Forests, Biodiversity Conservation, and the Kyoto Protocol: Challenges and Opportunities.[1]

By

Jean-Daniel Saphores[2] and Baishali Bakshi[3]

Abstract

This paper examines mechanisms based on terrestrial CO_2 sinks proposed in the Kyoto Protocol, and more particularly forests. After a review of the most recent scientific evidence and of the consequences of global warming, we highlight the importance of tropical forests in the preservation of biodiversity. We then review current forestry carbon sequestration projects and argue for the need to inscribe them in the larger context of sustainable development and poverty alleviation. Our policy recommendations include accepting only narrowly defined LULUCF activities, assisting developing countries in the development of comprehensive "green" accounting systems, compensating developing countries for the preservation of tropical areas, and extending forest certification programs.

Resume

Dans ce papier, nous examinons les mécanismes de captation du CO_2 proposés dans le Protocole de Kyoto, et plus particulièrement ceux qui mettent en oeuvre des forêts. Nous commençons par résumer les connaissances scientifiques les plus récentes sur le changement climatique et ses conséquences, puis nous nous penchons sur l'importance des forêts tropicales pour la biodiversité. Nous analysons ensuite les projets de captation du carbone actuellement en cours ainsi que les difficultés qu'ils rencontrent. Nous soulignons la nécessite impérieuse de les inscrire dans le contexte du développement durable et de la lutte contre la pauvreté. Parmi nos recommandations, il faut citer: la nécessite de ne considérer qu'un certain nombre d'activités bien définies dans le cadre de Kyoto, le besoin d'assister les pays en voie de développement dans la création de systèmes de comptabilité nationale verts, la nécessite de compenser les pays tropicaux pour la conservation des forêts tropicales, et la généralisations des programmes de certification des activités forestières.

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[2] Assistant Professor, School of Social Ecology and Economics Department, University of California, Irvine, CA 92697. E-mail: saphores@uci.edu
[3] Graduate Student, Economics Department, University of California, Irvine, CA 92697. E-mail: bbakshi@uci.edu

I. Introduction

The ratification of the Kyoto Protocol, adopted during the 3rd session of the conference of the parties (COP3) in December 1997, seems compromised. The COP6 meeting in The Hague at the end of 2000 ended without an agreement on how to implement the Protocol. In addition, the Bush administration has recently declared its opposition to the terms of the Kyoto Protocol (Lindsey 2001). Most OECD countries support it, however, and a follow-up meeting to The Hague will be held in Berlin during the summer.

The Kyoto Protocol is supposed to be the first step towards implementing the United Nations Framework Convention on Climate Change (UNFCCC). To start counteracting the upward trend in greenhouse gas (GHG) emissions that started two centuries ago with the industrial revolution, it sets targets for developed countries to reduce their collective emissions of six greenhouse gases by at least 5%.[1] These targets, which vary by country, must be achieved by the period 2008-2012. Cuts in the three most important greenhouse gases - carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) - are to be measured against 1990 emissions. Cuts in the other three gases - hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) -, three long-lived industrial gases, are to be measured either against 1990 or 1995 emissions. Since many industrialized countries did not meet earlier non-binding goals of returning to 1990 emissions by the year 2000, collective cuts in developed countries emissions under the Protocol could in fact represent a 20% reduction compared with emission levels projected for 2010 under a business-as-usual scenario.

[1] To-date, industrialized countries have contributed approximately 80% of the CO_2 buildup in the atmosphere. Looking at current emissions of carbon equivalent per capita per year, the U.S. emits more than 5,000 tons compared to only 290 tons for India and 760 tons for China. The U.S. also emits twice as much per capita as large European countries like France, Germany, or the United Kingdom. See http://www.igc.org/wri/powerpoints/climate/.

Four mechanisms are provided to reduce net emissions of GHG: 1) the Clean Development Mechanism (CDM) between developed and developing countries; 2) Joint Implementation (JI) activities among countries with binding legal commitments, such as the European Union, or between a country with an advanced market economy and a country with an economy in transition; 3) Trading of greenhouse gas emission permits between countries listed in Annex B; and 4) Enhancing the absorption of GHG through biological sinks or through physical sequestration of GHG.

Since the beginning of negotiations of the UNFCCC, it is clear that climate change is much more than just an environmental problem. It also has very important economic, social, and equity dimensions. Because the CO_2 build-up in the atmosphere is primarily due to the combustion of fossil fuels by industrialized economies, and to a lesser degree to deforestation in developing countries, the UNFCCC is often seen as an impediment to economic growth and to development. This has led to disagreements between developing and developed countries. The former argue that global warming was caused by industrialized countries in the first place and that they are in no position to commit now to reductions in their GHG emissions; they must be allowed to develop economically first. The later (led by the United States) argue that all countries should bear some portion of the burden to lower GHG emissions.[2]

To mend these conflicting points of view, which are threatening efforts to slow global warming, the Kyoto Protocol should be placed in the context of sustainable development, which calls for economic development in all countries in an environmentally sustainable way. Indeed, global climate change is likely to negatively affect all countries through, for example, increased occurrences of extreme weather events; disruptions in transportation and agricultural production;

[2] For background information on the politics of the Kyoto Protocol, see Schneider 1998.

flooded coastlines; new disease threats for people and animals; and significant losses of biodiversity.

