3. Economics of Avoiding Deforestation

Ewald Rametsteiner, Michael Obersteiner, Georg Kindermann, Brent Sohngen

Introduction

Deforestation is considered the second largest source of greenhouse gas emissions (IPCC 2007) and is expected to remain a major emission source. The deforestation issue has been at the centre of the international environmental debate for two decades. Yet, despite a large number of studies, commitments, initiatives and strategy papers, this activity has had little impact on deforestation rates: deforestation continues at a rate of about 13 million ha per year (FAO 2006). Apart from the loss of carbon, deforestation typically is associated with *inter alia* loss of biodiversity, disturbed water regulation and the destruction of livelihoods for many of the world's poorest (Williams 2003).

Government and non-governmental attempts to slow down, or even reverse, current trends of disappearing forests have not been successful as the result of many pressures, both local and international. While the more direct causes are rather well established as being agricultural expansion, infrastructure extension and wood extraction (Geist and Lambin 2002, Angelsen and Kaimowitz 1999, Schaeffer et al 2005), indirect drivers of deforestation are made up of a complex web of interlinked and place-specific factors, as described in the introduction of this volume.

Some see a glimmer of hope for more effective policies with the rise of innovative financial mechanisms under a global climate policy regime (Fearnside 2006, Schulze et al. 2003, Persson and Azar 2006, Moutinho et al. 2006, Gullison et al., 2007). Indeed, in 2005, Papua New Guinea proposed to the UNFCCC that carbon credits be provided to protect existing native forests[1]. The proposal triggered a flurry of discussion on the topic. The potential for synergies between forest and carbon policies is quite substantial. For instance, Soares-Filho et al. (2006) suggest that protecting around 130 million hectares of land from deforestation in the tropical Amazon could reduce global carbon emissions by 17 GtC over the next 50 years.

Official international discussions were initiated at the United Nations Framework Convention on Climate Change (UNFCCC) 11th Conference of Parties (COP) on the issue of reducing emissions from deforestation and degradation (REDD) in developing countries (UNFCCC, 2005). At COP-11 the UNFCCC launched a process for investigating the technical issues surrounding the feasibility of reducing greenhouse gas (GHG) emissions from deforestation. At the Bali United Nations Framework Convention on Climate Change meetings (UNFCCC) in December 2007, two processes were agreed in the negotiations to progress work on deforestation issues; including undertaking "a programme of work on methodological issues related to a range of policy approaches and positive incentives that aim to reduce emissions from deforestation and forest degradation in developing countries …" (see Decision – CP.13) and consideration of "policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation (REDD) in developing countries" (see Decision -CP.13 Bali Action Plan);

---

[1] FCCC/CD/2005?misc.1 11 November 2005.

What is unclear, however, is how much it would cost to achieve a substantial reduction of deforestation, and which types of policies could be most effective. There are two basic options available to influence behavior towards avoiding deforestation through financial mechanisms. One is to enhance the value of the existing forest through financial support for keeping the forest carbon stock, to be paid in certain time intervals. The other is to reduce the value of deforestation by increasing costs through taxing land conversion and thereby emissions from deforestation, e. g. through a land clearance tax and wood sales taxes.

In this chapter we use scenario modeling approaches to assess the costs of reducing global deforestation and examine the two different financial mechanisms to combat deforestation. In the first, the incentives-based mechanism, forest owners are benefiting from retaining forest biomass through periodically receiving a carbon price for the carbon stored in the standing forest biomass, e.g. a through a 'compensation' contract which is issued to known deforestation agents ex ante. In the second, the tax-based mechanism, a carbon price has to be paid for releasing the stored carbon to the atmosphere, through a 'tax'-type payment which is assumed to be enforceable by an impartial agency only ex post.

