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Changes in the use and management of forests for abating carbon emissions: issues and challenges under the Kyoto Protocol

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The global carbon cycle is significantly influenced by changes in the use and management of forests and agriculture. Humans have the potential through changes in land use and management to alter the magnitude of forest-carbon stocks and the direction of forest-carbon fluxes. However, controversy over the use of biological means to absorb or reduce emissions of CO_2 (often referred to as carbon 'sinks') has arisen in the context of the Kyoto Protocol. The controversy is based primarily on two arguments: sinks may allow developed nations to delay or avoid actions to reduce fossil fuel emissions, and the technical and operational difficulties are too threatening to the successful implementation of land use and forestry projects for providing carbon offsets. Here we discuss the importance of including carbon sinks in efforts to address global warming and the consequent additional social, environmental and economic benefits to host countries. Activities in tropical forest lands provide the lowest cost methods both of reducing emissions and reducing atmospheric concentrations of greenhouse gases. We conclude that the various objections raised as to the inclusion of carbon sinks to ameliorate climate change can be addressed by existing techniques and technology. Carbon sinks provide a practical available method of achieving meaningful reductions in atmospheric concentrations of carbon dioxide while at the same time contribute to national sustainable development goals.

Keywords: Kyoto Protocol; carbon emissions; land-use change; forestry; deforestation; emissions reduction

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1. Introduction

The global carbon cycle is recognized as one of the major biogeochemical cycles because of its role in regulating the concentration of carbon dioxide (CO_2), the most important greenhouse gas (GHG), in the atmosphere. Forests play an important role in the global carbon cycle because they store large quantities of carbon in vegetation and soil, exchange carbon with the atmosphere through photosynthesis and respiration, are sources of atmospheric carbon when they are disturbed by human or natural causes (e.g. use of poor harvesting practices, cleared and burned for conversion to non-forest uses, wildfires, etc.), and become atmospheric carbon sinks (i.e. net transfer of CO_2 from the atmosphere to the land) during land abandonment and regrowth after disturbance (Brown *et al.* 1996). Humans have the potential through changes in forest land use and management to alter the magnitude of forest-carbon stocks and the direction of forest-carbon fluxes, and thus alter their role in the carbon cycle.

The recognition that changes in land use and forest management (LUCF) activities could be both sources and sinks of carbon led to their inclusion in the Kyoto Protocol. There are several articles in the Protocol that make provisions, in relation to a country's reduction target, for net changes in GHG emissions by sources and removals by sinks on the land resulting from direct human-induced activities. Article 3.3 is limited to afforestation, reforestation and deforestation since the base year of 1990. Article 3.4 provides for additional human-induced activities such as forest management, cropland management, grazing land management, and revegetation since 1990. Article 6, or Joint Implementation, allows for emission-allowance trading between developed countries. Emission reduction units can result from projects aimed at reducing emissions by sources or enhancing sinks of GHGs in any sector of the economy, providing that any emission reduction units from a project are additional to any that would otherwise occur. Similarly, Article 12, or the Clean Development Mechanism (CDM), allows for emission-offset trading between developed and developing countries, while at the same time assisting developing countries achieve sustainable development. Emission reductions resulting from such project activities shall be real, measurable, long-term benefits related to mitigation of climate change, and additional to any that would occur without the project.

A recent decision on the CDM limited the LUCF activities to afforestation and reforestation (UNFCCC 2001), although as we will discuss in this paper, a large opportunity is lost without inclusion of projects that are designed to avoid deforestation and improve the sustainability of agriculture in developing countries (see also Niles *et al.* 2002). This decision to limit LUCF activities under the CDM is mainly a result of the controversy that has arisen over the use of biological means to absorb or reduce carbon emissions (often referred to as carbon sinks). Carbon sinks as used in this context refers to direct human-induced changes in how forests and agricultural lands are used and managed; it does not refer to enhancing carbon storage that might occur due to increases in atmospheric carbon dioxide or increased nitrogen deposition, for example. Objections to carbon sinks are based primarily on two arguments. First, sinks may allow developed nations to delay or avoid technological adjustments to reduce their reliance on fossil fuels. And, second, technical and operational difficulties would reduce the value of sinks, allowing for inflated claims of carbon offsets.

