substantial potential to help countries meet multiple sustainable development objectives. However, some authors have also expressed concern that some types of LULUCF projects pose significant risk of negative environmental and socioeconomic impacts (e.g. Cullet and Kameri-Mbote, 1998; German Advisory Council on Global Change, 1998).

This section follows on the general assessment of sustainable development aspects of LULUCF measures in Section 2.5 to address the following project-specific questions: what are the environmental and socioeconomic implications of different LULUCF project types? Do any pose inherently negative or positive impacts?

Representative data on the socioeconomic and environmental impacts of several LULUCF projects carried out under the AIJ pilot phase is provided in Box 5-1. Relatively few AIJ LULUCF projects have thus far provided detailed quantification of observed and expected local socioeconomic impacts (Witthoeft-Muehlmann, 1998). We draw upon the available pilot project data and information from similar LULUCF projects in the evaluation of associated impacts below.

5.5.1. Associated Impacts of Project Activities that Avoid Emissions

Pilot LULUCF projects designed to avoid emissions by reducing deforestation and forest degradation have produced marked environmental and socioeconomic co-benefits, including biodiversity conservation, protection of watershed and water resources, improved forest management and local capacity building and employment in local enterprises. Substantial biodiversity benefits, for example, have been realized in the Rio Bravo project in northwestern Belize (Table 6-8) and the AES Barbers Point C-offset project in Paraguay (Dixon *et al*. 1993), where protection of 56,800 ha of tropical forest can both conserve existing biodiversity and restore native flora lost due to logging activities.

Any LULUCF project that slows deforestation or degradation will help conserve biodiversity. But successful projects in threatened forests that contain an assemblage of species that is unusually rich, globally rare, or unique to that region can provide the greatest biodiversity co-benefits (Dinerstein *et al*, 1995; Olsen and Dinerstein, 1998). One example is the Noel Kempff Mercado carbon offset project in Bolivia, where in a region of globally outstanding biological distinctiveness, a 634,000 ha timber concession has been converted into an extension of a national park (USIJI, 1997b, Dinerstein *et al*. 1995, Box 5-1).

Projects designed to protect natural forests from land conversion or degradation could pose significant costs to some stakeholders if they restrict options for alternative land-uses, such as crop production. Such costs might be mitigated, however, by ensuring sited projects in regions where conservation measures are consistent with regional land-use policies, and by promoting sustainable agricultural intensification on associated non-forested lands. Indeed, forest conservation projects in areas where policies encourage agricultural expansion are unlikely to be successful. Critical to shaping project success in meeting carbon mitigation and sustainable development goals is the effective participation of local communities affected by project activities (Section 5.6). In the Noel Kempff Mercado case, this includes community-run revolving funds financed by the project that provide loans for local sustainable development enterprises such as ecotourism, bakeries and hearts of palm production (Brown *et al*., 1999).

LULUCF projects that protect forests from land conversion or degradation in key watersheds have substantial potential to slow soil erosion, protect water resources for rural communities and municipalities (Reid, 2000) and conserving biodiversity (Hardner, 1996, Frumhoff *et al*. 1998; Hardner *et al*., 2000)Benefits can also include reduced risk of flood damage and reduced siltation of rivers; the latter can protect fisheries and investment in hydroelectric power generation facilities (Chomitz and Kumari 1998). One AIJ pilot project designed to provide these benefits is Costa Rica's Private Forestry Project (Subak 1999).

Several AIJ pilot carbon offset projects include measures to reduce the impacts of logging and more generally improve the sustainability of forest management (Brown, 1998). As evidenced from a project in Sabah, Malaysia, such projects can combine reduced carbon emissions with reductions in the environmental impacts of commercial logging, and socioeconomic development through technical training (Pinard and Putz,1997; Pinard and Putz, 1996; Putz and Pinard, 1993).

Both the carbon and associated environmental benefits of reduced-impact logging are captured only in forest sites that would otherwise have been logged by conventional methods or converted to agriculture; they would not be gained in forests that would have otherwise been unlogged. In developing countries, such projects might under some conditions also slow deforestation by making long-term timber production more profitable than clearing forest for low-productivity agriculture or pasture (e.g. Boscolo *et al.,* 1997).

Projects designed to promote reduced-impact logging as a carbon offset may produce fewer biodiversity co-benefits than forest protection, but provide larger socio-economic benefits for local owners (Marland *et al*, 1997; Kurz *et al*., 1997, Frumhoff and Losos, 1998, Bawa and Seidler, 1998, Klooster and Masera, 2000). Policymakers may wish to identify and consider prospective trade-offs between meeting these objectives on a national or project-by-project basis.

5.5.2. Associated Impacts of Projects that Sequester Carbon

Under a carbon market, projects that promote afforestation through plantation forestry may be attractive to many prospective investors, given their potential to generate profitable financial returns in addition to carbon credits (Frumhoff *et al*., 1998). The potential impacts of projects designed to promote afforestation through plantation forestry will vary significantly with location, scale, use of native versus exotic tree species and intensity of management. Intensively managed plantations, for example, can help maintain and improve soil, properties particularly if understory vegetation and leaf litter is not cleared (Chomitz and Kumari, 1998), while providing a source for biomass fuels and other wood products. They can have highly variable impacts on water resources (Section 2.5.1). Plantations do not appear to typically reduce pressure on natural forests in the humid tropics (Kanowski *et al.,* 1992, Johns, 1997), because these forests are not generally cleared for the sawnwood, pulpwood and other products that plantations provide. Kanowski *et al*. (1992) suggest that fuelwood plantations might help reduce pressure on natural woodlands in relatively arid regions.. Thus, they might help stem desertification in some settings.

Plantation projects would have negative impacts on biodiversity if they replace native grassland or woodland habitat or if permanent plantations of exotic species were planted in sites where natural or assisted restoration of indigenous forests is feasible. Many grassland ecosystems, for example, are rich in endemic species; in the Mpumalanga Province of South Africa, the expansion of commercial plantations (*Eucalyptus* spp. and *Pinus* spp.) has led to significant declines in several endemic and threatened species of grassland birds (Allan *et al*. 1997).

In contrast, non-permanent plantations of exotic or native species can be designed to enhance biodiversity co-benefits by jump-starting the process of restoring natural forests (Parrotta *et al.,* 1997ab, Lugo, 1997, Keenan *et al.,* 1997). Commercial forestry plantations can also increase biodiversity co-benefits by adopting longer rotation times, reducing or eliminating measures to clear understory vegetation, using native tree species, and minimizing chemical inputs (e.g. Allen *et al.,* 1995ab, Da Silva Jr. *et al.,* 1995).

Afforestation or reforestation measures could have either positive or negative impacts on local communities. Negative impacts can result if projects are implemented on land for which communities have alternative priorities, such as agricultural production, and if communities are not effectively engaged in all phases of project design and implementation (Cullet and Kameri-Mbote, 1998; Section 6.6.3). In urban or periurban areas, they can also produce significant local socioeconomic benefits through improvements in air quality (McPherson, 1994).

Some observers have expressed concern that carbon-offset financing for reforestation projects in non-Annex 1 countries could promote deforestation by financing the expansion of plantations that replace natural forests whose associated emissions would not be constrained by a national cap (German Advisory Council on Global Change, 1998). Possible options should Parties wish to constrain such projects are discussed in Section 2.5.2.2.

Agroforestry activities can both sequester carbon and produce a range of environmental and socioeconomic benefits. For example, trees in agroforestry farms improve soil fertility through control of soil erosion, maintenance of soil organic matter and physical properties, increased nutrient inputs through nitrogen fixation and uptake from deep soil horizons and promotion of more closed nutrient cycling (Young, 1997). Thus, agroforestry systems which incorporate trees on farms are able to improve and conserve soil properties (MacDicken and Vergara, 1990; Nair, 1989), as is the case in the AES Thames Guatemala project (Dixon *et al*., 1993). Agroforestry projects also may provide local economic benefits, with farmers gaining higher income from timber, fruits, medicinals and extractives that they would from alternative agricultural practices (Cooper *et al*., 1996).

However, poorly planned and implemented agroforestry projects can fail or have negative impacts on local farmers. For example, the introduction of labor-intensive agroforestry technologies can lead to labor competition between agroforestry practices and traditional farming (Repollo and Castillo, 1989; Laquihon, 1989). Poorly planned projects can.also lead to excessive light and water competition between crops and trees as well reduce area available for food crops.