Whether or not a compromise can be found, the Kyoto Protocol has put forward a number of mechanisms that are likely to survive the Protocol's possible demise. In this paper, we focus on the mechanisms dealing with terrestrial CO_2 sinks, and more particularly with forests. These mechanisms have generated tremendous interest both as low cost means of sequestering CO_2 and as a way of promoting sustainability in the management of tropical forests.[3] Our goal here is to discuss obstacles to the implementation of these mechanisms and to assess their potential usefulness to the conservation of tropical forests.

This paper is organized as follows. In the next section, we review the latest scientific evidence on global warming based on recently published IPCC reports. In Section 3, we investigate the links between deforestation and global warming, before summarizing the importance of tropical forests for global biodiversity (Section 4). In Section 5, we consider some obstacles to the use of forests as viable sinks under the provisions of the Kyoto Protocol. Section 6 analyzes some carbon sequestration forestry projects currently under way. In Section 7, we highlight the essential role of indigenous people in sustainable forest management projects. Finally, our conclusions are summarized in Section 8.

II. Background on Global Warming

The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750 and CO_2 levels in the atmosphere are currently rising at an annual rate of about 1.5 parts per million (PPM) from human activities (Houghton et al., 1996). The atmospheric concentration of other greenhouse gases is also on the rise. For methane (CH_4), it has gone up 151% since 1750;

slightly more than 50% of CH_4 emissions are anthropogenic (fossil fuels, cattle, rice agriculture, and landfills). Likewise, the atmospheric concentration of nitrous oxide (N_2O) has increased by 17%; approximately 1/3 of current emissions are anthropogenic (agricultural soils, cattle feed lots, and chemical industry) (IPCC 2001a).

Scientists do not yet fully understand all of the impacts of rising GHG concentrations on the atmosphere, but the Intergovernmental Panel on Climate Change (IPCC) estimates that the global average earth surface temperature has increased by 0.6 ± 0.2^{o} C during the 20^{th} century.[4] As a result, the freeze-free season in many mid- and high latitude regions has lengthened, and global average sea levels have gone up between 0.1 and 0.2 meters. Moreover, the frequency of heavy precipitations events has increased by 2% to 4%; warm episodes of the El Niño-Southern Oscillations have been more frequent, persistent and intense; and large-scale droughts and severe wetness events have become slightly more common (IPCC 2001a).

With current emission patterns, the Earth's average temperature is likely to go up another 1.4^{o} C to 5.8^{o} C between 1990 and 2100 (IPCC 2001a). It is quite probable that landmasses will warm more rapidly than the global average, especially at northern high latitudes in the cold season. Affected areas include the northern regions of North America as well as northern and central Asia. In addition, global precipitations are likely to increase, but so will year-to-year variations; we can thus expect more intense rainstorms, tropical cyclones, and severe droughts. Glaciers and ice caps will continue their retreat, which will cause global mean sea levels to rise between 9 and 88 centimeters.

It is important to emphasize the long lasting effects of greenhouse gases. Even if we were able to keep CO_2 emissions at today's level, CO_2 concentration in the atmosphere compared to

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[3] In this paper, we talk about tropical forests to refer to both tropical and equatorial forests.
[4] This is a 95% confidence interval for global average temperatures.

pre-industrial levels would double by the end of the 21st century. It is not until a century later that CO_2 concentration would finally stabilize. The global mean sea level and the average surface temperature would continue to rise (although much more slowly than now) for centuries.

A number of ecosystems are likely to undergo "significant and irreversible damage" (IPCC 2001b) because of their limited adaptive capacity. The most threatened include coral reefs and atolls, mangroves, tropical forests, but also polar ecosystems, boreal forests, glaciers and alpine ecosystems, as well as prairie wetlands and some native grasslands. Climate change is thus quite likely to boost the rate of species extinction, even if some current species may increase in abundance or range (IPCC 2001b).

A number of human systems are likely to suffer from projected climate changes. First, generalized higher summer temperatures are likely to increase energy demand for cooling. In agriculture, current scenarios project a general reduction in potential crop yields in most tropical and sub-tropical regions. While some regions in mid-latitudes could benefit from slightly higher temperatures, increases of more than a few ^{o} C would reduce crop yields. Many populations in the sub-tropics could suffer from dwindling water supplies, and more people could become exposed to vector-borne diseases, such as malaria, or to water-borne diseases, such as cholera. To this already bleak picture, we need to add higher flooding risks due to precipitations or to rising sea levels in coastal areas. Finally, we can expect more droughts, more heat waves, and more windstorms.

On the positive side, we could see an increase in timber supply from appropriately managed forests, the availability of more water in a few water-scarce regions (such as southeast Asia), and higher winter temperatures that could lengthen growing seasons and reduce energy demand for heating at higher latitudes.

Quantifying the benefits and costs of potential climate changes is obviously quite difficult given, for example, difficulties in predicting climate variability and extreme events, or difficulties in valuing goods and services not traded in markets. Nevertheless, published studies suggest that increases in mean temperatures would cause net economic losses in many developing countries; these losses would grow with the magnitude of warming. By contrast, a small increase in mean temperatures could produce a mixture of gains and losses for developed countries; still higher temperatures would, however, cause net economic losses.

Global warming is likely to affect disproportionately the poor, especially in developing countries, because they have fewer resources and are less able to adapt to projected hardships. The economic gap between developed and developing countries would widen: in general, countries that are more vulnerable to climate change are also experiencing population growth, resource depletion, and poverty. Policies designed to reduce vulnerability to climate stresses should also address these problems. Consequently, global warming offers an opportunity to advance sustainability and equity.