The goals of this paper are to present the key component of the Kyoto Protocol with respect to emissions-reduction targets and what impact these targets may have on reducing the threat of climate change; the potential to mitigate carbon emissions by changes in the use and management of forests; the technical and scientific issues surrounding LUCF projects and how through experience gained by implementing pilot projects these are being addressed; and the ancillary benefits and technology transfer from such projects. The focus of our paper is on the potential of LUCF activities under the CDM, as this is where most of the controversy exists, yet it is also where most pilot projects exist and where most experience has been gained.

2. The Kyoto Protocol targets

In 1997, the Third Conference of the Parties (COP-3) to the UN Framework Convention on Climate Change (UNFCCC) met in Kyoto, Japan, and produced a document (the Kyoto Protocol) of appropriate actions for strengthening the commitments by developed countries to reduce their emission of GHGs. This Protocol included commitments by 38 developed countries to reduce their annual emissions of GHGs for the period 2008–2012 by an average of 5.2% below emissions in the baseline year of 1990. (The US pulled out of the Kyoto Protocol in 2001.) In 1990, those countries emitted 3.87 GtC (gigatonnes of carbon) (Marland *et al.* 2000). Emissions from the rest of the world in 1990 were 2.22 GtC (Marland *et al.* 2000). Thus the Kyoto Protocol would require a reduction of *ca.* 0.2 GtC yr^{-1} during the five-year commitment period, or a total of 1 GtC. However, deforestation, mainly in the tropics, accounted for an additional 1.6 GtC yr^{-1} or *ca.* 25% of the total fossil fuel emissions (Bolin & Sukumar 2000).

It is widely accepted that a reduction in carbon emissions of 1 Gt will have very little impact on projected climate change. To have a significant impact, reductions over the next few decades have to be much greater (Arnell *et al.* 2002). For example, to stabilize concentrations of CO_2 at 550 ppm by 2150, a stated policy of the European Union (in comparison with current levels of *ca.* 370 ppm; Keeling & Whorf 2000), carbon emissions will need to be reduced by *ca.* 136 Gt during the next 50 years from a business-as-usual scenario (IPCC IS92a emission scenario). To ensure that the world is on the path for stabilization at 550 ppm, carbon emissions would need to be reduced by *ca.* 8 Gt during the first Kyoto commitment period (see Arnell *et al.* (2002) and data from Nakicenovic *et al.* (2000)). Recent estimates have projected costs of emissions reduction but do not indicate that adjustments of the order of 8 GtC are achievable in the relevant time-frame, solely through technological means (Blok *et al.* 2001). Whether or not the Kyoto Protocol is ratified, it is evident to us that to have a meaningful impact on climate change, *all* available mechanisms for reducing atmospheric concentrations of CO_2 will have to be used.

3. The potential to mitigate carbon emissions by LUCF activities

Land-use change and forestry activities can mitigate carbon emissions by

(i) emission avoidance through conserving existing carbon stocks on the land (e.g. avoiding deforestation, changing harvesting regimes, converting from conventional to reduced-impact logging);

(ii) carbon sequestration or expanding the storage of carbon in forest ecosystems by increasing the area and/or carbon density of forests (e.g. by protecting secondary and other degraded forests to allow them to regenerate, restoring native forests through assisted and natural regeneration, establishing plantations on non-forested lands, and increasing the tree cover on agricultural or pasture lands); and

(iii) substitute sustainably grown wood for energy intensive and cement-based products (e.g. biofuels, construction materials) (Myers & Goreau 1991; Brown *et al.* 1996; Kauppi & Sedjo 2001).

Several projects that include such LUCF activities just described have been developed in the pilot phase of 'activities implemented jointly' (AIJ), established under the Berlin Mandate in 1995 (Trexler *et al.* 1999).