The associated environmental benefits of project activities that promote assisted regeneration of natural forests are similar to those of forest conservation. As the forest matures, key benefits may include protection of watersheds, soil fertility, and biodiversity. As with forest conservation or plantation forestry, assisted forest regeneration could lead to negative social impacts if communities are prevented from changing to preferred land uses in the future. This also can be reduced by ensuring that the designation of areas for reforestation are consistent with long-term regional land-use plans, and that community development priorities are effectively incorporated during project development and implementation (Section 5.6)

There is very limited experience of LULUCF pilot projects that sequester carbon or reduce carbon emissions from agricultural soils. However, there are vast areas of degraded and desertified land in developed and developing countries where well-designed projects can add carbon to the soil while increasing agricultural productivity and sustainability (Chapter 5).

5.5.3. Associated Impacts of Carbon Substitution Projects

Projects that use short-rotation tree plantations as woody biomass energy sources have equivalent associated impacts as the managed plantation projects described in Sec 5.5.2. There are also a broad range of prospective environmental and socioeconomic impacts associated with the production of biomass energy from agricultural crops, such as sugarcane and corn, and oil crops, such as soybeans. The impacts of substitution projects can occur both on-site where projects are located, and also off-site, where electricity or fuel supply is offset. On-site impacts include the local environmental and socioeconomic benefits of the forestry and energy generation components of a bioenergy project. The environmental impacts can include reclamation of degraded lands, potential promotion of biodiversity, provided part of the plantation area is left for natural regeneration (Carpentieri *et al*. 1993), and reduction of pressure on primary forests to the extent fuelwood derived from such sources is substituted by other energy sources. Rural bioenergy programs can also help local communities achieve self-reliance, and decentralize political power by giving control on resources to the local community (Ravindranath and Hall, 1995).

Provision of small-scale bioenergy in place of using wood may often directly benefit women more than men. The above options will decrease the labor and time needed to gather wood, and reduce indoor air pollution from smoke, a recognized health hazard. The success of rural projects depends on equitable distribution of benefits that community involvement in rural energy projects can provide (Agarwal and Narain, 1989). The on-site energy generation can increase the production of local pollutants. However, well-designed projects can offset another more polluting local source, as in the case of the Bio-Gen Biomass Power Generation Project in Honduras. There, the use of emission control technologies are included to produce fewer pollutants than would have been emitted in the non-project case, with the continued uncontrolled burning of sawmill and logging residues. Giampietro *et al*. (1997) provide a more general discussion of the environmental impacts of biofuel production.

In conclusion, there are no inherently good or bad LULUCF GHG mitigation projects in terms of their potential vironmental and socio-economic co-benefits. Adequately designed and implented, projects in each major category can provide significant socioeconomic and environmental benefits to host countries and local communities, though projects of all types pose some risk of negative impacts. The next section addresses how the sustainable development contributions of these projects can be strengthened and negative impacts mitigated.

5.6. Factors affecting the sustainable development contributions of LULUCF projects

Six factors have been identified that are critical to strengthen the SD contributions of LULUCF GHG mitigation projects:

- the consistency of project activities with international principles and criteria of sustainable development
- the consistency of project activities with nationally defined sustainable development and/or development goals, objectives and policies
- the availability of sufficient institutional and technical capacity to develop and implement project guidelines and safeguards
- the extent and effectiveness of local community participation in project development and implementation
- the transfer and local adaptation of technology (including both hardware and software)
- application of sound environmental and social assessment methodologies to assess sustainable development implications.

Chapter 2 highlights the international principles and criteria of sustainable development that may enable a more successful implementation of LULUCF projects. It also discusses the application of social and environmental assessment methodologies. In this section we discuss in more detail the other four factors.

5.6.1 Consistency with nationally-defined sustainable development and/or national development goals

Prospective investors in LULUCF projects and host countries may have different priorities in selecting projects. From the investors' perspective, criteria such as land availability and the suitability of the country to undertake the project, the estimated GHG benefits, the project cost-effectiveness, risk and other environmental effects are some of the major concerns. From the host country perspective, projects that more specifically consider regional or local land-use priorities, and significantly strengthen the sustainable development contributions will be favored. Some observers have also expressed concern that selecting only the cheapest projects will be detrimental to Non-Annex I countries if they subsequently take on GHG emissions (Lee et al 1997, Brown 1998). However, for LULUCF projects to be designed, conceived and implemented successfully to provide economic and environmental benefits, the support of different stakeholders of the project – project investors, host countries and the local communities –see next section- is crucial.

The voluntary nature of host country participation in climate mitigation projects increases the prospects of only those projects that satisfy both investor and host country interests will be implemented. Moreover, host countries can take steps to ensure that the goals of accepted projects are consistent with national and local development and natural resource protection priorities (Intarapravich 1995, Michaelowa and Schmidt 1997, Hardner et al, 2000). Dutch and Costa Rican criteria for approval of AIJ projects for example, state that projects should be compatible with, and supportive of, sustainable development priorities of each country, fulfill the obligations of various conventions, and enhance income opportunities and quality of life for rural people and members of certain vulnerable groups including cultural minorities (Andrasko *et al*., 1996, Ministry of Housing, Spatial Planning and the Environment, 1996, Subak, 1999).

One way to ensure that a mitigation project is consistent with the host country developmental goals, is for host country to set up a simple approval process for accepting projects, where criteria based on national and local needs are listed. Projects may not satisfy all criteria, but it is important to ensure that they adhere to all applicable laws and/or regulations of the host country. In order to meetnational or regional sustainable development priorities, project transaction costs should be kept low. High costs can both reduce investor interests in financing LULUCF climate mitigation projects (Section 5.2) and also reduce the proportion of funding available to promote and monitor environmental and social aspects of implemented projects.

To achieve consistency with national and regional environmental and development goals, it is also important to ensure that policies and programs support rather than undermine project objectives. Changes in key policies that may affect project sustainability either positively or negatively include financial subsidies for forestry or agriculture, land tenure, policies to expand agricultural production, import-export policies and paper recycling programs (World Bank 1997). For example, Brazil’s government-subsidized program to produce ethanol vehicle fuel from sugarcane withered in the face of low gasoline prices (La Rovere, 1998). Therefore, incorporating projects that minimise conflicts or institutional changes relative to existing land use policies in the host country may be essential.)

5.6.2 Availability of sufficient institutional and technical capacity to develop and implement project guidelines and safeguards

In industrialized countries, relatively good expertise exists to understand the technical issues involved in the preparation and implementation of LULUCF projects. In many developing countries, however, there is not enough technical capacity to design, implement, monitor and evaluate, LULUCF projects raising capacity building needs that are reviewed below.

5.6.2.1 Capacity Building

As suggested by COP 4 decisions, capacity building for country-driven projects needs to be greatly enlarged. If forestry and biofuel options are to play a key role in least cost and early (precautionary) GHG reductions, there is a need for experts to initiate and implement projects (Haque et al, 1999). Furthermore, the twin objectives of carbon mitigation and sustainable development present additional technical challenges to monitoring and verification (Andrasko, 1997) which is vital to the commercial credibility of LULUCF projects (Fearnside, 1997; MacDicken 1997a).

The capacity to implement LULUCF projects can be developed through investment in training in information programs, demonstration projects, training and outreach and general capacity building (Swisher, 1997). For instance, Australia and New Zealand have developed capacity building programs to facilitate strong awareness of modalities governing projects in developing countries (Warwick, 1998, UNFCCC, 1999a, Read, 1999) and in Africa capacity building is seen as an equity issue (Sokona, 1999). For example, Costa Rica integrated several NGOs into its AIJ program from the beginning which provided technical and operational support to the Costa Rica’s Office for joint implementation (OCIC) (MINAE, 1996).

At different stages of the project, appropriate meetings, information workshops, formal hearings, government-supervised notices, consultation, access to documents and reports, employment of members of the public, use of public third-party auditors and complaint and dispute resolution forms of participation may be most appropriate (Environmental Law Institute, 1996). Training in the gathering of a conjunction of stakeholders to obtain mutual benefits is a crucial aspect of generalist capacity building (Haque et al 1999).