III. Deforestation and Global Warming

Tropical deforestation alone is responsible for 20 to 30% of current anthropogenic greenhouse gases emissions (Kremen et al. 2000). Terrestrial ecosystems are an important component of the global carbon cycle: approximately 46% of the terrestrial carbon is stored in forests and another 25% is in grasslands and savannas. A large share of these percentages is in soils (IUCN 2000), as shown in Table 1.

It is estimated that half of all tropical forests are already lost (Myers 1992). Current rates of deforestation are imprecise and subject to interpretations. According to FAO’s Forest

Resources Assessment 2000, the global rate of deforestation averaged 9 million hectares per year during the 1990s, with a 20% slowdown compared to the rate of deforestation in the first half of the 1990s. This conclusion is questionable, however, because the FAO included plantation establishments in calculating a net rate of global forest change. According to WRI (2001), if forest plantations are excluded, natural forests in the tropic are currently being lost at the rate of approximately 16 million hectares per year. It seems that deforestation rates have increased in tropical Africa, remained constant in Central America, and declined slightly in Asia and South America. It should be noted that the available deforestation data from many developing countries is still quite poor (more than 10 years or incomplete). Moreover, because of methodological inconsistencies in reporting from Canada and Russia, which account for 65% of all forests in developed countries, forest data for temperate and boreal forests is likely skewed (WRI 2001).

Immediate causes of deforestation include agriculture, fuelwood collection (mostly in drier areas), and commercial logging. Large dams and large mining operations can also cause significant deforestation locally. The underlying causes of deforestation are much more complex. First, the debt burden of many developing countries forces them to sell forests concessions to pay interests on their debt. Second, governments in these countries may use forests as an outlet for landless peasants while a few landowners control very large properties.

Population growth has long been seen as the main underlying force behind deforestation: as the population grows or as mean income rises, demand for food increases and so does the pressure to clear more land for agriculture. Recent research by the World Wide Fund for Nature (WWF 1997) finds that commercial logging for international use is currently the most important cause of forest loss and degradation. On one hand, heavy machinery used to penetrate forests and to build roads can cause very severe damage by compacting soils (this makes natural regeneration more difficult); soil disturbances and clearing can also promote soil erosion, which causes siltation in nearby streams. On the other hand, landless farmers often follow logging roads to access forests and practice slash and burn agriculture. Large areas of forests are also cleared to create large ranching operations (even if tropical soils are often unfit for this activity) and huge monoculture plantations.

In addition, commercial logging tends to take place in biologically rich forests. One reason is that areas of high biodiversity often harbor the oldest, largest, and thus the most valuable trees. A second reason is the lack of well-defined property rights for forests in many developing countries, or rather the fact that indigenous people are deprived of their property rights by logging companies with the complicity of weak and cash-poor governments.

We should also mention the importance of illegal logging in many developing countries, including for example Kenya, The Democratic Republic of Congo, The Philippines, Indonesia, Brazil, Bolivia, or Russia, to name a few. Until recently, 50% of the mahogany leaving Brazil was exported illegally (Dudley, Jeanrenaud, and Sullivan 1996).

Deforestation, especially in tropical forests, is believed to affect regional as well as global climates (Andrews 2000). At the regional level, large-scale losses of tropical forests could affect the amount of incoming solar radiation (albedo effect), increase local earth surface temperature and evaporation, and reduce rainfall (it has been estimated that approximately 50% of tropical moisture is generated locally.) Unfortunately, global climatic effects from tropical deforestation are not understood as well as regional effects because they are combined with a number of other factors (such as El Niño for example), but the contribution of tropical deforestation to global CO_2 emissions is well established.[5] Forests, therefore, are much more than collections of trees.

[5] For a recent study of the interaction between deforestation and global climate change, see Zhang, Henderson-Sellers, and McGuffie 2001.

IV. Forests and Biodiversity

Around 10 million species live on earth, according to the best estimates (but only 1.4 million have actually been named), and tropical forests house between 50 and 90 percent of this total. Although it is difficult to calculate precisely the rate of extinction of species, biologists estimate it is between 100 and 1000 times greater today than before pre-human levels (Pimm et al., 1995). The crucible of extinction is believed to be in tropical forests with 14,000 to 40,000 species disappearing yearly (Kremen et al. 2000).[6]

Scientists estimate that at the current rates of deforestation, roughly 5 to 10 percent of tropical forest species may face extinction within the next 30 years. In many countries, relatively little natural vegetation remains pristine (Rodgers 1996). In Bangladesh, only 6 percent of the original vegetation remains. Forests around the Mediterranean Sea probably once covered 10 times their current area, and in the Netherlands and Britain, less than 4 percent of lowland raised bogs remain undamaged. Worldwide, some 492 genetically distinct tree species are endangered.

Tropical forests, along with coral reefs and almost certainly deep ocean floor sediments, have the greatest variety of organisms of all ecosystems (WCMC, 1992; UNEP, 1995). They provide the gene pool that can protect commercial plant strains against pests. Loss of genetic diversity could thus imperil agriculture. Moreover, some of the plants found in forest ecosystems may also be used as drugs or have other commercial uses.