Most of the land-use and forestry practices described above that mitigate GHG emissions make good social, economic and ecological sense even in the absence of climate-change considerations (Brown *et al.* 1996). Land-use and forestry activities for mitigation are often criticized because of the impression that GHG mitigation is the main goal of the project. Instead, LUCF activities can meet the more conventional objectives for managing forests such as: sustainable forest development; industrial wood and fuel production; traditional forest uses; protection of soil, water and biodiversity; recreation; rehabilitation of damaged lands, etc. The carbon conserved and sequestered from managing for these objectives will be an added benefit.

Because photosynthesis has been shown to increase at high CO_2 concentrations, it is assumed that plants will take up more CO_2 in an enriched carbon dioxide atmosphere of the future (CO_2-fertilization effect). Thus, using LUCF activities to mitigate carbon emissions may result in carbon gains that are due, in part, to the CO_2-fertilization effect. However, the Kyoto Protocol is explicit in saying that carbon credits can only accrue from direct human-induced changes in the use and management of the land and the carbon credits must be measurable, transparent, and verifiable. In fact, the IPCC special report 'Land use, land-use change, and forestry' (Watson *et al.* 2000) goes to great lengths in proposing how forestry activities could be measured to factor out the CO_2-fertilization effect. Recent research results suggest that, at least for a young pine forest in North Carolina, some initial stimulation in carbon fixation occurred when exposed to about twice the present atmospheric CO_2 concentrations but, after three years, soil-nutrient limitations caused the gain to diminish (Oren *et al.* 2001). If indeed such a CO_2-fertilization effect is small or even non-existent, as suggested in the article by Oren *et al.* (2001), then this makes the argument for additional forestry projects designed to abate carbon emissions even more compelling.

The IPCC Third Assessment Report (Kauppi & Sedjo 2001) confirms previous estimates (Brown *et al.* 1996) that the potential avoidance and removal of carbon emissions that could be achieved through the implementation of an aggressive program of changing forestry practices on *ca.* 700 million ha over the next 50 years is *ca.* 60–87 Gt, equivalent to *ca.* 12–15% of the 'business-as-usual' fossil-fuel emissions (IPCC IS92a scenario) over the same period. The Third Assessment Report also confirmed that activities in tropical forest lands are the lowest cost GHG mitigation strategy. As total reduction levels increase, tropical forestry's cost advantage over forestry in OECD countries, renewable energy, energy efficiency and fuel switching becomes increasingly significant (figure 1). Such cost-effective measures in developing countries are more likely to encourage developed countries to invest in such projects without major disruptions to their economies.

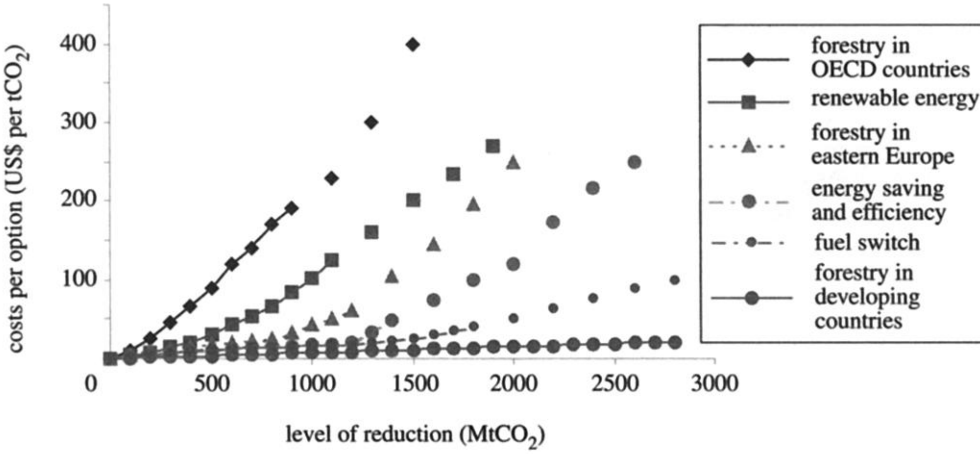

Figure 1. Indicative curves of costs (US$ per tCO_2) of emission reduction or carbon sequestration by level of total reduction. (From Kauppi & Sedjo 2001.)