5.6.3 Extent and effectiveness of local community participation in project development and implementation

The involvement of local communities who directly depend on forest resources is a pre-condition for the success of community-based projects (Grenier, 1998). Local communities can be involved in the project by designing projects to develop local skills, create employment in the project, and promote equity, leading to long term sustainability of the project activity. In the Scolel Te project, for instance, local communities and their agroforestry traditions are included in the project design process (Imaz *et al*, 1998). On the other hand, the ECOLAND project in Costa Rica has caused discontent among local residents, who did not sell their lands and now face hardships caused by the inclusion of their lands in a national park (Goldberg 1998). It is also important that the land titles and legal rights of indigenous people are recognised by the host country and the project designers so as to ensure their effective participation in the project (see Box 5.5 for the case of the social forestry program in India).

Local communities can be involved by designing LULUCF projects that help to develop local skills, create employment , and promote equity. For example, in bioenergy projects, the local youth could be trained in operation, and maintenance of biogas plants leading to creation of new jobs in rural areas and reduce migration to urban centers to achieve equitable development between rural and urban areas (Ravindranath and Hall, 1995). It will also promote sustainability of the project, by providing financial, social and environmental benefits even after the investors have withdrawn.

The success of community management projects also depends on equitable discussion, participation and distribution of benefits, which is crucial for the development of the rural areas (Sokona, 1999). It is important to have institutional arrangements to ensure land tenure and product ownership by local communities or to meaningfully involve them in decision-making processes regarding species choice, mode of production, harvesting and benefit sharing that makes them to commit themselves to the protection and management of LULUCF projects.

5.6.4 Transfer and local adaptation of technology

For LULUCF projects, technology adaptation, diffusion and transfer needs a broad definition. Such transfer may include sustainable forest management practices; forest conservation and protected area management systems; silvicultural practices for afforestation and reforestation programs; genetically superior planting material; efficient harvesting, processing, and end-use technologies; indigenous knowledge of forest conservation; and low tillage agriculture and ruminant management practices (Ravindranath et al., 2000).

Most LULUCF projects require transfer of such technology. Their absence may frustrate delivery of the mitigation and developmental benefits associated with them (Sathaye *et al*., 1999). Poorly designed LULUCF projects may lead to import of inadequate or inappropriate technologies into recipient countries. For example, in agroforestry projects, inappropriate selection of species and crop timbering process or machinery may not bring out the full potential of the associated co-benefits, which depend on local biophysical, social, cultural and organizational factors (Lemaster 1995).

Current and emerging pathways and mechanisms for technology transfer through LULUCF GHG mitigation projects have several limitations, namely, limited financial resources, inadequate information on costs and potential benefits of projects, limited host country technical capacity; absence of policies and institutions to process and evaluate mitigation projects, and long gestation periods. In addition, the forest sector faces land use regulation and other policies that favor conversion to other land uses such as agriculture and cattle ranching. Insecure land tenure, and subsidies favoring agriculture or livestock, are among the most important barriers to ensuring sustainable forest management and sustainability of GHG mitigation (Ravindranath et al., 2000).

START BOX 5-5 HERE _______

Box 5-5 Social forestry program in India

Several developmental projects in the forestry sector have been implemented in the tropics that could be a source for understanding the possible implications of future LULUCF projects. One such afforestation program was implemented in India, which was funded by a large number of donor agencies during the 1980s. In terms of number of trees planted (18,876 million trees between 1980-87, Chambers *et al*., 1989), the project was a success. The lessons learned from the program are briefly described below (Saxena, 1997).

Social forestry projects were implemented by the Forest Department in India with the goal of meeting the demands of rural people, and reduce burden on production forestry. The species planted in the village commons and revenue lands were mainly monocultures of *Eucalyptus*, *Casuarina* and *Acacia* sp. Tree planting and management was done by the Forest Department for the initial years and later handed over to the Panchayat (village governing body).

Local participation: The selection of species reflected the choice of the Forest Department rather than the local preferences. Participation was limited to a few members of the village elite. Community participation was limited to handing over the common land for plantation and as wage labor. In designing the project, foresters and foreign experts did not fully grasp the complexity of the rural power structure and assumed that the village panchayats represented the interests of all the concerned in the village (SIDA, 1992). Thus a large portion of the benefit from the project went to the urban areas, industries and retailers defeating the purpose of the project.

Land tenure: Throughout the social forestry phase, it was not clear whether village land belonged to the Forest Department, the Revenue Department or the village body. Such uncertainty about ownership and legal rights impeded community action. Often non-forest laws conflicted with the social forestry projects.

Technical issues: Species selection, spacing and other silvicultural issues were not properly examined and implemented. Benefits, which could flow to the poor from species yielding intermediate products, were not properly appreciated. The production of grass, legumes, leaf fodder, fruits and non-timber forest products was neglected. Close spacing was prescribed to avoid intermediate management options, to reduce plantation costs and to cut down on staff supervision time. As a consequence, thinning and pruning, which could have produced intermediate yields of grass and tree products for the people, were not undertaken (Saxena, 1997). Due to close spacing, grass production was affected. As projects were designed around the ultimate felling of the planted trees, degradation often set in after the trees were harvested.

Policy issues: The failure to define, establish and publicize the rights for marketing and allocating benefits to the community led to the failure of their participation. Rights to trees and distribution policy which was not an official preoccupation in the early stages of the tree planting led to inequitable distribution later.

Equity issues**:** A government review found that only 20% of the respondents knew about the woodlots during the planning stage, only 14% of the people participated in the meetings and about 83% of the low-status people were adversely affected by the closure of the community land. The landless farmers and artisans depend on the village commons to graze their animals and collect fuelwood.

Capacity building**:** The funding projects sponsored the Forest Department for vehicles and foreign training, but little emphasis was given on building the capacity of the Forest Department.

Multiplicity of donors: Multiplicity of donors with different priorities within single provinces resulted in conflicting policies being followed.

END BOX 5-5 HERE _______

LULUCF projects have surmounted some of these barriers through means that include extensive capacity building and establishing institutions at the local level (e.g., Noel Kempff, Bolivia, Scolel-Te, Mexico, Box 5-1); the development of improved forest management systems and joint ventures between private companies and local organizations (RIL, Malaysia, Box 5-1); and the design of a systems of financial incentives that directly benefit farmers by increasing the relative cost-effectiveness of forestry options (Costa Rica Joint Implementation Program, Box 5-1). LULUCF projects in non-Annex-I countries have the potential to fund improved technologies that can yield environmental benefits by: raising agricultural productivity through transfer of irrigation or management practices; increasing milling efficiency; improving silvicultural practices; sustainable forest management (Brown, 1998) as can be seen in the Senegal example (Box 5-6); or, where LULUCF projects involve biofuel production, supporting energy sector development that 'leap-frogs' the fossil fuel stage, moving directly to sustainable energy development (Read, 1999).

START BOX 5-6 HERE _______

Box 5-6: Technology transfer and capacity building in an agroforestry project in Senegal

Enda Syspro, an international institution, has developed an ecologically sustainable agroforestry practice in Senegal. This system involves planting hedges in the boundary of the fields with drip irrigation to produce various crops and vegetables for local markets and exports. This type of project improves food security that has been considered as the primary concern of African countries at the Abidjan (Ivory Coast, 1999) meeting for climate change. The agroforestry project not only reduces GHG emissions (by avoiding deforestation, sequestering carbon in hedges and soils and substituting fossil fuels by sustainably harvested firewood0, but the project also improves soil fertility and reduces soil erosion. The project maintains biodiversity by reducing deforestation and fragmentation of the landscape. By reducing the need of water for irrigation, it helps to reduce vulnerability to climate change in the Sahelenian countries. A training center has been set up for Senegal and Sahelian countries to replicate such farming systems. Various high technology agricultural activities including biotechnology transfer have been developed in Enda Spyro to improve food security and to measure carbon sequestration. Today more than 1000 ha of such agroforestry systems have been established in Senegal.

END BOX 5-6 HERE _________

5.7. Implications of Project-Based Activities for Countries With and Without Assigned Amounts of Emissions

All the major issues of project permanence, additionality, and potential leakage and risks, present different implications for countries with and without national assigned amounts. Some of these issues also show specific characteristics by project type (Table 5-10), The implications for carbon accounting as well as the associated socioeconomic and capacity building components are also different depending if the countries currently have or do not have national assigned amounts (Table 5-10).

(Insert Table 5-10 here].

