

# Is reducing emissions from deforestation financially feasible? A Panamanian case study

CATHERINE POTVIN<sup>1,3\*</sup>, BRUNO GUAY<sup>2</sup>, LUCIO PEDRONI<sup>4</sup>

<sup>1</sup> McGill University, Department of Biology, 1205 Docteur Penfield, Montreal H3A 1B1, Canada

<sup>2</sup> McGill University, Department of Political Sciences, 855 Sherbrooke Street West, Montreal H3A 2T7, Canada

<sup>3</sup> Smithsonian Tropical Research Institute, Panama

<sup>4</sup> Tropical Agricultural Research and Higher Education Center (CATIE), Turrialba, Costa Rica

Since 2005, negotiations aiming at reducing emissions from deforestation in developing countries (REDD) are ongoing in the UN Framework Convention on Climate Change. Two breeds of proposed REDD mechanisms are examined: market- or fund-based. Using Panama as a case study, the comparative ability of these types of mechanisms is assessed for addressing developing countries' concerns. In Panama, the protection of 5,000 ha of forest land corresponds to an annual reduction in emissions of 3,320,000 tCO<sub>2</sub>e with a break-even opportunity cost of US\$3,678,594. The additional costs of protection, transaction and administration would augment the overall cost by 25%. The total yearly cost of REDD for Panama would be comparable to the country's total spending for protected areas in 2005 of ~US\$3.5 million. Thus, implementing a REDD programme would double the conservation expenses of that country, underlying the crucial need to identify sufficient funding sources to sustain REDD. Our analysis suggests that none of the currently proposed mechanisms can provide the necessary incentives and flexibility to stimulate action. The proposed market-based approaches are likely to be too risky, while funds-based mechanisms lack explicit replenishment mechanisms. Alternative financial options must urgently be identified to give credibility to the ongoing efforts aimed at REDD.

*Keywords:* deforestation avoidance; developing countries; emissions reduction; market mechanisms; public policy

*Depuis 2005, les négociations visant la réduction des émissions dues à la déforestation dans les pays en développement (REDD) continuent dans le cadre de la convention cadre des nations unies sur le changement climatique. Deux types de mécanismes REDD sont analysés: mécanisme de marché et mécanisme de fonds. A l'aide d'une étude de cas panaméenne, la capacité de ces deux types de mécanismes à répondre aux intérêts des pays en développement, est comparée. En Panama, la protection annuelle de 5000 ha de forêts correspond à une réduction d'émissions de 3,320,000 tCO<sub>2</sub>e à un coût d'opportunité au seuil de rentabilité d'US\$3,678,594. Le coût additionnel de protection, de transaction et d'administration augmenterait le montant total de 25%. Le coût total annuel de REDD pour le Panama serait comparable aux dépenses totales du pays versées aux aires protégées en 2005 c'est-à-dire environ US\$3.5 millions. Ainsi, la mise en place d'un programme REDD doublerait les dépenses à la conservation dans ce pays, démontrant la nécessité d'identifier des sources de financement suffisantes pour soutenir REDD. Notre analyse suggère que les mécanismes proposés actuellement ne peuvent apporter ni la motivation et ni la flexibilité propice à stimuler l'action. Les approches de marché proposées présentent trop de risques alors que les mécanismes de fonds manquent de systèmes explicites de renouvellement. D'autres options financières doivent être identifiées pour rendre crédible les efforts actuels liés à l'initiative REDD.*

*Mots-clés:* déboisement évitée; mécanismes de marché; pays en développement; politique publique; réductions d'émissions

\*Corresponding author: E-mail: catherine.potvin@mcgill.ca

## 1. Introduction

Deforestation and forest degradation are responsible for anywhere between 15% and 35% of human-induced greenhouse gas emissions (Stocker et al., 2001; DeFries et al., 2002; Houghton, 2005). This realization has provided a new impetus to instigate initiatives aimed at reducing emissions from deforestation in developing countries (REDD). Most notably at the 11th Conference of the Parties (COP-11) to the United Nations Framework Convention on Climate Change (UNFCCC, November 2005), Costa Rica and Papua-New Guinea initiated the discussion by presenting the submission: 'Reducing emissions from deforestation in developing countries: approaches to stimulate action'. In decision FCCC/CP/2005/L.2, COP-11 encouraged submissions of views on this agenda item. The views submitted by many developing countries in March 2006 were analysed at the 24th meeting of the Subsidiary Body for Scientific and Technological Advice (SBSTA) in Bonn (May, 2006) and later at a UNFCCC workshop in Rome (August, 2006).

Various mechanisms for REDD have been put forward. The first breed of mechanisms relies on access to carbon (C) markets to provide positive incentives for the protection of forest C reservoirs (Achard et al., 2005; Santilli et al., 2005). The second breed of mechanisms, those proposed by Brazil and by the Commission des Forêts d'Afrique Centrale (COMIFAC), would provide positive incentives through a fund.

This article examines these two breeds of mechanisms to assess their capacity in addressing concerns expressed by developing countries in their March 2006 submissions (UNFCCC, 2006a, 2006b). To compare the mechanisms, we used Panama as a case study. Such an analysis is essential because, however attractive a given mechanism may be in theory, it cannot be implemented if it falls short of political, economic or social feasibility. In their submissions, several countries indicated the need for new policy and incentive measures (Table 1). Furthermore the Indonesian submission mentions that: 'The mechanism criteria ... should consider ... national interest' (UNFCCC, 2006a). When deciding whether they should enter a deforestation avoidance regime, decision-makers from developing countries are likely to ask questions such as: 'Can we reduce deforestation?' 'Is doing so in our nation's interest?' The answers to these questions obviously depend on the shape of the international instrument that will be agreed upon to provide the incentives and compensations needed to avoid deforestation.

## 2. Market-based mechanisms

Discussions on REDD have emerged from two concepts central to the negotiations of the Clean Development Mechanism (CDM): additionality and leakage (Auckland et al., 2003; Pedroni, 2005; Brown et al., 2007). These concepts have been largely debated during the Kyoto Protocol negotiations in order to establish a clear distinction between reductions attributable to voluntary efforts by governments versus contingent phenomena, thus ensuring a real benefit for the climate (Yamin and Depledge, 2004). Permanence, another concept pertaining to C sequestration projects which was debated during negotiations of the Protocol, does not apply to REDD, since emissions avoided are by definition permanent (Kelly, 2007). Keeping these issues in mind, two market-based methods (Achard et al., 2005; Santilli et al., 2005) have been developed. Both proposals are associated with baselines developed at the national level to prevent leakage (Brown et al., 2007). Countries should take on a national voluntary commitment to reduce their deforestation rates in the form of a reduction target vis-à-vis this national baseline. Developing countries meeting their target would be allowed to trade the achieved emission reductions, termed compensated reduction (CR), through a C market. The pros and cons of national baselines have been discussed elsewhere (Skutsch et al., 2008).