Tropical forests provide a number of goods and services to human economies, such as timber. They also offer essential ecological services (global public goods) that are typically very difficult to value. In addition to carbon sequestration and biodiversity protection, these services

[6] Problems stemming from the limits of current knowledge of species diversity are compounded by the lack of a central database of the world's species.

include watershed protection, climate regulation, and soil production. Biodiversity, for example, has a large “non-consumptive use value,” resulting from existence and option values.

Among all the sources of biodiversity change for terrestrial ecosystems (see Table 2 below), land use change will probably have the largest impact on biodiversity. Scientists project that most land-use changes will continue to occur in tropical forests and in the temperate forests of South America; the least will take place in the alpine and in northern temperate forests where reforestation is expected to exceed deforestation. The extent of habitat modification is projected to be modest in boreal forest and intermediate in savannas, grasslands and Mediterranean ecosystems. Table 2 lists expected changes for the year 2100 in the five major drivers of biodiversity change for the principal terrestrial biomes of the Earth. Table 3 shows the impact of a large change in each driver on the biodiversity of each biome.

V. Challenges to Implementing Sustainable Forestry Projects

Under Article 3.3 of the Kyoto Protocol, industrialized countries can invest in “land use, land use change, and forestry activities” (LULUCF) to meet their emission reduction commitments. There is, however, a controversy regarding the role that could be played by forest management, conservation, and agricultural soil sinks, because these are not explicitly mentioned in Article 3.3. Article 6, however, states that projects can be developed in any sector of the economy.[7] For carbon accounting purposes, it is also important to mention that the Protocol provides for credit only for human induced emission reductions begun in 1990 or later, and credits accrue only for carbon sequestrated during the 2008 to 2012 commitment period.

A number of methodological problems need to be addressed, however, before LULUCF activities can usefully be implemented.

- First, the terms “forest,” “deforestation,” “reforestation,” and “afforestation” need to be clearly defined. The definition of forests is usually based on canopy cover, but alternatives could refer to land use, biomass density, or legal, administrative, and cultural considerations. Likewise, the definition of “deforestation” is often based on the conversion of forested to non-forested land, but it could also depend on thresholds for canopy cover or carbon density. “Reforestation” and “afforestation” both refer to the conversion of non-forested to forested land; they differ based on the length of time during which land is without forest cover. For afforestation, this duration is usually 20 to 50 years.
- A second hurdle is the need to distinguish between natural and human-induced activities because the Kyoto Protocol admits only the latter. A related problem is to choose between an activity-based (land-use examples include the selection of a tillage method, fertilization, or the choice of a cover crop) and a land-based carbon accounting system. An activity-based system may be easier to monitor for well-defined activities, but it may be misleading if the activities don’t have an additive impact on carbon sequestration. Extensive monitoring of large land areas may be costly.
- Third, the determination of a baseline against which to assess carbon sequestration is critical to measure the contribution of various projects to carbon sequestration. Setting baselines has so far remained a scientific challenge. The concern for project additionality is closely related: do the carbon credits claimed by a project really correspond to the carbon sequestered over and above a “business as usual” policy? Indeed, there could be “leakage” and some gains obtained at the project level could be lost through activity displacement.

[7] E.g., see Sedjo, Sohngen, and Jagger 1998.

- Fourth, there are substantial uncertainties in the measurement of carbon stocks and sequestration activities, in quantifying baselines, and in the costs of carbon sequestration. While Annex I parties have the technical capacity to measure carbon stocks and net GHG emissions, these measurements are not done on a regular basis, particularly in soils. Under Articles 5, 7 and 8 of the Kyoto Protocol, industrialized countries should establish national accounting systems to track emissions from LULUCF. To monitor sustainability and the preservation of biodiversity, they should go further and build green accounts along the lines of the satellite accounts proposed by the United Nations.[8] While this may be doable (albeit costly) for developed countries, it will be much more difficult in developing countries to put in place green national accounting systems. It will require substantial capacity building efforts, as well as technical and financial assistance.
- Finally, and this point has not been emphasized enough in the literature, there is the danger that biologically rich forests will be replaced with exotic or genetically modified tree species to maximize short-term carbon storage. This would have dramatic effects on the many other essential ecological functions of natural forests. It is thus imperative that the national accounting systems mentioned above track all essential ecological and social services provided by forests, both locally and globally.

To see if the critiques above can be addressed, let us review some of forestry projects undertaken to-date in the context of global climate change.

VI. Mitigating Climate Change through Forest Management

Many LULUCF carbon sequestration projects currently under way are part of the so-called "Activities Implemented Jointly" (AIJ) program, but quite a few have also been undertaken

[8] E.g., see Bartelmus 1996.

independently by non-governmental organizations in collaboration with firms, cooperation agencies, and/or developing country governments.

AIJ was established by the first Conference of the Parties (COP1) in Berlin (1995) to enhance the transfer of technology and know-how that could reduce global warming, and to gather experience on related international projects. Under this program, sequestration or GHG reduction projects are carried out jointly between an investor from a developed country and a host in a developing country or an economy in transition. AIJ projects are supposed to provide blueprints for designing the project-based mechanisms under JI and CDM.