The fate of GHG benefits when the project ends, the risks associated with projects, leakage and additionality, are all major issues for countries without national assigned amounts –particularly for emissions avoidance and carbon sequestration projects – as these countries are not required to capture project activities in national GHG inventories. For the same reasons, the choice of accounting methods and the control of leakage are also critical. This last may be addressed voluntarily and reported on national communications (Table 5-10)

For countries with assigned amounts, project duration is important if the project does not fall into Articles 3.3 or 3.4, liability for post-project period emissions is not clear, or the commitment periods are not contiguous. Determining adequate baselines and establishing project additionality is required for projects that fall under Article 6 (and maybe under Article 12). Concerns regarding methods for GHG accounting at the project level are not as critical because all countries, including those with assigned amounts, are required to prepare a national GHG inventory. However ,double counting could be an issue if project activities cannot be captured in national inventories. Potential transnational leakage between countries with and without assigned amounts is important to consider as such leakage is not captured by the emissions limitation of Annex I countries (Gustavsson *et al*.., 1999)

5.7. Implications of Project-Based Activities for Countries With and Without Assigned Amounts of Emissions

All the major issues described in the chapter, that is project permanence, additionality, potential leakage and risks, present different implications for countries with and without assigned ammounts of emissions. Some of these issues also show specific characteristics by project type (Table 5-10). The implications for carbon accounting as well as the associated socio-economic and capacity building components are also different depending if the countries currently have or do not have national emission caps (Table 5-10).

[Insert Table 5-10 here]

The permanence of GHG benefits, i.e., the fate of carbon when the project ends, the risks associated with projects, leakage and additionality are all major issues for countries without national emission caps--and very specifically for emission avoidance and carbon sequestration projects--as these countries are not required to capture project activities in national GHG inventories. For the same reasons, the choice of accounting methods and the control of leakage are also critical. This last, may be addressed voluntarily and reported on national communications (Table 5-10).

For countries with caps, permanence is important, only if the project does not fall into Articles 3.3 or 3.4 or if commitment periods are not contiguous. Adequately determining baselines and showing project additionality is relevant only for projects that fall under Article 6. The methods for carbon accounting at the project level are not so critical, as the countries should keep a detailed national GHG inventory; however, double counting could be an issue if project activities cannot be captured in national inventories. Potential transnational leakage between countries with and without caps is important to consider as such leakage is not captured by the emission limitations of Annex I countries (Gustavsson *et al*., 1999).

Mitigating GHG emissions while providing environmental and socio-economic benefits that contribute to sustainable development is a general goal stated in Article 2 of the Kyoto Protocol. In this sense, the goal applies to both countries with and without national emission caps. However, for these last, project contribution to sustainable development is a central issue, and has been specifically highlighted in Article 12. Capacity building and technology transfer are relevant issues for some Annex I and Annex 2 countries, and a major issue for countries without emission caps. Several decisions of COP3 and COP4 have emphasized the need to reinforce these aspects.

5.8. References

Allen, R.K., K. Platt and S. Wiser, 1995a: Biodiversity in New Zealand plantation. *New Zealand Forestry* (February), 26-29.

Allen, R.K., K.H. Platt and R.E.J. Coker, 1995b: Understory species composition patterns in a *Pinus radiata* plantation on the central North Island volcanic plateau, New Zealand. *New Zealand Journal of Forestry Science* 25: 301-317.

Andrasko, K. 1997: Forest management for greenhouse gas benefits: Resolving monitoring issues across project and national boundaries. *Mitigation and Adaptation Strategies for Global Change* 2: 117-132.

Andrasko, K., L. Carter, and W. van der Gaast, 1996: Technical Issues in JI/AIJ Projects: A Survey and Potential Responses. Prepared for UNEP AIJ Conference: New Partnerships to Reduce the Buildup of Greenhouse Gases, San Jose, Costa Rica, pp 13-48.

Austin, D., and Faeth, P. (eds.), 2000: *Opportunities for financing sustainable development via the Clean Development Mechanism*. World Resources Institute, Washington, DC. 113 pp (in press).

Bass, S., Ford, J., Dubois, O., Moura-Costa, P., Wilson, C., Pinard, M., Tipper, R., 2000: *Rural Livelihoods and Carbon Management: An issues paper*. IIED, London. (in press).

Baumert, K.A., 1998: *The Clean Development Mechanism: understanding additionality*. Draft Working Papers, CSDA, FIELD, WRI. pp 23-31.

Bawa, K.S. and R. Seidler, 1998: Natural forest management and conservation of biodiversity in tropical forests. *Conservation Biology* 12: 46-55.

Boscolo, M., J. Buongiorno and T. Panayotou, 1997: *Environment and Development Economics* 2: 241-263.

Brown, K., 1996: *The Utility of Remote Sensing Technology for Carbon Sequestration*. Winrock International, 1611 N. Kent St., Suite 600, Arlington, VA 22209, USA.

Brown, P., 1998: *Climate, Biodiversity and Forests*. World Resources Institute, Washington, DC. 35 pp.

Brown, P., B. Cabarle and R. Livernash, 1997: *Carbon counts: estimating climate change mitigation in forestry projects*. World Resources Institute, Washington, DC. 25 pp.

Brown, S., 1997: *Estimating biomass and biomass change of tropical forests: a primer*. FAO Forestry Paper 134, Rome, Italy.

Brown, S., J. Sathaye, M. Cannell and P. Kauppi, 1996: Management of forests for mitigation of greenhouse gas emissions. Chapter 24. In R. T. Watson, M.C. Zinyowera, and R.H. Moss (eds.), *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge and New York.

Brown, S., M. Burnham, M. Delany, R. Vaca, M. Powell and A. Moreno, 2000: Issues and Challenges for Forest-Based Carbon-Offset Projects: A Case Study of the Noel Kempff Climate Action Project in Bolivia. *Mitigation and Adaptation Strategies for Global Change* (in press).

Brown, S., M. Calmon, and M. Delaney, 1999a: Development of a deforestation and forest degradation trend model for the Guaraquecaba Climate Action Project. Winrock International, Carbon Monitoring Program, 1611 N Kent St., Arlington, VA 22209, USA.

Brown, S., M. Calmon, and M. Delaney, 1999b: Carbon inventory and monitoring plan for the Guaraqueçaba Climate Action Project. Winrock International, Carbon Monitoring Program, 1611 N Kent St., Suite 600, Arlington, VA 22209, USA.

Busch C., J. Sathaye, G, Sanchez-Azofeifa, 1999. *Lessons for greenhouse gas accounting: A case study of Costa Rica's Protected Areas Project*. Lawrence Berkeley National Laboratory Report LBNL-42289, Berkeley, CA.

Cairns, M.A., S. Brown, E.H. Helmer and G.A. Baumgardner, 1997: Root biomass allocation in the world's upland forests. *Oecologia* 111: 1-11.

Carbon Storage Trust, 1998: The Carbon Storage Trust and Climate Care – a detailed analysis. The Carbon Storage Trust, Oxford, UK.

Carpentieri A., E. Larson and J. Woods, 1993: Future biomass based electricity supply in Brazil. *Biomass and Bioenergy* 4: 149-76.

Carter, L., 1997a: Additionality: The USIJI Experience. Paper presented at the Workshop on environmental benefits of AIJ, 9-10 September, Paris, IEA.

Carter, L., 1997b: Modalities for the operationalization of additionality. Paper presented at the UNEP/German Federal Minstry of Environment, Workshop on AIJ, Leipzig, March 1997.

Center for Clean Air Policy, 1998: Top-down baselines to simplify setting of project emission baselines for JI and the CDM, Washington

Chambers, R., N.C. Saxena and T. Shah, 1989: *To the hands of the Poor: Water and Trees*. Oxford University Press and IBH, New Delhi and Intermediate Technology, London.

Chomitz, K. 2000: Evaluating carbon offsets from forestry and energy projects: how do they compare? Development Research Group, The World Bank, Washington, DC, USA.

Chomitz, K., 1998: *Baselines for greenhouse gas reductions: problems, precedents, solutions*. Draft paper, Carbon Offsets Unit, World Bank.

Chomitz, K.M. and K. Kumari, 1998: The domestic benefits of tropical forests: A critical review. *The World Bank Research Observer* 13(1): 13-35.

Chomitz, K.M., E. Brenes, and L. Constantino, 1999, "Financing Environmental Services: The Costa Rican Experience and its Implications". *The Science of the Total Environment* 240, 157-169.