**TABLE 1a** Developing countries' concerns as expressed in their submissions to UNFCCC (UNFCCC, 2006a). It should be noted that Bolivia, Costa Rica and El Salvador each sent a submission in addition to the group submissions in which they take part. These explicated some national experiences but do not change the preoccupations listed here. Chile and Uruguay sent their submissions at a later date (UNFCCC, 2006b) and their preoccupations closely match those of the submission by Peru

Country	Real benefits for the climate	Protect the integrity of existing mechanisms	Fairness/equity	Synergy with development goals and existing MEAs	Implementation and targets
Panama (on behalf of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama)	High standards of reliability and transparency	AD should not weaken the environmental integrity of the UNFCCC and Kyoto	Allow all parties to participate Fair distribution of benefits (1) between countries: large countries should not reap all the benefits (2) within countries: money should be fairly distributed among stakeholders	Right to fulfill development needs: poverty eradication is the priority Synergy with adaptation and MEAs (some small forest areas have great importance) -CBD biodiversity -Desertification -Meso-American corridor SFM	Voluntary participation Strengthening - Government - Private sector - Civil society - NGOs Need to develop sustainable uses of forest: Ecotourism SFM Non timber forest products
Peru (on behalf of Colombia, Costa Rica, Ecuador, Nicaragua, Panama and Peru)	Measures must be: (1) On adequate scale to address problem (reach objectives of Convention) (2) ASAP (no delay in implementation) (3) Unlikely to delay other emission reduction efforts	AD should not weaken the environmental integrity of the UNFCCC and Kyoto	Allow all parties to participate Fair distribution of benefits between countries: large countries should not reap all the benefits	Right to fulfill development needs development needs	Voluntary participation Up to the countries to decide how to implement (sovereignty) Develop more efficient and intensive sustainable land uses SFM Involvement of private sector and indigenous communities Consolidate protected areas Deal with leakages National as well as local-Project based (project can be regional or even national)

**TABLE 1a** Developing countries' concerns as expressed in their submissions to UNFCCC (UNFCCC, 2006a). It should be noted that Bolivia, Costa Rica and El Salvador each sent a submission in addition to the group submissions in which they take part. These explicated some national experiences but do not change the preoccupations listed here. Chile and Uruguay sent their submissions at a later date (UNFCCC, 2006b) and their preoccupations closely match those of the submission by Peru (*Cont'd*)

Country	Real benefits for the climate	Protect the integrity of existing mechanisms	Fairness/equity	Synergy with development goals and existing MEAs	Implementation and targets
Bolivia (on behalf of Papua-New Guinea, Costa Rica, Nicaragua and Bolivia)	Measurable benefits for climate: (1) Adequate scale to address problem (reach objectives of Convention) (2) ASAP (no delay in implementation) (3) Unlikely to delay other emission reduction efforts	Fair distribution of responsibilities and benefits between and among countries	Synergy with biodiversity protection Enhancing water quality, agricultural production, fisheries, coral reefs Control of infectious diseases, medicinal cures Social stability	Synergy with development goals and existing MEAs	Up to the countries to decide how to implement (sovereignty) Develop more efficient and intensive sustainable land uses SFM Involvement of private sector and indigenous communities Conservation activities
Malaysia	Conservative approach dealing with leakages, additionality and permanence	Clear and fair	Recognize socio-economic impacts (forestry is an important economic sector)	Zoning (1) Totally protected areas (2) Permanent reserved forests (SFM) (3) Conversion forests	
Indonesia	Need for certainty in emission reduction: credible reporting in national communication. Need to develop monitoring capacity	Allow all parties to participate	Recognize synergies with CBD, CCD, UNFF, ITTO, FAO Forest conservation, biodiversity -community benefits -benefit sharing -capacity building -technology transfer	Allow all parties to participate Broad array of activities can be included Pilot projects (learning by doing approach)	

**TABLE 1a** Developing countries' concerns as expressed in their submissions to UNFCCC (UNFCCC, 2006a). It should be noted that Bolivia, Costa Rica and El Salvador each sent a submission in addition to the group submissions in which they take part. These explicated some national experiences but do not change the preoccupations listed here. Chile and Uruguay sent their submissions at a later date (UNFCCC, 2006b) and their preoccupations closely match those of the submission by Peru (*Cont'd*)

Country	Real benefits for the climate	Protect the integrity of existing mechanisms	Fairness/equity	Synergy with development goals and existing MEAs	Implementation and targets
Brazil		Annex 1 countries should not be allowed to reach their obligations under Kyoto through buying AD carbon offsets	Annex 1 countries should not be allowed to reach their obligations under Kyoto through buying AD carbon offsets	Technology transfer	Voluntary Cannot be associated with targets
Gabon (on behalf of Cameroun, Chad, Central African Rep., Congo, Eq. Guinea, Dem. Rep. Congo and Gabon)	Measures must be: (1) Adequate scale to address problem (2) ASAP (no delay in implementation) (3) Unlikely to delay other emission reduction efforts	AD should not weaken the environmental integrity of the UNFCCC and Kyoto	Allow all parties to participate Fair distribution of benefits (1) between countries: large countries should not reap all the benefits (2) within countries: money should be fairly distributed among stakeholders	Right to fulfill development needs	Up to the countries to decide how to implement (sovereignty) Develop more efficient and intensive sustainable land uses SFM Involvement of private sector and indigenous communities Conservation activities
Morocco		AD should be linked to additional Annex 1 parties' commitments	Flexible and account for national circumstances	Synergies with CBD, watershed management and local economies	National target Conservation activities