A recent update of the IPCC assessment of the amount of carbon emissions that could be prevented from entering the atmosphere through reducing deforestation in the tropics resulted in an estimate of 40 MtC yr^{-1} (Niles 2000), compared with the 120–350 MtC yr^{-1} reported in Brown *et al.* (1996). The Niles (2000) study only considered 25 tropical countries with deforestation rates greater than 120 000 ha yr^{-1} and included factors such as operational and institutional constraints and the record of long-term success of projects in each country. Niles estimated that *ca.* 342 000 ha yr^{-1} of forests could be practically protected from deforestation or *ca.* 3% of the current deforestation rates. Deforestation is generally accomplished by burning considerable quantities of biomass, which converts its nitrogen content to nitrous oxide, another potent GHG. Preventing deforestation therefore also avoids considerable nitrous oxide emissions, the quantity of which is not well known (Houghton *et al.* 1997).

It has also recently been shown that many mature tropical forests continue to sequester carbon from the atmosphere. Several studies in the Amazon indicate a sink strength of the order of 1 ha yr^{-1} or less (Phillips *et al.* 1998; Bolin & Sukumar 2000; Malhi & Grace 2000). Although it is not clear what the mechanism is for this sink, conserving tropical forests under threat of destruction both avoids GHG emissions and sequesters additional carbon (Niles 2000; Chambers *et al.* 2001).

Although there is potential to avoid carbon emissions through changes in forest harvesting (e.g. conventional to reduced-impact logging), the magnitude of these potential savings has not been estimated to date. According to the Food and Agriculture Organization's recent assessment of tropical forests (FAO 2001), *ca.* 11.5 Mha of tropical forests were harvested per year during the 1990s. Based on an analysis of logging practices in Papua New Guinea and Indonesia, implementation of reduced-impact logging over conventional logging would avoid *ca.* 1.6–2.1 tC ha^{-1} yr^{-1} (S. Brown 2000, unpublished analysis). Assuming similar savings if reduced-impact logging was adopted globally in the tropics, a first approximation of the carbon emissions avoided would equal up to *ca.* 20 Mt yr^{-1}. However, reduced-impact logging results in less timber being produced per unit area, which might cause an increase in the area under logging to maintain timber output and thus the amount of carbon emissions avoided would be smaller.

During the Kyoto commitment period of 2008–2012, establishing new forests (regeneration, agroforestry, and plantations) and slowing tropical deforestation could avoid and sequester *ca.* 410 MtC (210 Mt for establishing new forests (from Trexler & Haugen 1995) and 200 Mt for slowing deforestation (Niles 2000)) or *ca.* 40% of the 1 GtC target for the first commitment period. However, the carbon mitigation potential is just that, and achieving these potentials would require a significant global effort. In this scenario, technological change by developed countries must account for the largest proportion of emissions reduction, more than 60%; thus there is no escape from technological change through carbon sinks; there is no 'loophole'.

4. Technical and scientific issues surrounding LUCF activities

Objections have been raised to carbon sinks on the grounds of 'permanence', 'additionality', 'leakage', measurement, verification and lack of technology transfer. There is nothing unique about carbon sinks in respect to permanence, additionality, leakage, measurement, verification, or technology transfer. Means exist, or can be devised relying on existing principles and technology, to deal with all of these concerns with respect to carbon sinks, as we discuss below. Further details about measuring, monitoring and verification of carbon benefits are presented in the paper by Brown (2002), and will not be discussed further here.

There are many LUCF projects in various stages of design and implementation around the world, ranging from forest protection, changes in forest management, forestation (afforestation, reforestation and restoration), and community forestry and agroforestry (Brown *et al.* 2000). Most of the forestation projects are in non-tropical countries and most of the other project types are in tropical countries. Much experience has been gained to date by these projects in advancing the field in permanence, carbon monitoring, without-project baseline development, and leakage prevention. The focus in this section is on how these issues are being addressed in CDM-type pilot projects where these issues are viewed as being the most challenging.

(*a*) *Permanence/duration of projects*

The life spans of forests (except those planted for wood products) are measured in centuries and extend beyond any currently advanced target period for reduction of atmospheric CO_2 and far beyond the life of any alternative technology-based installation. Recent research has demonstrated that tropical forests continue to sequester CO_2 throughout their life (Chambers *et al.* 2001). Projects that continue to store or sequester carbon for the selected target period or beyond are 'permanent' for all relevant purposes.