Cooper, P.J.M., R.R.B. Leakey, M.R. Rao and I. Reynolds, 1996: Agroforestry and the mitigation of land degradation in the humid and sub-humid tropics of Africa. *Experimental Agriculture* 32: 235-290.

Cullet, P. and A.P. Kameri-Mbote, 1998: Joint implementation and forestry projects: conceptual and operational fallacies. *International Affairs* 74(2): 393-408.

Da Silva, Jr., F., S. Rubio and F. de Souza, 1995: Regeneration of an Atlantic forest formation in the understory of a *Eucalyptus grandis* plantation in south-eastern Brazil. *Journal of Tropical Ecology* 11: 147-152.

de Jong, B.H., R. Tipper and J. Taylor, 1997: A Framework for Monitoring and Evaluation of Carbon Mitigation by Farm Forestry Projects: example of a demonstration project in Chiapas, Mexico. *Mitigation and Adaptation Strategies for Global Change* 2: 231-246.

Department of Forestry and Conservation Management, University of Massachusetts, 1999: *Final report and results on assessing dual camera videography and 3D terrain reconstruction as tools to estimate carbon sequestration in forests, Crooksville, Ohio Test Site*. Report to Winrock International, 38 Winrock Dr., Morrilton, Arkansas.

Detwiler, R.P., 1986: Land use change and the global carbon cycle: the role of tropical soils. *Biogeochemistry* 2: 67-93.

Dinerstein, E., D.M. Olson, D.J. Graham, A.L. Webster, S.A. Primm, M.P. Bookbinder and G. Ledec, 1995: *A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean*. The World Wildlife Fund, The World Bank, Washington, DC.

Dixon, R.K., J.K. Winjum, K.J. Andrasko and P.E. Schroeder, 1994: Integrated land-use systems: assessment of promising agroforest and alternative land-use practices to enhance carbon conservation and sequestration. *Climate Change* 30: 1-23.

Dixon, R.K., K.J. Andrasko, F.G. Sussman, M.A. Lavinson, M.C. Trexler and T.S. Vinson, 1993: Forest sector carbon offset projects: near-term opportunities to mitigate greenhouse gas emissions. *Water, Air and Soil Pollution* 70: 561-577.

Dixon, R.K., P.E. Schroeder and J. Winjum (eds), 1991: *Assessment of promising forest management practices and technologies for enhancing the conservation and sequestration of atmospheric carbon and their costs at the site level*. Report of the US Environmental Protection Agency No. EPA/600/3-91/067. Environmental Research Laboratory, Corvallis, Oregon.

Dobes, L., I. Enting and C. Mitchell, 1998: Accounting for carbon sinks: the problem of time. In: Dobes, L. (ed.) *Trading Greenhouse emissions: some Australian perspectives*. Occasional papers No 115. Bureau of Transport Economics, Australia.

EcoSecurities Ltd., 1997: *SGS Forestry Carbon Offset Verification Services*. Draft. SGS Forestry, Oxford, England.

Ellis, J. and Bosi, M., 1999*: Options for project emission baselines*. OECD and IEA Information paper. OECD, Paris.

Environmental Law Institute, 1996: *Incorporating Public Participation in Joint Implementation of the Framework Convention on Climate Change*, Washington, DC

EPA/USIJI (US Environmental Protection Agency and US Initiative on Joint Implementation), 1998: *Activities implemented jointly: third report to the Secretariat of the United Nations Framework Convention on Climate Change*, 2 volumes, Washington, DC, EPA report 236-R-98-004, November.

Face Foundation, 1998: *Annual Report 1997*. FACE Foundation, Arnhem, The Netherlands. 28 pp.

Faeth, P., C. Cort and R. Livernash, 1994: *Evaluating the Carbon Sequestration Benefits of Forestry Projects in Developing Countries*. World Resource Institute, Washington.

Fearnside, P., 1997: Monitoring needs to transform Amazonian forest maintenance into a global warming-mitigation option. *Mitigation and Adaptation Strategies for Global Change* 2: 285-302.

Fearnside, P.M., 1995: Global warming response options in Brazil's forest sector: Comparison of project-level costs and benefits. *Biomass and Bioenergy* 8(5): 309-322.

Fearnside, P.M., D.A. Lashof and P. Moura-Costa, 2000: Accounting for time in mitigating global warming. *Mitigation and Adaptation Strategies for Global Change* (in press).

Friedman, S., 1999: The use of benchmarks to determine emissions additionality in the Clean Development Mechanism, Paper presented at the GISPRI baseline workshop, 25-26 February, Tokyo.

Frumhoff, P.C. and E.C. Losos, 1998: *Setting priorities for conserving biological diversity in tropical timber production forests*. Union of Concerned Scientists, Cambridge, Mass. 14 pp.

Frumhoff, P.C., D.C. Goetze and J.J. Hardner, 1998: *Linking Solutions to Climate Change and Biodiversity Loss Through the Kyoto Protocol's Clean Development Mechanism*. Union of Concerned Scientists, Cambridge, Mass. 14 pp.

German Advisory Council on Global Change (WBGU), 1998: *The Accounting of Biological Sinks and Sources Under the Kyoto Protocol—A Step Forwards or Backwards for Global Environmental Protection?* WBGU, Bremerhaven, Germany. 75 pp.

Giampietro, M., S. Ulgiati and D. Pimentel, 1997: Feasibility of large-scale biofuel production. *BioScience* 47(9): 587-600.

Greenpeace, 1998. Making the Clean Development Mechanism clean and green. Greenpeace Position Paper, Fourth Conference of the Parties to the United Nations Framework Convention on Climate Change, Amsterdam, Greenpeace International.

Goldberg, D.M., 1998: *Carbon Conservation Climate Change, Forests and the Clean Development Mechanism*. Center for International Environmental Law, Costa Rica.

Greenhouse Challenge Office, 1997: *Greenhouse Challenge Carbon Sinks Workbook: A discussion paper*. Greenhouse Challenge Office, Canberra, Australia.Gustavsson, L., T. Karjalainen, G. Marland, B. Savolainen, B. Schlamadinger and M. Apps, 1999: http://www.joanneum.ac.at/iea-bioenergy-task25/publication/fpubl.htm

Hamburg, S. P., 2000: Simple rules for measuring changes in ecosystem carbon in forestry-offset projects. Mitigation and Adaptation Strategies for Climate Change, in press

Haque, A.K.E., P. Read and M.E. Ali, 1999: *The Bangladesh MSP Pilot Project proposal for GEF funding of capacity building for country driven projects*. Working Paper, IDESS, North-South University, Dhaka, Bangladesh.

Hardner, J., 1996: *Forest conservation and watershed protection in Ilheus, Bahia: An avoided cost approach*. Prepared for Conservation International and Instituto de Estudos Socio-Ambientais do Sul da Bahia.

Hardner, J.J., P.C. Frumhoff, and D.C. Goetze, 2000: Prospects for mitigating carbon, conserving biodiversity, and promoting socioeconomic development objectives through the Clean Development Mechanism. *Mitigation and Adaptation Strategies for Global Change* (in press)

Hargrave, T.; Helme, N.; Puhl, I., 1998: Options for simplifying baseline setting for Joint Implementation and Clean Development Mechanism projects, Washington.

Houghton, J.T., L.G. Meira Filho, B. Lim, K. Treanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander, 1997: *Revised 1996 Guidelines for National Greenhouse Gas Inventories: Reference Manual*. IPCC/OECD/IEA.

Imaz, M., C. Gay, R. Friedmann and B. Goldberg, 1998: *Mexico Joins the Venture: Joint Implementation and Greenhouse Gas Emissions Reduction*. LBNL-42000, Berkeley National Laboratory, Berkeley.

Intarapravich, Duangjai, 1995: *Joint Implementation: Thailand Environment Institute's Perspective*. Presented at Southeast Asian Regional Workshop on International Prospects for Joint Implementation, Bangkok, Thailand, pp 2-6.

International Centre for Research in Agroforestry, *Soil Changes Under Agroforestry (SCUAF)*. Gigiri, PO Box 306077, Nairobi, Kenya.

IPCC, 1992: *Climate Change 1992: The supplementary report to the IPCC scientific assessment*. Houghton.

IPCC, 1996: *Climate change 1995: The science of climate change. Contribution of the WGI to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Houghton, J.T., Meira Filho, L.G., Callander, B.A., E., Harris, N., Kattenberg, A., and Maskell, K. (eds.). Cambridge University Press, Cambridge, UK, 572 pp.