**TABLE 1b** Developing countries' concerns as expressed in their submissions to UNFCCC (UNFCCC, 2006a)

Country	Policy and incentives requirements	Market instruments	Non-market funding source	Mechanisms	Future process
Panama (on behalf of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama)	A priori funding to create technical, technological (monitoring) and institutional capacity New and additional funding to cover expenses linked to implementation		Special climate change fund Adaptation fund GEF Bilateral and multilateral programmes	National level Negotiated baselines according to country circumstances Payment for environmental services	Under COP for now Options should not be excluded The discussion on technical issues should not delay or prevent the adoption of policy approaches
Peru (on behalf of Colombia, Costa Rica, Ecuador, Nicaragua, Panama and Peru)	A priori funding to create technical, technological and institutional capacity New and additional funding sufficient to cover implementation, transaction and opportunity costs (cost-effectiveness)	Possibility for prompt starting experiences Necessary to address deforestation at sufficient scale, unless other innovative source of financing (international commodity taxes)	Revolving funds Advanced payments ODA and new donor programmes Public-private partnerships	Take historical trends into account Not disadvantage countries who have taken early action Project-based (project can be regional or even national)	Continue under UNFCCC, not exclude inclusion in second commitment period of Kyoto The discussion on technical issues should not delay or prevent the adoption of policy approaches
Bolivia (on behalf of Papua-New Guinea, Costa Rica, Nicaragua and Bolivia)	Sufficient to cover implementation costs including opportunity costs and help alleviate poverty. (cost-effectiveness) New and additional funding A priori funding to build technical, market and regulatory capacity	Develop market instrument based on carbon offsets	Revolving funds Advanced payments ODA and new donor programmes Public-private partnerships Debt-for-nature swaps Tax on carbon-intensive commodities, air travel, military	Not disadvantage countries who have taken early action (credit for early action) Sectoral CDM approach Annex C national approach Bilateral or multilateral emissions trading agreements Optional protocol	Continue under UNFCCC, not exclude inclusion in second commitment period of Kyoto The discussion on technical issues should not delay or prevent the adoption of policy approaches

**TABLE 1b** Developing countries' concerns as expressed in their submissions to UNFCCC (UNFCCC, 2006a) (Cont'd)

Country	Policy and incentives requirements	Market instruments	Non-market funding source	Mechanisms	Future process
Malaysia				Not disadvantage countries who have taken early action Not generate perverse incentives Pilot projects	Against optional protocol
Indonesia	A priori funding for – Capacity-building – techno transfer – To set up pilot projects	Stable market with balanced supply and demand. Necessary to have a discount for carbon credits from deforestation Voluntary markets to gain experience			Pilot projects to start with Clarity on incentives and policy approaches should precede technical discussions
Brazil	New and additional financial resources to built capacity and for technology transfer Funding should be channelled to governmental programmes	Strongly opposes the use of market instruments Annex 1 countries should not be allowed to reach their obligations under Kyoto through buying AD carbon offsets	New AD fund	Brazil Proposal	Against inclusion in Kyoto Supports initiative to reduce emissions from deforestation within UNFCCC
Gabon (on behalf of Cameroun, Chad, Central African Rep., Congo, Eq. Guinea, Dem. Rep. Congo and Gabon)	A priori funding to create technical, technological and institutional capacity New and additional funding to build technical, market and regulatory capacity	Possibility for prompt starting experiences Necessary to achieve significant GHG reductions Should be linked with reduction commitments by Annex 1	Revolving funds Advanced payments ODA and new donor programmes Public-private partnerships Tax on carbon-intensive commodities, air travel, military Bilateral and multilateral agreements	COMIFAC Proposal Sectoral approach on national or regional level if market approach is used	Continue under UNFCCC, not exclude inclusion in second commitment period of Kyoto The discussion on technical issues should not delay or prevent the adoption of policy approaches
Morocco	AD should be linked to additional Annex 1 Parties' commitments	Flexible and account for national circumstances and local economies		Synergies with CBD, watershed management and local economies	National target

One of the challenges that merits further consideration pertains to the difficulty in establishing credible baseline scenarios for future deforestation rates because of the many drivers of deforestation and the complex interlinkages between them (Lambin et al., 2003). It has been suggested that many developing countries (e.g. China, Costa Rica, South Korea, peninsular Malaysia, Morocco and Rwanda) are in the midst of a forest transition (Rudel et al., 2005). Forest transition (Mather, 1992) refers to the tendency for forests to decrease in the first stage of development and population growth, which then rebounds, either because of higher wages in more productive farmlands and urban employment or because wood scarcity induces reforestation (Rudel et al., 2005). The result is that deforestation rates follow a Kuznets curve with low deforestation in a first stage of development, high deforestation rates in a second stage of development, and finally low deforestation or even reforestation at an advanced stage.

Baselines determined using past deforestation rates cannot take into account the Kuznets curve effects which modify deforestation rates through time as a function of economic development, thereby creating: (1) an important premium for countries which have massively deforested in the recent past (e.g. South-East Asia) and where remaining forested areas are hard to access, and (2) a great disadvantage for countries which have never deforested on a large scale (e.g. Bolivia, Peru, African countries) or developing countries which have deforested in the past but have stopped this process decades ago (e.g. India). However, a preoccupation with fairness/equity is at the forefront of many developing countries' submissions (Table 1). A future REDD regime that fails to recognize the specific characteristics and history of deforestation in different countries would not satisfy these countries' concerns.

Our case study provides insights into the possible economy of deforestation avoidance, and hence the adequacy of the proposed mechanisms. As a model we used Panama, a small Central American country with a total area of 74,927 km<sup>2</sup> (ANAM, 2003). According to Panama's officials, the best information available on land-use change comes from a study sponsored by the International Tropical Timber Organization (ANAM, 2003). ANAM (2003) indicates that Panama's forest cover is 33,645 km<sup>2</sup> accounting for 45% of the total area of the country. The national system of protected areas (PAs) consists of 65 legally recognized areas covering 10,801 km<sup>2</sup> of forest area; therefore 29.1% of forests are under governmental protection. Outside the PAs, Panama is experiencing a rapid rate of deforestation estimated at 1.12% for the period 1992–2000 (Table 2). Analysis of changes in forest cover per province highlights three main zones of deforestation located eastward in the provinces of Panama (–1.53%) and Darien (–1.74%) and in the indigenous territory of the Ngobe-Bugle (–2.72%). For the period 1992–2000, annual deforestation was estimated to be 41,321 ha (ANAM, 2003).

Panama hopes to encourage the implementation of pilot activities in the context of the ongoing UNFCCC discussions of REDD and of the possible World Bank 'Forest Carbon Partnership Facility'. The national commitment of Panama to move forward and tackle deforestation would be sustained by a loan already approved by the World Bank to initiate a project entitled 'Productividad Rural and Corredor Biológico Mesoamericano del Atlántico Panameño II' (PP-CBMAPII) (E. Reyes, personal communication). The project covers an area of 675,775 ha and includes 14 protected areas. PP-CBMAP II, with its focus on the implementation of forest conservation, would serve as the backbone for a national effort on REDD relying on education, micro-credit and community development as strategies to alleviate poverty and promote sustainable land uses.