The list of projects in the AIJ database has grown over time following the 1998 decision to prolong the pilot phase beyond 1999.[9] There are now 12 investors and 39 host countries, versus only 9 investors for 27 host countries 2 years ago. As noted in Schwarze (2000), many of these projects have been undertaken independently of the AIJ program with the expectation that the pilot phase would be extended beyond 2000 and/or would end up been credited.[10]

At the end of April 2001, only 14 out of the 145 projects in the AIJ database are forestry projects: 1 deals with afforestation (RUSAFOR, funded by the US in Russia), 5 focus on reforestation, and 8 are forest preservation projects. Of these, 12 out or 14 are funded by the US (the US funds 38 AIJ projects), 1 is funded by the FACE Foundation from the Netherlands (the Krkonose and Sumava national parks in the Czech Republic), and the last one is funded by Norway in Costa Rica. Globally, 10 projects are located in Latin America, 3 in Europe (2 in Russia, 1 in the Czech Republic), and 1 in Asia (Indonesia). Africa has no AIJ forestry project.[11]

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[9] UNFCCC web site as of April 30, 2001 (http://maindb.unfccc.int:8080/aij/).

[10] The crediting of emission reductions to investor countries is prohibited during the pilot phase but possible under Articles 6 and 12 (respectively CDM and JI) of the Kyoto Protocol.

[11] Most AIJ projects are intra-European, intra-Asian, and intra-American; they follow institutional links of development cooperation. Investor country preferences have a big impact on the type of project undertaken: U.S. projects are usually large in cost and effects, not very focused on technology, privately funded, and located in South

In general, the average GHG reduction is much greater for land use/forestry projects than for fossil fuel projects: they make up ~10% of the number of AIJ projects but account for ~40% of the total GHG reductions. Some forestry projects are quite large: the territorial and financial consolidation of Costa Rican National Parks and Biological Reserves is expected to sequester 57 million tons of CO_2 equivalent over 25 years, just slightly more than the Noel Kempf Mercado climate project in Bolivia (55 million tons of CO_2 equivalent over 30 years).

Looking at the gross average reduction cost of AIJ projects by activity type, Schwarze (2000) finds \$2.6 per ton of CO_2 for LULUCF projects, with compares very favorably with projects based on efficient energy (\$3.2 / ton of CO_2), renewable energy (\$14.0 / ton of CO_2), and fuel substitution (\$15.4 / ton of CO_2), although these numbers do not take into account fuel savings.[12] Fugitive gas capture is, however, the cheapest option with only \$0.1 / ton of CO_2.[13]

We do not know how issues related to the definition of "forest," uncertainties in benefits measurement, or the preservation of biodiversity have been addressed because of insufficient information in official AIJ reports. Looking at all the AIJ projects (not only forestry related ones), Schwarze (2000) finds that 95% of them adopted a fixed baseline (fixed once and for all at the beginning of the project) while only 5% accepted to take unforeseen events into account. Moreover, 2/3 of the projects retained a static baseline (the status quo is extrapolated over the entire lifetime of the project), as opposed to a dynamic baseline that accounts for current trends in technology, economic conditions, or policy. In addition, 97% of projects also opted to measure only direct effects; only 3% chose to also include indirect effects such as leakage from shifting

America. By contrast, European projects are usually small, related to energy efficiency or fuel substitution, publicly funded, and located in Eastern Europe. For a global analysis of AIJ projects, see Schwarze (2000).

[12] In a detailed case study in Madagascar, Kremen et al. (2000) find similar costs for forest conservation (between \$0.23 and \$4.34 per ton of CO_2).

[13] Calculations of net project costs are impossible because of incomplete and inconsistent data in official project reports (Schwarze 2000).

deforestation. These choices, which may have been partially motivated to simplify procedures, also suggest that reported benefits may have been overestimated. By contrast, 70% of projects accepted relatively expensive external verifications and 30% preferred internal verification mechanisms. According to Schwarze (2000), this can be explained by the strong support for external reviews by countries like the US and Costa Rica.

The assessment of AIJ forestry projects is limited by a number of factors but we see clearly that the some of the poorest countries in Africa and Asia with biologically rich tropical forests have been left out. This is problematic if the fight against global warming is to contribute to sustainability and to the preservation of forest biodiversity. This situation may be partly explainable by civil war, chronic political instability, the lack of secure land rights, or the absence of adequate forestry legislation.[14]

When some minimum requirements can be met, however, the experience accumulated by the FACE foundation (see box) proves that public-private partnerships can lead to successful forestry projects for sequestering carbon while at the same time promoting sustainability and the well being of local populations.

A glance at the history of forestry projects in developing countries indicates that a necessary condition for long-term success is the active involvement of local stakeholders, especially indigenous people, both at the design and execution level of a project (IPCC 2000). Unfortunately, this has often been more the exception than the rule in practice.

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[14] Some of these problems are related to the legacy from the colonial period.

The FACE Foundation

The FACE Foundation is a non-profit organization, created in 1990 in the Netherlands. Its goal is to sequester CO_2 by planting, restoring and conserving forest. CO_2 sequestration is certified and monitored by an international accredited certification agency.

Through its forestry projects, FACE and Triodos Bank (a European bank, which has set up a Climate Clearing House to facilitate transactions in certified, sequestered CO_2), give firms and households a way to compensate for their yearly emissions of CO_2. They can enter into a one-year contract with Triodos Bank and get credit for an agreed-upon amount of CO_2 sequestered in one of FACE's projects. FACE owns only the forest's CO_2 absorbing capacity while an independent party owns the land and the trees. The money goes to fund another FACE afforestation project to sequester more CO_2.