Janssen, 1997. Problems and Solutions associated with an AIJ Project - an Example from a Forest Management Project in Central Mexico. In: Greenhouse gas mitigation. Technologies for activities implemented jointly. Proceedings of Technologies for AIJ Conference. Vancouver, May 1997. Riermer, P.W.F., Smith, A.Y. and Thambimuthu, K.V. (Eds.). Elsevier, Oxford.

Jepma, C., 1995: *Tropical Deforestation: a socio-economic approach*. Earthscan, London.

Jepma, C., 1999: Determining a baseline for project co-operation under the Kyoto Protocol: a general overview, Paper presented at the GISPRI baseline workshop, 25-26 February, Tokyo.

Johns, A.G., 1997: *Timber Production and biodiversity conservation in tropical rain forests*. Cambridge University Press, Cambridge, England. 225 pp.

Kanowski, P.J., P.S. Savill, P.G. Adlard, J. Burley, J. Evans, J.R. Palmer and P.J. Wood, 1992: Plantation forestry. In: Sharma, N.P. (ed.), *Managing the world's forests*. Kendall-Hunt. pp 375-401.

Keenan, R., D. Lamb, O. Woldring, T. Irvine and R. Jensen, 1997: Restoration of plant biodiversity beneath tropical tree plantations in Northern Australia. *Forest Ecology and Management* 99: 117-131.

Klooster, D. and O.R. Masera, 2000. Community forest management in Mexico: Making carbon sequestration a by-product of sustainable rural development. *Global Environmental Change* (in press).

Kurz, W.A., S.J. Beukema and M.J. Apps, 1997: Carbon budget implications of the transition from natural to managed disturbance regimes in forest landscapes. *Mitigation and Adaptation Strategies for Global Change* 2: 405-421.

La Rovere, E.L, 1998: *The Challenge of Limiting Greenhouse Gas emissions through activities implemented jointly in developing countries: A Brazilian perspective*. LBNL-41998, Berkeley National Laboratory, Berkeley, United States.

Laquihon, W.A., 1989: Some key determinants of SALT adoption in the Philippines: viewpoints of farmer cooperators. In: N.T. Vergara and R.A. Fernandez (eds) *Social Forestry in Asia*, pp 79-116. SEARCA, Los Banos, Philippines.

Lasco, R.D. and F.B. Pulhin, 1999: Forest land use change in the Philippines and climate change mitigation. *Mitigation and Adaptation Strategies for Global Change* (accepted).

Lashof, D. and Hare, B., 1999: The role of biotic carbon stocks in stabilizing greenhouse gas concentrations at safe levels. *Environmental Science and Policy* 2 (2): 101-110.

Lee, R., *et al*., 1997: *Understanding Concerns About Joint Implementation*. Joint Institute for Energy and Environment, Tennessee, pp 1-53.

Lemaster, L., 1995: The relationship between environmental barriers and modes of technology transfer: A study of United States companies with operations in Mexico. *Journal of International Business Studies* 26(3): 690-691.

Losos, E., 1999: Can forestry carbon offset projects play a significant role in conserving forest wildlife and their habitats? In: Fimbel, A. Grajal, and J. Robinson (eds.), *Conserving Wildlife in Managed Tropical Forests*. Columbia University Press, New York.

Ludeke, A.K., 1990: An analysis of anthropogenic deforestation using logistic regression and GIS. *Journal of Environmental Management* 31: 247-259

Lugo, A., 1997: The apparent paradox of reestablishing species richness on degraded lands with tree monocultures. *Forest Ecology and Management* 99: 9-19.

MacDicken, K., 1997a: *A guide to monitoring carbon storage in forestry and agroforestry projects*. Winrock International, 1611 N. Kent St., Suite 600, Arlington, VA 22209, USA.

MacDicken, K., 1997b: Project specific monitoring and verification: state of the art and challenges. *Mitigation and Adaptation Strategies for Global Change* 2: 191-202.

MacDicken, K.G. and N.T. Vergara, 1990: Introduction to agroforestry. In: MacDicken, K.G. and N.T. Vergara (eds.), *Agroforestry: Classification and Management*. John Wiley and Sons, New York, pp 1-30.

Maclaren, J. P., 1996: Plantation forestry—its role as a carbon sink: conclusions from calculations based on New Zealand’s planted forest estate. In: M.J. Apps and D.T. Price (eds.), *Forest Ecosystems, Forest Management, and the Global Carbon Cycle*. Springer Verlag, Berlin. pp 257-270.

Maclaren, P, 1999: Carbon accounting methodologies - a comparison of real-time, tonne-years, and one-off stock change approaches. Unpublished manuscript.

Makundi, W. and Okiting’ati, A., 1995: Carbon flows and economic evaluation of mitigation options in Tanzania’s forest sector. *Biomass and Bioenergy* 8(5): 381-393.

Makundi, W.P., 1997: Global climate change mitigation and sustainable forest management- the challenge of monitoring and verification. *Mitigation and Adaptation Strategies for Global Change* 2: 133-155.

Marland, G., B. Schlamadinger and L. Canella, 1997: Forest management for mitigation of CO2 emissions: How much mitigation and who gets the credits? *Mitigation and Adaptation Strategies for Global Change* 2: 303-318.

Manne, A, and R. Richels, 1999. The Kyoto Protocol: a cost –effective strategy for meeting environmental objectives? In: The costs of the Kyoto Protocol: A multi-model evaluation, *Energy Journal* Special Issue: 1-24.

Masera, O.R., M. Bellon and G. Segura, 1995: Forest management options for sequestering carbon in Mexico. *Biomass and Bioenergy* 8(5): 357-368.

Masera, O.R., 1995: Carbon Mitigation Scenarios for Mexican Forests: Methodological Considerations and Results. *Interciencia* 20: 388-395.

Matsuo, N., 1999: Baselines as the critical issue of CDM – possible pathways to standardization, Paper presented at the GISPRI baseline workshop, 25-26 February, Tokyo.

Maya, R.S. and J. Gupta (eds.), 1996: *Joint Implementation: carbon colonies or business opportunities?* Southern Centre for Energy and Environment, Harare, Zimbabwe. 164 pp.

McPherson, G., 1994: *Chicago’s Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project*. General Technical Report NE-186, USDA Forest Service, Northeastern Forest Experiment Station, Radnor, PA.

Michaelowa, A. and H. Schimdt, 1997: A dynamic crediting regime for joint implementation to foster innovation in the long term. *Mitigation and Adaptation Strategies for Global Change* 2: 45-56.

Michaelowa, A., 1998: Joint Implementation - the baseline issue. *Global Environmental Change* 8: 81-92.

Michaelowa, A., 1999. Baseline methodologies for the CDM – which road to take. Paper presented at the IGES meeting, 23 June 1999, Tokyo, Japan.

MINAE, 1996: National System of Conservation Areas, Situacion de Tenencia de la Tierra en las Areas Sivestres Protegidas del Pais, Proyectos Gruas.

Ministry of Housing, Spatial Planning and the Environment, Directorate General for Environmental Protection, Climate Change Department, 1996: *Activities Implemented Jointly: The Netherlands Pilot Phase Programme*. The Hague, Netherlands.

Mohren, G.M.J., J.F. Garza Caligaris, O. Masera, M. Kanninen, T. Karjalainen and G.J. Nabuurs, 1999: *CO_2FIX for windows: a dynamic model of the CO_2 fixation in forest stands*. Institute for Forestry and Nature Research, The Netherlands, Instituto de Ecologia, UNAM, Mexico, Centro Agronomico Tropicalde Investigacion y Enseñanza, Costa Rica, European Forest Institute, Finland. 27 pp.

Moura-Costa, P.H., 1996a: Tropical forestry practices for carbon sequestration: A review and case study from Southeast Asia. *Ambio* 25: 279-283.

Moura-Costa, P.H., 1996b: Tropical forestry practices for carbon sequestration. In: A. Schulte and D. Schone (eds.), *Dipterocarp Forest Ecosystems - Towards sustainable management,* World Scientific, Singapore, pp 308-334.

Moura-Costa, P.H., 1993: Large scale enrichment planting with dipterocarps, methods and preliminary results. In: K. Suzuki, S. Sakurai and K. Ishii (eds.), Proceedings of the Yogyakarta Workshop, BIO-REFOR/IUFRO/SPDC: Bio-reforestation in Asia-Pacific Region. pp 72-77.