In this study, we assume that Panama would reduce deforestation on an area of 5,000 ha per year, an assumption deemed realistic by government officials (C. Melgarejo, personal communication). This area is equivalent to 12% of the current annual forest loss. The net effect, at the country level, would be an annual reduction of 0.98% of the national rate of deforestation. Since REDD is based on reductions in annual deforestation, after 25 years 125,000 additional



**TABLE 2** Land and forest area (km<sup>2</sup>) as well as forest lost and annual deforestation in % in the provinces and Comarcas (indigenous territories) of the Republic of Panama

Province	Area	Forest 1992	Forest 2000	Forest lost	Annual percentage lost
Bocas	4,662.55	3,522.52	3,421.91	100.61	0.36
Cocle	4,947.33	691.15	654.22	36.93	0.67
Colon	4,832.5	2,844.72	2,606.26	238.46	1.05
Chiriqui	6,513.08	1,049.41	1,211.12	-161.71	-1.93
Darien	11,943.08	9,907.37	8,531.25	1,376.12	1.74
Herrera	2,337.71	102.25	93.21	9.04	1.11
Los Santos	3,791.79	212.3	279.71	-67.41	-3.97
Panama	11,718.34	5,670.53	4,978.32	692.21	1.53
Veraguas	10,577.74	3,019.05	2,830.53	188.52	0.78
C. KY	2,422.75	2,155.64	2,123.42	32.22	0.19
C. Embera-Wounaan	4,342.7	4,018.92	3,976.14	42.78	0.13
C. Ngobe-Bugle	6,818.2	3,757.75	2,939.82	817.93	2.72
Total	74,926.77	36,951.6	33,645.91	3,305.69	1.12

Data are from ANAM (2006)

hectares of forests would have been conserved. Using an above-ground C content measurement of 181.1 tC per hectare for mature forest in Panama (Kirby, 2005), the protection of 5,000 ha of forest land would correspond to a reduction in emissions of 3,320,000 tCO<sub>2</sub>e per year, with a cumulative value of 83,000,000 tCO<sub>2</sub>e over a period of 25 years (Table 3).

What would be the cost to Panama of REDD? Different sources of information provide indications of the opportunity cost of land use in the country. A report for ANAM on payment for ecosystem services (PES) indicated that in the Panama Canal Watershed income ranges between US\$45.00 and US\$69.00/ha (Louis Berger Group, 2006). Another study suggested a value of US\$60.00/ha in a proposed PES project related to the development of hydroelectric dams in the Province of Bocas del Toro (Barzev, 2006). Finally, Coomes et al. (2008) estimated a non-discounted gross income of US\$61.00/ha for small-scale cattle ranching in an indigenous community of eastern Panama. This figure represents the average yearly benefit obtained from 1 ha of land over 25 years. Using the yearly flow of benefits, they estimated the corresponding net present value (NPV) of the land as US\$735.72 (discount rate 5%). Assuming a C concentration of 181.1 tC/ha (Kirby, 2005), the corresponding break-even opportunity cost, on a C basis, can be simply estimated as NPV/[CO<sub>2</sub>] or US\$1.11 per tCO<sub>2</sub>e (NPV discount rate 5%) over a lifetime project of 25 years.

In Panama the deforestation frontier is clearly related to the expansion of agriculture (Table 2). Therefore, we used the estimate of Coomes et al. (2008) to develop a national scenario. Under the assumption that small-scale cattle ranching is the most attractive land use, Panama would need to sell CRs for a yearly value of US\$3,678,594 (or US\$735.72\*5,000) in order to compensate for the opportunity cost of avoided deforestation for 25 years. Obviously the estimate of the break-even opportunity cost is likely to vary in both space and time. In Panama, other land uses such as intensive agriculture, infrastructure or tourist development generate higher income than

**TABLE 3** Reduction in emissions from deforestation in moist lowland tropical forest in Panama. Above-ground carbon (C) stocks were estimated by Kirby (2005). Conversion between C and CO<sub>2</sub> was based on molecular mass

Area (ha)	Above-ground C content (tC)	CO <sub>2</sub> equivalent emission (t)
1	181.1	664
5,000	905,500	3,320,000
125,000	22,637,500	83,000,000

small-scale cattle ranching. Therefore our figure of >US\$3 million is a conservative estimate of the level of funding that would be needed to implement REDD rather than a precise value. The importance of this amount is best understood in the context of existing conservation efforts in Panama. In 2005, the National Authority for the Environment (ANAM) (Contraloria, 2006) had a budget of US\$27 million, representing 0.3% of the country's budget. PAs are managed through a trust fund, Fideicomiso Ecológico de Panamá (FIDECO), with contributions from USAID-TNC (US\$10 million in a debt-for-nature swap and US\$15 million from the Panamanian government). Total spending by FIDECO for 2005 was US\$3,750,909 (ANAM, 2006). Therefore implementing a REDD programme would at least double the conservation expenses of Panama. Clearly the request of developing countries for a sufficient, new and additional fund (Table 1) is supported by our analysis.

In this context, we argue that a national market-based approach falls short on at least two important issues: namely risks and mechanism integrity. First, the proposed mechanisms (Achard et al., 2005; Santilli et al., 2005) link the market approach to the achievement of national commitments. Yet, developing countries might be reluctant to take on voluntary commitments to reduce deforestation if they are uncertain of the income, to be generated by the market, on which they can base their interventions. At an early stage of the market, price uncertainty can be high because demand and supply are still unknown (as is currently the case for Afforestation/Reforestation-CDM CER prices). Even when the market develops, C price variations and uncertainty about future commitments will represent a considerable uncertainty, making investment in REDD particularly risky. This investor's risk will be transmitted to governments, who would have to accept a national commitment to participate. Falling prices could imply that a government programme would no longer be able to pay the opportunity costs and honour contracts signed with private forest owners, which could lead to deforestation, social unrest and governance problems.

Second, in a fully fungible market, REDD credits are likely to be relatively cheap. Coomes et al. (2008) estimate that the break-even price to offset opportunity costs for a CR would be worth half the value of an A/R CER. Indeed from the perspective of poor rural households, reducing deforestation does not present the same initial financial requirements as Afforestation/Reforestation projects (i.e. high set-up costs for distant and uncertain returns) and could therefore be achieved at a significantly lower cost. Several countries are worried by the possibility that if CRs emitted in the context of avoided deforestation are cheap, their emission might compromise the functioning of the existing flexibility mechanisms (Table 1). Cheapness is a virtue in the context of climate change (see Article 3.3 UNFCCC), as it allows deeper emission cuts to be pursued globally. However, it raises a 'chicken or egg' question. Higher emission reduction targets are needed to allow REDD credits in a regime that would not undermine existing mechanisms, and cheap emission reduction options should be available to persuade Annex 1 Parties to commit themselves to more stringent emission reduction targets (see Table 1 and UNFCCC, 2006a for mention of Annex 1 commitments).