All FACE projects are recognized jointly by the Dutch government and the government of the host country. FACE adheres to the UNFCCC guidelines, which means that:

1) Afforestation activities must result in the plantation of additional forests. This establishes the link between the sale of CO_2 credits and actual CO_2 sequestration.

2) Host countries must have sufficient physical and financial capacity, the technical expertise to plant and manage large-scale forests, long-term land rights, and adequate forestry legislation.

3) Each project must satisfy stringent ecological (use indigenous species and abstain from chemical treatment) and economic (cost-effectiveness) criteria, have broad social acceptance, and contribute to the socioeconomic well being of the local population.

4) To minimize profit-seeking destruction of old growth forests, the area to be afforested may not have been deforested after 1989, or, in the case of damaged forest, such damage may not have occurred after 1989.

FACE does not a-priori discard any country when searching for suitable project locations. However, tropical areas are preferred because of faster tree growth and thus faster CO_2 sequestration. Tropical areas also need reforestation and assistance the most. Hence, FACE has projects across Africa (Uganda), Asia, and Latin America (Ecuador), but some projects have also been undertaken in Poland, the Czech Republic, and in the Netherlands.

For more information, see http://www.facefoundation.nl/Eng/introFaceE.html.

VII. Indigenous People and Sustainable Forest Management

Indigenous people have long been living in most tropical forests and mangroves, and they use or claim very large areas of tropical, equatorial, temperate, and boreal forests. From either a strictly legal or an ethical point of view, they should thus have the right to at least use these areas. However, development or forest management projects as well as conventional forestry practices have typically denied indigenous people their land rights and ignored their knowledge, with severe consequences for biodiversity, forest preservation, soil erosion, and global warming.

Customary tenure systems have usually been ignored in forestry zoning and indigenous peoples' rights have typically been heavily curtailed or extinguished when forest reserves have been established on their territories. The resulting dependency has fostered the emergence of corrupt, exploitative, and even violent relations between forestry officials and indigenous peoples, whose fundamental rights have often been violated (including destruction of property, arbitrary arrests, detentions without charge or summary executions).

Logging, especially industrial timber extraction, has caused major problems for indigenous peoples ever since the colonial era. Indigenous peoples have sometimes welcomed logging operations because they were lured by promises of employment opportunities, road access, clinics, and schools. Commonly, however, if they are at all provided, such services fall into disrepair when the industry moves on. Moreover, because they often lack formal education or training, indigenous people are employed in dangerous, low-paid, and short-term occupations, with no concern for their health and safety. In Sarawak in the 1980s, for example, the rates of death and injury of forest workers were 21 times as high as in Canada, and compensation for loss or injury was nominal (See Colchester 2000).

Industrial-scale tree plantations on indigenous peoples' lands have not proven better for them. A cursory review of the literature reveals that they typically receive inadequate compensation for their loss of land and livelihoods, when their land rights are not just ignored. Where they are accepted into the workforce of the plantations, indigenous peoples often find poor working conditions and low wages. Promised land titles and services are slow to appear, while repayments for housing and start-up costs are demanded up-front. Conditions of 'debt-slavery' sometimes result.

The loss of forest territories usually leads to the breakdown of traditional resource management systems, impoverishment, as well as cultural and social collapse. It also reinforces political marginalization. For example, adjusting to life on plantations is often difficult because working regimes typically do not fit customary life-styles. Division of communities into nucleated households disrupts traditional social networks and rituals. Many indigenous people end up migrating to slums in mushrooming urban areas.[15]

In addition, industrial forestry practices tend to impact the hydrological cycle. Effluent from plantations and processing works pollute water supplies. This reduces the availability of drinking water, limits water for bathing, and affects fishing opportunities. Changes in disease ecology are often accompanied with rising incidences of malaria, dengue fever, or typhus.

About 1 billion people are dependent on forest products for their livelihoods. As many as two billion people, including many of the urban poor in developing countries, continue to rely indirectly on forests to satisfy their fuelwood needs. Consequently, forestry projects motivated by the fight against global warming should not be only or mostly about carbon sequestration. They should be designed around the goals of poverty alleviation and sustainability. The fulfillment of these goals requires the close association of indigenous people in respect of the

Charter prepared before the 1992 Rio Summit by the International Alliance of Indigenous and Tribal Peoples of the Tropical Forests. Charter principles include:

- First, the right to the ownership, control and use of their territory.
- Second, the need to obtain the prior, free and informed consent of indigenous people for forestry projects on their territories.
- Third, the institution of clear and mutually acceptable mechanisms, preferably in the form of freely negotiated contracts, to ensure benefit sharing, shared management and control of decision-making, and community-involvement in monitoring and evaluation. Priority should be given to meeting the basic needs of the communities concerned, not only for its basic livelihood but also in terms of health, education, social cohesion and cultural identity.

VIII. Conclusions and Policy Recommendations

A review of experiences accumulated to date has shown that some LULUCF activities, especially forest conservation, reforestation, and afforestation are economically attractive for mitigating the build-up of GHG in the atmosphere, compared for example with projects based on efficient energy, renewable energy, or fuel substitution. By contrast with solutions relying on technology to reduce GHG emissions, forest sequestration has no unknown risks, it is well understood, and carbon stocks can be readily measured. However, a number of definitional and methodological problems must first be addressed before these LULUCF activities can be employed on a wide scale. Several pitfalls must also be avoided.