Moura-Costa, P., and M. Stuart, 1998: Forestry based greenhouse gas mitigation: a story of market evolution. Commonwealth Forestry Review 77: 191-202.

Moura-Costa, P., M. Stuart, M. Pinard and G. Phillips, 2000: Issues related to monitoring, verification and certification of forestry-based carbon offset projects. *Mitigation and Adaptation Strategies for Global Change* (in press).

Moura-Costa, P.H. and C. Wilson, 2000: An equivalence factor between CO_2 avoided emissions and sequestration – description and applications in forestry. *Mitigation and Adaptation Strategies for Global Change* (in press).

Moura-Costa, P.H., S.W. Yap, C.L. Ong, A. Ganing, R. Nussbaum and T. Mojiun, 1996: Large scale enrichment planting with dipterocarps as an alternative for carbon offset - methods and preliminary results. In: S. Appanah and K.C. Khoo (eds.) Proceedings of the 5th Round Table Conference on Dipterocarps. Chiang Mai, Thailand, November 1994. FRIM, Kepong. pp 386-396.

Muehlmann, A.W., 1999: *Carbon sequestration and sustainable forestry: an overview from ongoing AIJ-forestry projects Working paper W 75*. Final Draft. International Academy of the Environment and Wuppertal Institute for Climate, Environment, Energy.

Mulongoy, K., J. Smith, P. Alirol and A. Witthoeft-Muehlmann, 1998: *Are Joint Implementation and the Clean Development Mechanism opportunities for forest sustainable management through carbon sequestration projects?* Geneva, International Academy of the Environment, Background paper 1, Climate Change in the Global Economy Programme, 36 pp.

Nabuurs, G. J., A. Dolman, E.Verkaik, P. Kuikman, C. van Diepen, A. Whitmore, W. Daamen, O. Oenema, P. Kabat, G. Mohren, 2000. Article 3.3 and 3.4 of the Kyoto Protocol: consequences for industrialised countries' commitment, the monitoring needs, and possible side effects. *Environmental Science and Polic*y, in press.

Nair, P.K.R., 1989: The role of trees in soil productivity and protection. In: Nair, P.K.R. (ed.), *Agroforestry Systems in the Tropics*, pp 567-589. Kluwer Academic Publishers, Dordrecht.

Niles, J. and R. Schwarze, 2000: Long-term forest sector emission reductions under the Kyoto Protocol's Article 12. In B. Schlamadinger and K. Robertson (Eds). Proceedings of the IEA Bioenergy Task 25 workshop on: Bioenergy for Mitigation of CO2 emissions: the power, transportation and industrial sectors. Medienfabrik Graz, Graz, Austria.

Padbury, G., 1999. Soil carbon initiatives on prairies. Ministry of Agriculture and Agri-Food Canada website: http://res.agr.ca/clm/padbury.htm

Parrotta, J., J. Turnbull and N. Jones., 1997a: Catalyzing native forest regeneration on degraded tropical lands. *Forest Ecology and Management* 99: 1-7.

Parrotta, J., O. Knowles and J. Wunderle, Jr., 1997b: Development of floristic diversity in 10-year-old restoration forests on a bauxite mined site in Amazonia. *Forest Ecology and Management* 99: 21-42.

Paustian, K., E. Levine, W.M. Post, and I.R. Ryzhova, 1997: The use of models to integrate information and understanding of soil C at the regional scale. *Geoderma* 79: 227-260.

Phillips, D.L., S.L. Brown, P.E. Schroeder and R.A. Birdsey, 2000: Toward error analysis of large-scale forest carbon budgets. *Global Ecology and Bioegeography* (in press).

Pinard, M. and F. Putz, 1997: Monitoring carbon sequestration benefits associated with reduced-impact logging project in Malaysia. *Mitigation and Adaptation Strategies for Global Change* 2: 203-215.

Pinard, M.A. and F.E. Putz, 1996: Retaining forest biomass by reduced impact logging damage. *Biotropica* 28: 278-295.

Post, W.M., R.C. Izaurralde, L.K. Mann, and N. Bliss, 1999: Monitoring and verification of soil organic carbon sequestration. In: Symposium: Carbon sequestration in soils science, monitoring and beyond, December 3-5, St. Michaels, MD.

Powell, M.H., 1999: *Effects of inventory precision and variance on the estimated number of sample plots and inventory variable cost: the Noel Kempff Climate Action Project*. Winrock International, 38 Winrock Dr., Morrilton, Arkansas.

Programme for Belize, 1997a: *Rio Bravo Carbon Sequestration Pilot Project*. Offsets attributable to project actions for Project Year 2 (1996). Report to USIJI and Government of Belize.

Programme for Belize, 1997b: Rio Bravo Carbon Sequestration Pilot Project: Operational protocol 3. Belize City, June.

Puhl, I., 1998: Status of research on project baselines under the UNFCCC and the Kyoto Protocol, OECD and IEA Information Paper, Paris

Putz, F.E. and M.A. Pinard, 1993: Reduced impact logging as a carbon-offset project. *Conservation Biology* 7(4): 755-757.

Ravindranath N. and D. Hall, 1995: *Biomass, energy, and environment, A developing country perspective from India*. Oxford University Press. London.

Ravindranath N.H.(Coord), N. Byron, R. Dixon, P. Fearnside, K. MacDicken, W. Makundi, O. Masera, A. DiNicola and Nandita Mongia. 2000. Intergovernmental Panel on Climate Change: Special Report on Technology Transfer: Technology Transfer in the Forestry Sector. Cambridge University Press. (In Press).

Ravindranath, N. and Somashekhar, B., 1995: Potential and economics of forestry options for carbon sequestration in India. *Biomass and Bioenergy* 8(5): 323-336

Ravindranath, N.H. and P.R. Bhat, 1997: Monitoring of carbon abatement in forestry projects-case study of Western Ghat Project. *Mitigation and Adaptation Strategies for Global Change* 2: 217-230.

Ravindranath, N.H., A. Meili and R. Anita, 1998: *AIJ in the Non-Energy Sector in India: Opportunities and Concerns*. LBNL-41999, Berkeley National Laboratory, Berkeley.

Read, P., 1999: Cooperative implementation after Kyoto: Joint Implementation and the need for commercialized offsets trading. In C. Jepma and W. van der Gaast (eds.) *Dealing with Carbon Credits after Kyoto*, Pergamon, in press.

Reid, W.V., 2000: Capturing the value of ecosystem services to protect biodiversity. In: *Managing Human-Dominated Ecosystems*. Island Press, Washington, D.C. and Missouri Botanical Gardens, St. Louis, Missouri (in press).

Reppeto, R. and M. Gillis, 1988. *Public Polices and the Misuse of Forest Resources*. Cambridge University Press, Cambridge, UK.

Repollo, A.Q., and E.R. Castillo, 1989: Agroforestry technology in hillyland households: factors affecting its adoption. In: N.T. Vergara and R.A. Fernandez (eds) *Social Forestry in Asia*, pp 117-132. SEARCA, Los Banos, Philippines.

Richards, K.R. and C. Stokes, 1994: *Regional studies of carbon sequestration: a review and critique*. Paper written for the US Department of Energy, Contract DE-AC06-76RLO 1830. 40 pp.

Ridley, M.A., 1998. *Lowering the Cost of Emission Reduction: Joint Implementation in the Framework Convention on Climate Change*. Kluwer Academic Publishers, Dordrecht, Netherlands

Sathaye, J., K. Andrasko, W. Makundi, E.L. La Rovere, N.H. Ravindranath, A. Melli, A. Rangachari, M. Imaz, C. Gay, R. Friedmann, B. Goldberg, C. Van Horen, G. Simmonds and G. Parker, 1999: Concerns about climate change mitigation projects; summary of findings from case studies in Brazil, India, Mexico and South Africa. *Environmental Science and Policy* 2(2): 187-198.

Saxena, N.C., 1997: *The saga of participatory forest management in India*. CIFOR Special Publication, Indonesia.

Schlamadinger, B. and G. Marland, 1996: Carbon implications of forest management strategies. In: M.J. Apps and D.T. Price (eds.), *Forest Ecosystems, Forest Management, and the Global Carbon Cycle*, pp 217-229. Springer-Verlag, Berlin.

Schroeder, P., 1992: Carbon storage potential of short rotation tropical tree plantations. *Forest Ecology and Management* 50: 31-41.