### 3. Fund-based mechanisms

Two fund-based mechanisms were presented at the Rome Workshop. The COMIFAC proposed a fund (Fds) that would be allocated through grants, the size of which would be estimated by two components: (1) a management grant acting as an incentive to engage in sustainable forestry practices ( $MG_i$ ), and (2) a climate regulation grant ( $RG_i$ ) allocated as a function of forest area but weighted by deforestation rate (see [http://unfccc.int/files/methods\\_and\\_science/lulucf/application/pdf/060830\\_malibangar.pdf](http://unfccc.int/files/methods_and_science/lulucf/application/pdf/060830_malibangar.pdf)). The COMIFAC proposal deals with additionality by rewarding countries engaging in sustainable land-use practice. In the long run, funds would flow into countries where effective reduction in deforestation is occurring without the need for a country's commitment. The mechanism does not have any penalty but simply provides fewer financial rewards to countries that do less. In contrast with other proposals, the COMIFAC mechanism is based on forest cover and makes no attempt to convert area into related emissions. The proposal is also the only one which allows for sustainable forest management rather than forest conservation alone.

Using data from the Food and Agriculture Organization (FRA, 2005), we estimated the total forest area of Parties not included in Annex 1 ( $FA_i$ ) to be 20,763,190 km<sup>2</sup>, while Panama's forest cover ( $FA_i$ ) represents 33,645.91 km<sup>2</sup>, or 0.16% of non-Annex 1 forests (ANAM, 2003). Table 4 suggests that, for small countries like Panama, augmenting the area under sustainable forest management (SFM) is unlikely to significantly modify grant size, because the proportion of forest area under SFM is expressed as a proportion of total forest area for Parties not included in Annex 1 ( $FA_i$ ). In fact, the attribution rules of Fds would clearly benefit countries with large forest areas, as  $MG_i$  and  $RG_i$  are both expressed as fractions of  $FA_i$ . We used a hypothetical fund of US\$500 million to examine the sensitivity of the grant to be received for engaging in deforestation reduction ( $DG_i$ ) to efforts in that direction. While, under business-as-usual, Panama would receive US\$309,669 for its conservation efforts, this amount would increase to US\$810,229 if the country was able to completely halt deforestation and maintain 100% of its forests under sustainable management (Table 4). This represents merely 10% of the amount currently spent by FIDECO for PAs and is, therefore, clearly insufficient. We also estimated that only a fund of US\$5.9 billion would allow Panama to receive adequate compensation to offset the opportunity cost of deforestation. To put this figure in perspective, a recent UN study established that international funding for forestry has amounted to US\$1.1 billion over the last decade (Tomaselli, 2006). Our calculation, based on small-sized Panama, suggests that it is unlikely that sufficient money could ever be found to distribute grants to all developing countries, some of them with extensive forest cover, and allow them to offset the cost of REDD.

Brazil's proposal (see [http://unfccc.int/methods\\_and\\_science/lulucf/items/3745.php](http://unfccc.int/methods_and_science/lulucf/items/3745.php)) involves the creation of a credit and debit system that rewards countries for bringing deforestation rates under an agreed historically predetermined reference rate. The reference rate is determined based on the annual deforestation rate observed over a given period of time and would be periodically updated. This reference rate of deforestation would be used to estimate annual deforestation emissions based on agreed standard values of C in biomass. Countries would be credited with reductions in emissions from deforestation, while they would be debited if their emissions exceeded the agreed rate. The incentive given to a country would be proportional to the sum of credits and debits over a time period. In the Brazilian proposal, contribution to the REDD fund would be voluntary and would not be linked to any Annex 1 country's commitment. Thus no guarantee exists on the size of the fund, and therefore developing countries do not know whether or not a sufficient sum could indeed be obtained. The fund would be divided among participating countries as a proportion of their share in global CO<sub>2</sub> emission reductions. While the calculations to allocate

**TABLE 4** Estimated size of financial incentives obtained by Panama for REDD following the proposal of COMIFAC. In scenario 1,  $AM_i$  was set to the area of forests under protection as PAs for Panama (10,801 km<sup>2</sup>) with the current rate of deforestation (1.11%). Scenario 2 assumes that the country was able to stop deforestation ( $R_x = 0$ ) and therefore that  $FA_i$  and  $AM_i$  are equal to 33,945 km<sup>2</sup>. Areas are expressed as km<sup>2</sup>. See [http://unfccc.int/files/methods\\_and\\_science/lulucf/application/pdf/060830\\_malibangar.pdf](http://unfccc.int/files/methods_and_science/lulucf/application/pdf/060830_malibangar.pdf)

	Variables	Panama 1	Panama 2
$FA_i$ (1)	Non-Annex 1 forest area	20,763,190	20,763,190
$FA_i$ (2)	Country's forest area	33,645	33,645
$AM_i$ (3)	Country's managed forest area	10,801	33,645
$R_x$ (4)	Deforestation rate	1.11	0
$\lambda$ (5)		10	10
Fds	Fund	500,000,000	500,000,000
(2)/(1)		0.00052	0.00162
[(2)-(3)/(1)]		0.0011	0
(4)*(5)		11.1	9.8
$MG_i$	Management grant	260,109	810,229
$RG_i$	Climate grant	550,120	0
$EG_i$		49560	0
$DG_i$	Total grant	309,669	810,229

financial incentives seem simple enough, the financial incentives to be received by any country will be contingent upon the number of participating countries and their reductions. We argue that this mechanism could generate perverse incentives, since the lower the global success in reducing deforestation, the higher the CO<sub>2</sub>e price will be. Countries that invest more resources in REDD will be, in all likelihood, unable to recover their costs and will be particularly harshly penalized, while those doing nothing will have no costs and be better off. Furthermore the Brazilian proposal is fraught with potential inequity issues in ways very similar to those discussed by Santilli et al. (2005).

The Brazilian and COMIFAC proposals circumvent the difficulty of national baseline determination and the limitation of relying on a C market plagued with uncertainty. A major difficulty with these fund-based mechanisms is that no effort has been made by the proponents to identify a constant and sufficient source of funding to replenish them. However, submissions from developing countries indicate that financing is of paramount importance (Table 1). Fifteen years ago, the UN Conference on Environment and Development Secretariat estimated that US\$561.5 billion a year in new and additional resources would be needed to finance sustainable development: US\$141.9 billion of which the North would provide in Overseas Development Assistance (ODA) and US\$419.6 billion in the Southern domestic resources. This was also contained in the Agenda 21 document, Chapter 33, stating that '[t]he implementation of the huge sustainable

development programs of Agenda 21 will require the provision to developing countries of substantial new and additional financial resources'. It was agreed by all parties that this would require a much stricter adherence to the 0.7% of gross national product target established by the 1969 Pearson Report. In reality, in 2000, bilateral donors on average channelled 0.22% of GNP to development assistance (Martens, 2001). While private investment would be encouraged, aid for sustainable development was conceptualized from the very beginning as absolutely indispensable to inducing Southern cooperation on environmental issues. Framing the issue in this way proved deeply problematic because Western donors completely lacked the domestic political will to elevate aid to such levels (Parks, 2003). Developing countries have often felt betrayed and duped by the Northern refusal to honour its side of the central policy bargain (i.e. new and additional funding) (Najam, 2002).