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[15] To understand the impact of industrial logging on indigenous people, also see Colchester 1997.

First, the terms “forest,” “deforestation,” “reforestation,” and “afforestation” need to be clarified based on internationally recognized and ecologically meaningful definitions since they define the framework for LULUCF activities.

Second, to implement a credible and equitable GHG accounting system, the number of acceptable LULUCF activities should be narrowly defined, based on current scientific limitations and the difficulty of distinguishing between natural and human-induced activities (Houghton 2001). For example, accurately estimating the impact of soil management on GHG emissions is currently scientifically difficult (Denier van der Gon et al. 2000) and probably too costly for most developing countries; we may thus want to ignore soils in a global GHG accounting system for now, while promoting best management practices through the diffusion of information and subsidies at the national level.

Third, to establish credible, conservative baselines, projects should, whenever possible, take into account unforeseen natural events as well as reasonable current trends in technology, economic conditions, or policy. They should also try to account for indirect effects such as leakage from shifting deforestation. External verifications of benefits by a recognized, independent third party are essential.

Fourth, forestry projects in developing countries should meet UNFCCC guidelines and contribute to sustainable development and poverty alleviation. They should thus satisfy stringent ecological and economic criteria, have broad social acceptance, and contribute to the socioeconomic well being of local population, especially indigenous populations. This is a necessary condition to generalize successful programs like the one organized by the FACE foundation. Forestry projects cannot be only about carbon sequestration because we would then destroy biodiversity in the name of global climate change.

Developing countries will need international assistance (e.g., through institutions such as the World Bank and international NGOs) to establish and enforce forest property rights, that take into account the historical rights of indigenous people, and to fight illegal logging. To monitor sustainability and track changes in biodiversity, green satellite accounts should also be established with the assistance of developed countries.

The best way to reduce GHG emissions from tropical developing countries is to prevent deforestation, a leading cause of biodiversity losses. It is essential that developing countries be compensated for the opportunity cost to them of forgoing income from logging and agriculture in order to provide the rest of the world with global public goods (e.g., biodiversity and climate benefits from tropical forests). Painful structural measures, such as land reform and redistributional policies may also be needed to reduce the pressures of growing populations on forests.

Other measures that developed countries should seriously consider include generalizing certification programs for the sustainable production of forest products, promoting paper recycling, and stimulating research on fast growing tree varieties (e.g. eucalyptus and hybrid poplars; see Victor and Ausubel 2000).

Forestry mechanisms proposed in the Kyoto Protocol give us an opportunity to mitigate global warming while preserving biodiversity and contributing to poverty reduction. It is urgent to take advantage of this opportunity.

References

Andrews, S. 2000. "The Effect of Tropical Deforestation on Climate Change." http://www.geog.ucl.ac.uk/~sandrews/gcm_essay.html.

Bartelmus, P. 1996. "Green Accounting for Sustainable Development," Peter May and Ronaldo da Motta, eds. *Pricing the planet: Economic analysis for sustainable development*. New York: Columbia University Press, p. 180-96.

Colchester, M. 2000. "Indigenous Peoples and the new 'Global Vision' on Forests: Implications and Prospects," http://greatrestoration.rockefeller.edu/21Jan2000/Colchester.htm.

Colchester, M. 1997. *Guyana Fragile Frontier – Loggers, Miners, and Forest People*. Latin America Bureau, World Rainforest Movement, Ian Randle Publishers.

Denier van der Gon, H. A. C., P. H. Verburg, P. M. van Bodegom, S. Houweling, and N. van Breemen, October 2000. "The Reliability of Greenhouse Gas Emission Estimates (with emphasis on CH_4 from diffuse sources)," Wageningen University, the Netherlands.

Dudley N., J.-P. Jeanrenaud, and F. Sullivan, 1996. *Bad Harvest: The Timber Trade and the Degradation of Global Forests*, report to the World Wildlife Fund for Nature. Earthscan Publications Ltd.

Hecht, J. E. and B. Orlando, 1998. "Can the Kyoto Protocol Support Biodiversity Conservation? Legal and Financial Challenges," *Environmental Law Reporter, News & Analysis*, September, 10508-10518.

Houghton, R. A. 2001. "Counting Terrestrial Sources and Sinks of Carbon," *Climatic Change* 48: 525-534.

IPCC, 2000. "Summary for Policymakers: Land Use, Land-Use Change, and Forestry." Summary approved at IPCC Plenary XVI, Montreal, Canada, 1-8 May.

IPCC, 2001a. "Summary for Policymakers – A Report of Working Group 1 on the Intergovernmental Panel on Climate Change," http://www.ipcc.ch/index.html.

IPCC, 2001b. "Summary for Policymakers – Climate Change 2001: Impacts, Adaptation, and Vulnerability," http://www.ipcc.ch/index.html.

IUCN, 2000. "Carbon Sequestration, Biodiversity, and Sustainable Livelihoods," November. http://www.iucn.org/themes/climate.

Kremen C., J. O. Niles, M. G. Dalton, G. C. Daily, P. R. Ehrlich, J. P. Fay, D. Grewal, and R. P. Guillery, 2000. "Economic Incentives for Rainforest Conservation Across Scales," *Science* 288 (June 9): 1828-1832.

Lindsey, L. 2001. Speech to the AAAS Science and Technology Policy Colloquium, May 3. http://www.aaas.org/spp/dspp/rd/colloqu.htm.