Concerns about permanence of biological sinks emerge because of the risk that the stored carbon could be released back to the atmosphere by natural (e.g. fires, disease outbreaks, hurricanes) or anthropogenic events (e.g. the non-enforcement of contracts, non-compliance with guarantees, expropriation, uncertain property rights, policy changes, land tenure, market risks). Of recent concern is the potential impact of future climate change on forest-carbon budgets, with models predicting that climate warming will enhance soil and plant respiration, thus reducing a forest's sink capacity. However, a recent review of this issue concluded that there is considerable uncertainty in these projections (The Royal Society 2001). For example, the models used to make the predictions are based on: business-as-usual CO_2 emission scenarios with no consideration for mitigation of emissions, the assumption of a pristine terrestrial biosphere, a relation between temperature and soil respiration that has recently been challenged by new findings, and no allowance for changes in the way humans manage the terrestrial biosphere.

Several practical approaches have been proposed for dealing with the problem that carbon stored in biological systems may be released to the atmosphere. One is to acknowledge that carbon sinks are a temporary means for abating emissions of GHGs and to assess the economic and environmental benefits of temporary storage (Chomitz 2000). The economic and environmental reasons include postponing climate change, buying time for developing and discovering alternative technologies to abate emissions, buying time for capital stock turnover, offering limited periods which are capable of being insured and, providing a means for host countries (who may be unwilling to lock up their lands in carbon projects forever) to preserve sovereignty and the opportunity to follow other future development pathways (Chomitz 2000; Marland *et al.* 2001).

Proposals have been made that basically view forestry projects as providing a service from nature that can be 'rented' (Ministry of the Environment, Government of Colombia 2000; Marland *et al.* 2001). The traditional system of a rental contract for limited-term use of an asset is ideally suited for the transfer of carbon credits where permanence is neither guaranteed nor wanted (Marland *et al.* 2001). The renter (or purchaser such as an entity in an Annex 1 country) can benefit from the limited-term carbon credits, while the seller retains long-term discretion over the resource. Under these proposals, at the end of the rental period the renter would have to replace the credits by renting new credits, purchase permanent credits, or incur a debit. When the credits expire, the land would be released from any further obligations; or the owner might decide to extend the project for another time period and be free to renegotiate.

(b) *Additionality and baselines*

There is a concern that many carbon-sink projects would have happened anyway for commercial or political reasons other than the climate-change obligations and therefore add nothing to the effort to reduce global warming. In other words, there is no real reduction in emissions below business as usual, or no additionality, as required by the language of the climate agreements. While additionality assessments for a given mitigation project have different components and are based on multiple sources of information, most additionality problems apply equally to projects in the energy or forestry sectors (Chomitz 2000).

Not all forestry projects are alike when it comes to showing additionality (Chomitz 2000). For example, projects that have direct financial benefits and involve practices that are well understood may be adopted regardless of concerns for carbon credits. An example of this is industrial-scale exotic-tree plantations for pulpwood or sawtimber. Although these plantations could sequester large amounts of carbon, the financial returns are high enough that they might have been implemented regardless of climate change (business as usual). Tree plantation projects for timber products

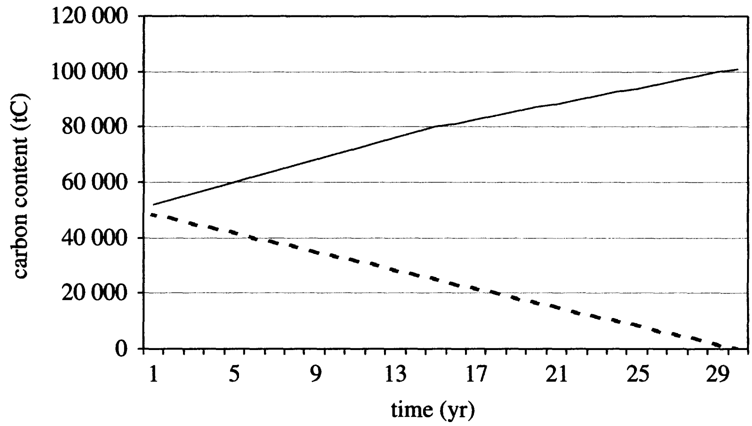

Figure 2. An example of a without-project or business-as-usual baseline (dashed line) and a with-project scenario (solid line). The carbon offsets would be the difference between the with- and without-project cases. This example represents a project that protects *ca.* 1000 ha of secondary forest from further degradation and deforestation over a 30-year period.