National submissions have suggested both funds and markets as possible ways to finance REDD, with many countries emphasizing the need to identify a variety of funding sources (Table 1). The fund option and the C market are likely to operate differently and would draw resources from different sources. In the case of funds, money could come from ODA and from specific programmes of the Global Environment Facility and the World Bank: that is to say, developed countries' would supply the funds. Yet the Northern commitment to new and additional funding has never been strong, and funding has decreased in recent years, which should 'red flag' any proposal for a new fund. Conversely, the C market would be open to a vast array of buyers, from companies to governments to investment bankers. A market may be able generate more money for REDD simply because it allows for more actors to buy REDD credits, exploiting willingness to pay to a greater extent. However, as pointed out earlier, the market is characterized by uncertainty and may not be able to provide a stable source of funds for risky projects.

#### **4. Protection, transaction costs, and macro policies**

The problem to be analysed is even more complex than that depicted above. The case study with Panama so far only accounts for the opportunity cost of REDD and neglects to account for several additional costs likely to be incurred by developing countries agreeing to reduce deforestation (Grieg-Gran, 2006). If compensation payments are to be delivered for reductions in national deforestation rates, in accordance with principle of sovereignty (Table 1), it will be up to the state to devise a national plan to curb deforestation. Some resources will inevitably be consumed in this process. The costs of administration depend on the country's specific economic, institutional, legal and political arrangements. Many developing countries would probably have to incur at least three types of expenses to implement REDD measures: (1) the cost of developing alternative land-use strategies to ensure that small-scale farmers are not penalized by the avoided deforestation system, (2) the cost of protecting the territory (e.g. enforcing agreements), (3) the cost of institutional reorganization and administration.

Initiatives to reduce deforestation are unlikely to promote development and alleviate poverty (see Table 1) unless resources are successfully used to create alternative economic opportunities for deforestation's stakeholders (Potvin et al., 2007). As underlined by Niles et al. (2002), measures to prevent tropical deforestation should complement reforestation and sustainable agriculture. At the national level, in Panama, the land area allocated to intensive agricultural practices (including annual and perennial crops as well as cattle ranching) decreased by 500,000 ha between 1992 and 2000, while during that same period subsistence agriculture was practiced on 7.5%, then 10.9%, of the national territory (ANAM, 2003). A closer look at land-use trends in the provinces identified as being hot spots of deforestation (Table 2), suggests that forests are being replaced largely by subsistence

agriculture. According to the Head of Panama's Forest Service, 70% of deforestation is due to the expansion of the agricultural frontier (C. Melgarejo, personal communication). The literature has emphasized the fact that it is sometimes more cost-effective to financially compensate the stakeholders directly (Wunder, 2005). Populations living in poverty will, understandably, value the fulfilment of immediate needs such as food, shelter and water over sustainable resource management (Parks, 2003). However, a compensation system that would give peasants a one-time payment to leave the rainforest frontier, in the expectation that they will be easily re-employed in other economic sectors – despite their low level of education, in countries where rapid urbanization and unemployment are already rampant problems – is not a realistic option. At the same time, a system that would make frontier communities stewards of the forest by providing them with a constant flow of income could generate serious perverse incentives to move to the forest frontier (Wunder, 2005). Finally there exist tremendous inequalities in rights and income distribution stemming from the marginalization of many of the poorest citizens of the tropics, and this is especially true in forest areas (Chomitz, 2006). The costs of reorganizing agricultural production are hard to determine, yet we contend that if these issues are not taken into consideration, avoiding deforestation could prove a highly divisive and unpopular endeavour. Stakeholders who are asked to stop deforesting but are not given alternative activities may simply relocate their activities in another area that is not currently under deforestation pressure. Studies have shown that leakage ratios are not 1:1 (Chomitz, 2002), but we can expect leakage to be significant in cases where subsistence is at stake.

It is easier to provide a cost estimate for the other costs. In the case of Panama, we estimated the cost of protection to US\$7.40/ha per year (Oestreicher et al., unpublished) based on the assumption that protection requires three guards per 100 km<sup>2</sup> (Bruner et al., 2001). Over the 25-year horizon, direct spending for protection of the forest and its C stocks would represent a total sum of US\$12,025,000, or an average yearly cost of US\$481,000. Little know-how exists for estimating transaction costs for REDD projects, but the costs of developing methodologies and installing the monitoring system for the 643,667 ha of the Noel Kempf Climate Action Project were reported to be US\$1,079,667 (Winrock, 2002). The cost of baseline establishment was around US\$20,000. Monitoring deforestation in subsequent years should be around US\$39,000 (every 2 years), as plot monitoring has been estimated to cost around US\$130 per plot every two years, with 300 plots needed and remote sensing over 5 years costing around US\$50,000 (J. Seifert-Ganzin, personal communication). In Panama, Coomes et al. (2008) estimated the transaction cost of a planned REDD project of 600 ha to be US\$50,000. Depending on the project size and on the variability in biomass, one can therefore envision transaction costs ranging between US\$2.00 and US\$90.00 per hectare. These transaction costs would be likely to increase if the C was traded as part of an UNFCCC trading market (P. Moura-Costa, personal communication).

A REDD system compensating stakeholders for preserving forest cover could be similar to existing payment for environmental services (PES). Administrative cost estimates from PES schemes in Costa Rica amount to 12–18% of the total contract size (Grieg-Gran, 2006). Based on the Costa Rican estimate, this would amount to an administrative cost of US\$3.00/ha. In a study on the feasibility of PES for the Panama Canal Watershed, a similar figure of 10% was proposed (Louis Berger Group, 2006). Using our earlier estimates for land use of US\$735.72 (NPV, discount rate 5%), we estimate the total amount necessary to offset opportunity costs to be more than US\$90 million and administration costs to be more than US\$9 million. Therefore, the cost that Panama must contemplate in order to engage in REDD of 5,000 ha is close to US\$115 million over a 25-year period (Table 5) to cover the opportunity and protection costs as well as administration and transaction costs. This represents an increase of close to 25% above the break-even opportunity cost alone. These numbers are significant, as much of these expenses are fixed costs that will have to be borne up-front by developing countries.