Moomaw, W., K. Ramakrishna, K. Gallagher, and T. Freid, 1999. "The Kyoto Protocol: A Blueprint for Sustainable Development," *Journal of Environment and Development*, 8(1): 82-90.

Pimm, S. L., G. J. Russell, J. L. Gittleman et T. M. Brooks, 1995. "The Future of Biodiversity," *Science* 269: 347-350.

Rodgers, A. 1996. "Forest Biodiversity Loss," presented at the *Economics of Biodiversity Loss*, in Gland Switzerland (April). Workshop organized by IUCN in collaboration with UNEP and WRI. http://biodiversityeconomics.org/incentives/960401-03.htm .

Schwarze, R., 2000. "Activities Implemented Jointly: Another Look at the Facts," *Ecological Economics* 32: 255-267.

Schneider, S. H. 1998. "Kyoto Protocol: The Unfinished Agenda – An Editorial Essay," *Climatic Change* 39: 1-21.

Sedjo, R. and B. Sohngen, September 2000. "Forestry Sequestration of CO_2 and Markets for Timber," *Discussion Paper 00-35*, Resources for the Future, Washington, D.C.

Sedjo, R., B. Sohngen, and P. Jagger October 1998. "Carbon Sinks in the Post-Kyoto World: Part II," *Weathervane*, Resources for the Future, Washnigton, D.C.

Van Bogedom, A. J., H. J. F. Savenije, and G. van Tol, June 2000. *The Challenge of Including Forests as Sinks within the Clean Development Mechanism.* International Agricultural Center (IAC), Wageningen, the Netherlands.

Victor, D. G., and J. H. Ausubel, 2000. "Restoring the Forests," *Foreign Affairs* 79(6): 127-144.

World Resources Institute, 2000. The global carbon cycle, http://www/wri.org/climate/carboncy.html

World Resources Institute, 2000. Mitigating climate change through forest management, http://www/wri.org/climate/mitigate.html

World Resources Institute, 2001. "WRI study reports deforestation may be higher than FAO estimates," News Releases, March 12 http://www/wri.org/press/fao_fra5.html

World Resources Institute, 2001. "Understanding the FRA 2000," by Emily Matthews. http://www.wri.org/press/fao_fra5.html

Zhang, H., A. Henderson-Sellers, & K. McGuffie, 2001. "The Compounding Effects of Tropical Deforestation and Greenhouse Warming on Climate," *Climatic Change* 49(3): 309-338.

Table 1: Global carbon stocks in vegetation and soil carbon pools down to a depth of 1 m.

Biome	Area	Global Carbon Stocks (Gt C)		
	(10^9 ha)	Vegetation	Soil	Total
Tropical forests	1.76	212	216	428
Temperate forests	1.04	59	100	159
Boreal forests	1.37	88	471	559
Tropical savannas	2.25	66	264	330
Temperate grasslands	1.25	9	295	304
Deserts and semi-deserts	4.55	8	191	199
Tundra	0.95	6	121	127
Wetlands	0.35	15	225	240
Croplands	1.60	3	128	131
Total	15.12	466	2011	2477

Note: this table provides only orders of magnitude of carbon stocks in terrestrial ecosystems. There is considerable uncertainty in the numbers reported, partly linked to ambiguities in the definition of biomes. Source: IPCC 2000, Table 1.

Table 2: Expected changes by 2100 in the five major drivers of biodiversity change for the principal terrestrial biomes. Estimates vary from low (1) to high (5).

	Land use	Climate	Nitrogen deposition	Biotic exchange	Atmospheric CO_2
Arctic tundra	1	5	1	1	2.5
Alpine tundra	1	3	3	1	2.5
Boreal forest	2	4	3	2	2.5
Grasslands	3	2	3	3	2.5
Savannas	3	2	2	3	2.5
Mediterranean ecosystems	3	2	3	5	2.5
Desert	2	2	2	3	2.5
Northern temperate Forests	1	2	5	3	2.5
Southern temperate Forests	4	2	1	2	2.5
Tropical Forests	5	1	2	2	2.5

Table 3: Impact of a large change in each driver on the biodiversity of each biome. Estimates vary from low (1) to high (5).

	Land use	Climate	Nitrogen deposition	Biotic exchange	Atmospheric CO_2
Arctic	5	4	3	1	1
Alpine	5	4	3	1	1
Boreal	5	3.5	3	1	1
Grassland	5	3	2	2	3
Savanna	5	3	2	2	3
Mediterranean	5	3	2	3	2
Desert	5	4	1	2	2
Northern temperate Forests	5	2	3	1.5	1.5
Southern temperate Forests	5	2	3	3	1.5
Tropical Forests	5	3	1	1.5	1

Source: Reference—Global Biodiversity Scenarios for the year 2100 – Science (Biodata 2)

Notes for Tables 2 and 3: A unit change of the driver was defined for land use as conversion of 50% of land area to agriculture; for CO_2 as a 2.5-fold increase in elevated CO_2 as projected by 2100; for nitrogen deposition as 20 kg per ha per year; for climate as a 4°C change or 30% change in precipitation; and for biotic exchange as the arrival of 200 new plant or animal species by 2100. For both tables, estimates vary from low (1) to high (5) and result from existing global scenarios of the physical environment and knowledge from experts in each biome.