could have serious difficulties in showing additionality, particularly as the area of industrial plantations in developing countries has grown at *ca.* 4 Mha yr^{-1} over the past 10 years or so (Brown 2000). On the other hand, forestry projects that have little to no monetary benefits and yet impose ongoing costs on a developer are unlikely to be undertaken spontaneously and thus are likely to meet the additionality criterion (Chomitz 2000). Examples of this situation include forest protection from logging, forest restoration on degraded lands, reforestation for watershed protection and plantations in remote areas where tree growth rates are slow.

Once additionality has been demonstrated, a baseline or a projection of the 'business-as-usual' carbon emissions or storage needs to be developed for all mitigation projects. The difference between the carbon emissions or removals of the baseline for without-project activities and the carbon emissions or removals for with-project activities represents the carbon value. Figure 2 provides an example of a project baseline without-project carbon stocks and with-project carbon stocks. It represents a project that protects *ca.* 1000 ha of secondary forest from further degradation and deforestation over a 30-year period. By protecting the forest, it is allowed to rebuild carbon stocks as well as avoid emissions from the deforestation. By the end of this example project, *ca.* 100 ktC may be generated from avoided emissions and sequestration.

Baselines can be established by projecting past trends and current situations to calculate the amount of carbon stored or emitted based on the conventional pattern of land use and forestry. Comparable baselines are used in planning virtually all infrastructure and long-term capital investments such as power plants. Other methods include benchmarking models, similar to those used in industry, and those of minimum performance benchmarks (Brown 1998).

Changes in land use are not random phenomena, but rather are predictable, based on some combination of biophysical factors, presence of transportation networks, access to markets, and agroclimatic suitability (Kaimowitz & Angelsen 1998; Chomitz 2000). An array of tools including remote-sensing data, spatial land-use change models, forest growth models and field measurements is already being used to develop relatively simple, yet credible, baselines by project type and region.

(*c*) *Leakage*

Leakage is defined as the unanticipated decrease or increase in GHG benefits outside of a project's accounting boundary, as a result of the project activities. Potential leakage results from two effects: market effects, when project activities change supply and demand equilibrium; and activity shifting, when the activity causing carbon emissions in the project area is displaced outside a project's boundary. Identification and quantification of leakage remains one of the most challenging technical issues related to the development of carbon projects. This has been the subject of many studies, and it appears to be equally problematic for both land-use and energy projects (Chomitz 2000; Schlamadinger & Marland 2000). The mere presence of the potential for leakage does not make a project unattractive; instead strategies need to be developed to either mitigate it and/or account for it. Further discussion and a framework for addressing leakage in forestry projects are presented in the papers by Schwarze *et al.* (2002) and Brown (1998) and will not be discussed further here.

Experience to date has been limited to a few projects, and hindered by the lack of data, and short time-frames since project inception. Qualitative methods may need to be developed further, together with efforts to generate more-accurate data at the right level of definition (Aukland *et al.* 2002).

5. Ancillary benefits and technology transfer

Forest-based carbon projects can provide numerous additional environmental and socio-economic benefits to host countries and local communities (Chomitz & Kumari 1998; Frumhoff *et al.* 1998; Klooster & Masera 2000). Carbon-sink projects can provide the capital needed to help countries meet multiple national and local sustainable development objectives: technology transfer, expansion of national parks, alleviation of poverty among the rural poor and increased country capacity to adapt to and thus reduce vulnerability to climate change.