**TABLE 5** Overall cost estimates to avoid deforesting 5,000 ha per year in Panama for 25 years. The land-use opportunity costs were calculated as the net present value of land, 5% discount rate, using small-scale cattle ranching as the most attractive land use

Year	Yearly costs	
1	Land opportunity cost	US\$3,678,594
1	Cost of protection	US\$481,000
1	Transaction cost	US\$10,000
1	Cost of administration	US\$416,959
25	Total 25 years	US\$114,663,825

An earlier analysis reported a potential income in developing countries from preventing deforestation (Niles et al., 2002). Their analysis predicted an income of US\$157.1 million (NPV, 3% discount rate) for a reduction of deforestation of 12,800 ha in Panama, leading the authors to the optimistic conclusion that land-use changes could provide an interesting income for developing countries. What are the differences between the estimates of Niles et al. (2002) and the present estimate? First, Niles et al. (2002) did not estimate the opportunity costs of land use nor the ancillary costs detailed above, ignoring the economic benefits derived from the conversion of forest into pasture or agricultural land and the enforcement costs of reducing deforestation. Furthermore, Niles et al. (2002) estimated their hypothetical income based on a fixed value of C, set at US\$10.00 per tonne, ignoring the fluctuation in C price, and hence the risk taken by countries engaging in REDD. The economic aspects of REDD are clearly more complicated than previously envisaged, as developing country decision-makers view the reality as a cost-benefit analysis where the right to fulfil development goals is a priority (Table 1).

## 5. Conclusion: What remains to be done?

The financial mechanism that will be adopted globally must allow countries to use both micro- and macro- instruments to reach their REDD objective. Our study suggests that none of the mechanisms proposed to date can provide the necessary financial incentives and flexibility to stimulate action. Article 4.3 of the UNFCCC states that developing countries should count with 'adequacy and predictability in the flow of funds' regarding the commitment, as defined in Article 12.1. Thus, all the proposed mechanisms fail to take into account the *modus operandi* of the UNFCCC. In order to have a real effect on deforestation emissions, the chosen financial mechanism will have to find a compromise between donor requirements and developing country needs. A very restrictive (binding) mechanism that involves high transaction costs will not draw many participants and will not significantly reduce emissions from deforestation, whereas too lax a mechanism will generate unacceptable levels of 'hot air'.

The financial aspects of REDD need to be resolved. Our analysis emphasizes the high fixed costs, hence risk, taken by developing countries who engage in REDD at the national scale. Advances in monitoring technology have made it possible to develop a system based on conditionality in payments for the global service of reducing emissions from deforestation but, just as in any

innovative venture, large investments and reforms need to be undertaken to put the initiative on its feet; and this involves risks. We emphasize that a C market might be neither sufficient in size nor sufficiently secure to stimulate REDD action. At the same time, the proposals based on funds do not address replenishment, making them even more insecure than market-based approaches. Alternative financial options must urgently be identified to give credibility to the ongoing efforts aimed at reducing emissions from deforestation in developing countries. For example, allowing for market approaches at the project level might provide an alternative solution, since costs would be paid by private investors rather than, or in addition to, the government. The possibility of using the Adaptation Fund (Yamin and Depledge, 2004) as a model to design a fund linking a REDD mechanism to other flexibility mechanisms, such as Emissions Trading and Joint Implementation, should be explored. Creating a fee on C-intensive commodities and services is a possibility that has been mentioned by some countries (Table 1). Moreover, if market-based approaches were linked to increased emission reduction targets for Annex 1 countries, this could create a stronger incentive for buyers and sellers to invest in REDD (Table 1). The possibility of basing a mechanism on both market and funds and of acting in conjunction with conservation targets should be explored, bearing in mind that decision-makers from developing countries will probably base their decision to take part in a REDD mechanism not only on the potential economic benefits but also on the political and financial risks likely to be incurred.

Finally, in their submissions, several developing countries highlight the need for *a priori* funding (Table 1). Significant start-up investments will be required if developing countries are to understand the deforestation process taking place in their respective countries and are able to identify the best possible way to deal with the problem. According to Santilli et al. (2005), *a priori* or up-front financing could come from the sale of options on future markets for CRs. However when it comes to including future contracts on CO<sub>2</sub> emissions reductions that have not yet been generated, it is unlikely that funds will be available on a sufficient scale for the prospective and very risky market for credits from REDD (Ebeling, 2006). If mechanisms based on a fund are retained in the negotiation, the success of the regime will probably depend on the existence of a capacity-building fund allowing countries to prepare their national avoided deforestation action plan.

## Acknowledgements

This article was made possible by the constant support of the civil servants of ANAM especially E. Reyes, as well as C. Melgarejo, D. Martinez and Edgar Salinas. We are most grateful for the opportunity that we had to discuss all of these ideas with them. Discussions with M. Estrada Porrua were also fundamental. Comments from two anonymous reviewers were helpful. We are grateful to Jordan Oestreicher for her careful proof-reading of the manuscript in its final stage. We acknowledge support by the Office National Des Forêts International (France) and Coopération Suisse for supporting the 'Grupo Latino Americano de discussion sobre cambios climaticos', which allowed us to have discussions on a regular basis with delegates from other Latin American countries. Financial support to attend UNFCCC meetings was provided by ANAM, the Faculty of Science of McGill University, and the Smithsonian Tropical Research Institute.

## References

- Achard, F., Belward, A.S., Eva, H.D., Frederici, S., Mollicone, D., Raes, F., 2005, 'Accounting for avoided conversion of intact and non-intact forests', in: *Technical Option and a Proposal for a Policy Tool*, Montréal, 2005, EU Joint Research Group Side Event, COP-11.