SGS, 1998: *Final report of the Assessment of project design and schedule of emission reduction units for the Protected Areas Project of the Costa Rican Office for Joint Implementation*. SGS, Oxford. 133 pp.

Shapiro, A.C., 1996: *Multinational financial Management, 5th edition*. Prentice Hall, Upper Saddle River.

SIDA, 1992: *An evaluation of the SIDA supported social forestry project in Tamil Nadu and Orissa*. Swedish International Development Agency. New Delhi.

Smith, J., K. Mulongoy, R. Persson and J. Sayer, 1999: *Harnessing Carbon Markets for Tropical Forest Conservation: Towards a More Realistic Assessment*. Center for International Forestry Research, Bogor, Indonesia, and International Academy of the Environment, Geneva, Switzerland.

Sokona, Y., 1999: *The Clean Development Mechanism: What Prospects for Africa?*. ENDA Energy, Dakar, Senegal.

Stewart, R., D. Anderson, M. A. Aslam, C. Eyre, G. Jones, P. Sands, M. Stuart and F. Yamin, 1999: *The Clean Development Mechanism: Building International Public-Private Partnerships. A Preliminary Examination of Technical, Financial & Institutional Issues*. UNCTAD (United Nations Conference on Trade and Development), Geneva.

Stuart, M.D. and P.H. Moura-Costa, 1998: Greenhouse gas mitigation: A review of international policies and initiatives. In: *Policies that Work for People Series No 8*. International Institute of Environment and Development, London.

Stuart, M.D., 1998: Financial tools and the Clean Development Mechanism. In: *Design and Implementation of the Clean Development Mechanism: a Concept Paper for the International Working Group on the Clean Development Mechanism*. UNCTAD (United Nations Conference on Trade and Development), Geneva.

Subak, S., 1999. Costa Rica's Private Forestry Project: evaluation of a Clean Development Mechanism prototype. *Environmental Management* August: 1-16

Swisher, J. and Masters, G., 1992. A mechanism to reconcile equity and efficiency in global climate protection: international carbon emissions offsets. *Ambio* 21 (2): 154-159.

Swisher, J.N. 1997: Joint implementation under the UN Framework convention on climate change: Technical and institutional challenges. *Mitigation and Adaptation Strategies for Global Change* 2: 57-80.

Tattenbach, F., 1996: Certifiable, Tradeable Offsets in Costa Rica. *Joint Implementation Quarterly* 2(2).

Tietenberg, T., M. Grubb, A. Michaelowa, B. Swift and X.Z. Zhong, 1998: *International Rules for Greenhouse Gas Emissions Trading. Defining the principles, modalities, rules and guidelines for verification, reporting and accountability*. UNCTAD (United Nations Conference on Trade and Development), Geneva.

Tipper, R. and B.H. de Jong, 1998: Quantification and regulation of carbon offsets from forestry: comparison of alternative methodologies, with special reference to Chiapas, Mexico. *Commonwealth Forestry Review* 77: 219-228.

Tipper, R., B.H. de Jong, S. Ochoa-Gaona, M.L Soto-Pinto, M.A. Castillo-Santiago, G. Montoya-Gómez and I. March-Mifsut, 1998: *Assessment of the Cost of Large Scale Forestry for CO_2 Sequestration: Evidence from Chiapas, Mexico*. Report PH12. International Energy Agency Greenhouse Gas R&D Programme. Cheltenham, Glosc. UK.

TNC (The Nature Conservancy), 1999. Written information for and comments on IPCC LUCF Special Report draft 1 for expert review, August

Trexler and Associates, Inc., 1998: *Final report of the Biotic Offsets Assessment Workshop, Baltimore, Maryland Sept. 5-7 1997*. Prepared for United States Environmental Protection Agency, Washington, DC. 107 pp.

Trexler, M., L. Kosloff and R. Gibbons, 1999: Forestry and land-use change in the AIJ pilot phase: The evolution of issues and methods to address them. In: Dixon, R. (ed.), *The UN Framework Convention on Climate Change Activities Implemented Jointly pilot: experiences and lessons learned*. Kluwer, 30 pp.

Trexler, M., P. Faeth and J. Kramer, 1989: *Forestry as a response to global warming: an analysis of the Guatemala agroforestry and carbon sequestration project*. World Resources Institute, Washington, DC.

Trexler, M.C. and L.H. Kosloff, 1998: The 1997 Kyoto Protocol: What does it mean for project-based climate change mitigation? *Mitigation and Adaptation Strategies for Global Change* 3: 1-58.

Trines, E., 1998a: Assessing and monitoring carbon offset projects: the Costa Rican case. *Commonwealth Forestry Review* 77: 214-218.

Trines, E. 1998b: SGS's carbon offset verification service. *Commonwealth Forestry Review* 77: 209-213.

UNCCCS, 1997: *UNFCCC AIJ Methodological issues*. UN Climate Change Convention Secretariat. (www.unfccc.de/fccc/ccinfo/inf3.htm)

United Nations Framework Convention on Climate Change (UNFCCC), 1995: *Decision 5/CP.1* from the Conference of the Parties on its First Session, , Held at Berlin from 28 March to 7 April 1995" Addendum (FCCC(CP/1995/7/Add.1).

UNFCCC, 1998: *Activities Implemented Jointly: review of progress under the pilot*. FCCC/ CP/ 1998/ 2 2, October .

UNFCCC, 1999a: *Views on the review process of activities implemented jointly under the pilot phase and information on experience gained and lessons learned, including on the uniform reporting format*. FCCC/SB/1999/MISC.1. http://www.unfccc.de.

UNFCCC, 1999b: *UNFCCC-CC: Info /AIJ – List of AIJ Projects*. At UNFCCC Web site: http://www.unfccc.de/fccc/ccinfo/aijproj.htm

United States Initiative on Joint Implementation (USIJI), 1996: *Guidelines for a USIJI Project Proposal*. US Initiative on Joint Implementation, Washington, DC.

USIJI, 1997a: *USIJI Project Criteria*. US Initiative on Joint Implementation, 1000 Independence Avenue, S.W. PO6 Washington DC 20585.

USIJI, 1997b: *Activities implemented jointly: 2nd report to the UN Framework Convention on Climate Change, Vol. 2*. Environmental Protection Agency, Office of Policy, Planning and Evaluation, Washington, DC.

Verweij, H.J.A. and I.M. Emmer, 1998: Implementing carbon sequestration projects in two contrasting areas: the Czech Republic and Uganda. *The Commonwealth Forestry Review* 77(3): 203-208.

Vine, E., J. Sathaye, and W. Makundi, 1999: *Guidelines for the monitoring, evaluation, reporting, verification, and certification of forestry projects for climate change mitigation*. LBNL-41877, Energy Analysis Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720.

Vrolijk, C., 1999. The potential size of the Clean Development Mechanism. Paper presented at Second International Conference, Emerging Markets for Emissions Trading, April 26-27, London.

Wangwacharakul, V. and R. Bowonwiwat, 1995: Economic evaluation of CO_2 response options in the forestry sector: the case of Thailand. *Biomass and Bioenergy* 8(5): 293-308.

Winjum, J.K., S. Brown and B. Schlamadinger, 1998: Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284.

Winrock International, 1999: *Field tests for carbon monitoring methods in forestry projects*. Forest Carbon Monitoring Program, Winrock International, 1611 N Kent St., Suite 600, Arlington, VA 22209, USA.

Winrock International, 1998: *Noel Kempff Climate Action Project: Project Case Carbon Inventory and Offset Benefits*. Winrock International, 1611 N Kent St., Suite 600, Arlington, VA 22209, USA.

Witthoeft-Muehlmann, A., 1998: *Carbon sequestration and sustainable forestry: an overview from ongoing AIJ-forestry projects*. W-75 Working Paper, International Academy of the Environment, Geneva.

World Bank, 1997: *Guidelines for climate change global overlays*. Paper No. 047, Environment Department Papers, Climate Change Series.

World Business Council for a Sustainable Development, 1997: *Climate Change Projects: Guidelines for Completing Proposals*. Web page: www.wbcsd.climatechange.com/home.html.

Xu, D., 1995: The potential for reducing atmospheric carbon by large-scale afforestation in China and related cost/benefit analysis. *Biomass and Bioenergy* 8(5): 323-336.

Young, A., 1997: *Agroforestry for Soil Management (2nd ed)*. CAB International, Oxford, UK. 320 pp.