Environmental co-benefits from forest projects include conservation of existing, or restoration of, biodiversity, protection of habitat and protection of soil and water resources. Protection of water resources results in improved water-flow regimes and water quality, which in turn reduce siltation and flood risk, which in turn protects downstream water users, fisheries, coastal coral reefs and hydroelectric facilities (Chomitz & Kumari 1998). Most projects involving improvements in forest management provide substantial environmental and socio-economic benefits for the local owners (Klooster & Masera 2000). For example, in Michoacan, Mexico, a community-owned logging operation in the common-property forested (ejido) land provides rural development benefits (e.g. community stores, library, public transportation, recreational facility and agriculture extension) and employment for a majority of the communities' male population, while at the same time careful logging and reforestation activities increases the coverage and quality of the community forest and increases its carbon stocks. The average long-term increase in carbon stocks was *ca.* 1.8 Mt, yet the community (and others like it in Mexico) receives no financial compensation for the global benefits of these activities (Klooster & Masera 2000).

Establishment of fuel-wood plantations can reduce impacts on native woodlands, especially in arid regions (Kanowski *et al.* 1992), and thus may help to slow the pace of desertification. However, if exotic forest plantations are used to replace native ecosystems such as grasslands or woodlands, biodiversity would be reduced. Such projects should be disallowed except in situations where plantations of non-native species are all that will grow on severely degraded lands, and serve as a 'nursery' for regeneration of native species (Lugo *et al.* 1993).

One of the concerns about allowing forestry projects in the CDM revolves around the assertion that the transfer of emission-reducing technology to developing countries may be reduced. The fear is that carbon sinks will provide a substitute for, or disincentive to, transfer of clean energy technology to developing countries. However, the benefits of technology transfer will depend on the nature of the technology. For example, small-scale, locally replicable technology is likely to diffuse faster and have greater benefits to employment and poverty alleviation than the importation of large-scale sophisticated technology (Chomitz 2000). There are many forestry-related technologies, such as tree selection, nursery management, improved silvicultural practices, improved forest management and harvesting technologies, biodiversity conservation, wildlife management, etc., that lend themselves to local adoption and diffusion to the rural poor. Projects that incorporate alternative provision of fuel would also transfer biofuel or small-scale electrification technologies. Projects that incorporate improved agricultural practices to address the loss of agricultural land would transfer improved crop production technologies.

6. Conclusions

Recent international effort regarding global warming has focused on the Kyoto Protocol. In that context, controversy has arisen over the use of biological means to absorb or reduce emissions of CO_2 (often referred to as carbon 'sinks'). Objections to carbon sinks are based primarily on two arguments. First, sinks may allow developed nations to delay or avoid technological adjustments: the 'loophole' argument. Second, technical and operational difficulties would reduce the value of sinks, allowing for inflated claims of carbon offsets: the 'floodgates' argument. We conclude that neither argument bears scrutiny.

The atmosphere does not distinguish between emissions and removals. In order to achieve any significant change in atmospheric concentrations of GHG, both emissions reductions and emissions removals can be effective and, as we discussed here, both are needed. Carbon sinks, unlike most mitigation strategies, offer opportunities both to reduce CO_2 emissions through avoiding further deforestation and improving forest management and to remove atmospheric CO_2 through establishment of new forests on marginal lands or protection of secondary forests. As carbon-sink strategies can be implemented relatively quickly because little new technology is needed, they readily lend themselves to local adoption and diffusion to the rural poor.

The Third Assessment Report of the IPCC concluded that biological sinks can make an important, albeit limited, contribution to the transition to a lower emissions environment, and can do so at significantly lower cost than other mitigation techniques. This is the case regardless of whether or not the Kyoto Protocol is ratified. Well-designed forestry projects can, in addition, provide significant environmental and socio-economic benefits to host countries and local communities, particularly in the tropics. There is no meaningful distinction between carbon sinks and other mitigation techniques in so far as difficulty of regulation is concerned. A regulatory framework for such projects can be implemented relying on existing principles and techniques. A well-designed regulatory framework, including adhesion to international agreements on bio-diversity, desertification, wetlands, and indigenous peoples' rights, would strengthen sustainable development, while at the same time enhancing efforts to address climate change.

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