- ANAM, 2003, *Informe final de resultados de la cobertura boscosa y uso del suelo de la Republica de Panama: 1992-2000*, ANAM, 107.
- ANAM, 2006, *Estado de la Gestión Compartida de Áreas Protegidas en Panamá*, IUCN.
- Auckland, L., Moura-Costa P., Brown S., 2003, 'A conceptual framework and its application for addressing leakage: the case of avoided deforestation', *Climate Policy* 3, 123–136.
- Barzev, R., 2006, *Programa multifase de desarrollo sostenible de Bocas del Toro autoridad nacional del ambiente*, Segundo Informe de Avances, 15 August, ANAM.
- Brown, S., Hall, M., Andrasko, K., Ruiz, F., Marzoli, W., Guerrero, G., Masera, O., Dushku, A., DeJong, B., Cornell, J., 2007, 'Baselines for land-use change in the tropics: application to avoided deforestation projects', *Mitigation and Adaptation Strategies for Global Change* 12(6), 1001–1026.
- Bruner, A.G., Gullison, R.E., Rice, R.E., da Fonseca, G.A.B., 2001, 'Effectiveness of parks in protecting tropical biodiversity', *Science* 291, 125–128.
- Chomitz, K., 2002, 'Baselines, leakage and measurement issues: how do energy and forestry projects compare?', *Climate Policy* 2(1), 35–49.
- Chomitz, K., 2006, *At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests*, World Bank Policy Research Report, Washington, DC.
- Coomes, O.T., Grimard, F., Potvin, C., Sima, P., 2008, 'The fate of tropical forests: cows or carbon?', *Ecological Economics* 64.
- Contraloría General de la República de Panamá (ed.), 2006, 'Ejecución presupuestaria 2005', In: *Informe del Contralor General de la República 2005*, Panama.
- DeFries, R.S., Houghton, R.A., Hansen, M.C., Field, C.B., Skole, D., Townshend, J., 2002, 'Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 1990s', *Proceedings of the National Academy of Sciences of the USA* 99, 14256–14261.
- Ebeling, J., 2006, 'Tropical deforestation and climate change: towards an international mitigation strategy', dissertation for the degree of MSc., University of Oxford, Oxford, 8–85.
- FRA, 2005, *Global Forest Resources Assessment 2005*, Food and Agriculture Organization [available at [www.fao.org/forestry/fra2005](http://www.fao.org/forestry/fra2005)].
- Grieg-Gran, M., 2006, *The Cost of Avoiding Deforestation*, Report for the Stern Review of the Economics of Climate Change, London, International Institute for Environment and Development.
- Houghton, R.A., 2005, 'Aboveground forest biomass and the global carbon balance', *Global Change Biology* 11(6), 945–958.
- Kelly, R., 2007, *Carbon Sequestration Projects*, UNDP MDG Carbon Facility, Bio Carbon Certification Course, Panama, 15–20 October.
- Kirby, K., 2005, *Land-use change in the Neotropics: regional-scale predictors of deforestation and local effects on carbon storage and tree-species diversity*. MSc thesis, Department of Biology, Neotropical Environments Option, McGill University, Montreal.
- Lambin, E.F., Geist, H.J., Lepers, E., 2003, 'Dynamics of land-use and land-cover change in tropical regions', *Annual Review of Environment and Resources* 28, 205–241.
- Louis Berger Group, 2006, *Establecimiento de un mecanismo financiero para pago por servicios ambientales (PSA) en la cuenca hidografica del Canal de Panama*. Informe final, 18 September.
- Mather, A.S., 1992, 'The forest transition', *AREA-Institute of British Geographers* 24(4), 367–379.
- Martens, J., 2001, *Rethinking ODA: Towards a Renewal of Official Development Assistance*, Background paper for the United Nations Financing for Development Process, Heinrich Boell Foundation.
- Najam, A., 2002, 'Unravelling the Rio bargain', *Politics and the Life Sciences* 21(2) [available at <http://www.bsos.umd.edu/harrison/SymposiumII.pdf>].
- Niles, J.O., Brown, S., Pretty, J., Ball, A.S., Fay, J., 2002, 'Potential carbon mitigation and income in developing countries from changes in use and management of agriculture and forest lands', *Philosophical Transactions of the Royal Society London Series A* 360, 1621–1639.
- Parks, B.C., 2003, *To the aid of the environment? a preliminary exploration of recipient-level factors determining bilateral 'green' aid allocation*, Honours thesis for the degree of BA, College of William and Mary, Williamsburg, VA.
- Pedroni, L., 2005, 'Carbon accounting for sinks in the CDM after CoP-9', *Climate Policy* 5, 407–419.
- Potvin, C., Coomes, O.T., Grimard, F., 2007, 'Will RED work where it should?', *Science* 10 July [available at [www.sciencemag.org/cgi/eletters/316/5827/985](http://www.sciencemag.org/cgi/eletters/316/5827/985)].

- Rudel, T.K., Coomes, O.T., Moran, E., Achard, F., Angelsen, A., Xu, J., Lambin, E., 2005, 'Forest transitions: towards a global understanding of land use change', *Global Environmental Change A* 15(1), 23–31.
- Santilli, M., Moutinho, P., Schwartzman, S., Nepstad, D., Curran, L., Nobre, C., 2005, 'Tropical deforestation and the Kyoto Protocol', *Climatic Change* 71, 267–276.
- Skutsch, M., Bird, N., Trines, E., Dutschke, M., Frumhoff, P., de Jong, B.H.J., van Laake, P., Masera, O., Murdiyarto, D., 2008, 'Clearing the way for reducing emissions from tropical deforestation', *Environmental Science and Policy* 11, [available at [www.utwente.nl/cstm/staff/cv/skutsch.doc](http://www.utwente.nl/cstm/staff/cv/skutsch.doc)].
- Stocker, T.F., Clarke, G.K.C., Treut, H.L., Lindzen, R.S., Meleshko, V.P., Mugara, R.K., Palmer, T.N., Pierrehumbert, R.T., Sellers, P.J., Trenberth, K.E., Willebrand, J., 2001, 'Physical climate processes and feedbacks', in: S. Manabe, P. Mason, P. (eds), *Climate Change 2001: The Scientific Basis* [available at [www.ipcc.ch/ipccreports/tar/wg1/260.htm](http://www.ipcc.ch/ipccreports/tar/wg1/260.htm)].
- Tomaselli, I., 2006, 'Brief study on funding and finance for forestry and forest based sector', in: *United Nations Forum on Forests*.
- UNFCCC, 2006a, *Issues Related to Reducing Emissions from Deforestation in Developing Countries and Recommendation on any Further Process*, FCCC/SBSTA/2006/MISC.5, 24th session, item 6 of the provisional agenda, Submissions from Parties, UNFCCC Subsidiary Body for Scientific and Technological Advice, Bonn.
- UNFCCC, 2006b, *Issues Related to Reducing Emissions from Deforestation in Developing Countries and Recommendation on any Further Process: Addendum*, FCCC/SBSTA/2006/MISC.5 A1, 24th session, item 6 of the provisional agenda, Submission from Parties, UNFCCC Subsidiary Body for Scientific and Technological Advice, Bonn.
- Winrock International, 2002, *2001 Analysis of Leakage, Baselines, and Carbon Benefits for the Noel Kempff Climate Action Project*, Report prepared for the Nature Conservancy.
- Wunder, S., 2005, *Payment for Environmental Services: Some Nuts and Bolts*, CIFOR Occasional Paper No. 42, Center for International Forestry Research (CIFOR), Bogor, Indonesia.
- Yamin, F., Depledge, J., 2004, *The International Climate Change Regime: A Guide to Rules, Institutions and Procedures*, Cambridge University Press, Cambridge, UK.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.