Methods

We use a spatially explicit biophysical and socio-economic land use model (Kindermann et al. 2006), mainly based on the global afforestation model of Benitez and Obersteiner (2006). Land use changes are simulated in the model as a decision based on a difference between net present value of income from production on agricultural land versus net present value of income from forest products. The impact of economic incentives to reduce deforestation is then calculated by comparing shifts in net present values (NPV) of competing forms of land use to existing forest land. Assuming fixed technology, the model calculates for each 0.5◦ grid cell the net present value difference between agricultural and forest land-uses in one-year time steps. Key model parameters, such as agricultural land use and production, population growth, deforestation and forest product consumption rates were calibrated against historical rates. The model results are annual, spatially explicit estimates of the forest area and biomass development from 2000 to 2100, with particular focus on the period 2006 to 2025.

The net present value of forestry is mainly driven by planting costs, income from carbon sequestration, wood increment, rotation period length, discount rates, planting costs wood prices (fuelwood and timber), and, to some extent, ancilliary benefits from forests. Main drivers for the net present value of agriculture on current forest land are population density, agricultural suitability and risk adjusted discount rates. These two values are compared against each other and, assuming profit maximizing behavior by the owners, deforestation is subsequently predicted to occur in the base scenario when the agricultural value exceeds the forest value by a certain margin. The speed of deforestation itself is in turn constrained by a range of factors, in particular regional forest share, agricultural suitability, population density and economic wealth of the country. For our scenarios the maximum possible deforestation is set to 5% of the total land area per year in a certain location. That means, an area of about 50 ×50 km covered totally with forests can not be deforested in a shorter time period than 20 years.

To estimate the impact of financial incentives to reduce deforestation we calculate differences in net present value of different land uses. When carbon market prices, transferred through a financial mechanism, balance out differences between the net present value of agricultural land and forest-related income, it is assumed, given profit maximising behavior, that deforestation is avoided. As said, the net present value difference of forest versus other land uses can be balanced out through two mechanisms. One is to reduce the difference by adding costs to conversion through taxing emissions from deforestation, e. g. through a land clearance tax and wood sales taxes. The other is to enhance the value of the existing forest by financial support when keeping the forest carbon stock, to be paid in certain time intervals. In principle, such payments to avoid emissions from deforestation can be transferred to cover all of the globe's forests, they can target to large "deforestation regions" or small areas. The approach taken here is to focus money transfers to those regions where a change in biomass takes place or is foreseen to take place.

The value of forest carbon stock was assumed to be pegged to carbon market prices and the incentives examined are within the range of recently observed carbon prices such as for Certified Emission Reduction (CER) Units within the Clean Development Mechanism (CDM), i.e. 0–50 US$/tC. The modeling results for different hypothetical tax or subsidy levels show the potential magnitude of avoided deforestation through financial incentive or disincentive mechanisms. The carbon price represents the effective benefit which will directly go to the forest owner. Different levels of transaction costs are considered, based on the governance indicators data collected by the World Bank on "political stability", "government effectiveness" and "control of corruption" (World Bank 2007).

Costs of cutting deforestation in half

Based on the above, the model results estimate baseline deforestation without economic incentives close to 212 million ha or around 5% of today's forest area between 2006 and 2025, resulting in a release of some 17.5 GtC. The maximum allowable base-line deforestation rates were estimated statistically using forest share, agricultural suitability, population density and economic wealth as independent variables. Sub-Saharan Africa is modeled to be responsible for about 50% of global deforestation emissions over the coming 20 years, while Latin America contributes 35% and Asia 12% respectively (Table 1 and Figure 1).

When aiming to reduce the deforestation rate by, say, 50% until 2025, an arbitrarily chosen reduction rate and year, the model calculation results show that financial resources required to balance out net present value differences on exactly those forests that would otherwise be converted to rise from some US$0.16 bn in 2006 to US$2.9 bn in 2025 due to increasing geographic coverage of the carbon incentive scheme. The lack of precise information on areas that are about to be cut and a range of monitoring and administrative difficulties between parties involved make it impossible to design a perfectly targeted instrument. In the contrarian case of complete absence of information on deforestation pressure, a global forest carbon conservation program aiming at avoiding half of baseline deforestation would require financial resources in the much higher order of US$197 bn in 2006 and US$188 bn in 2025 (i.e. on average US$6/tC/5years (Table 1)). More realistic assumptions of targeted payments to identifiable deforestation agents in areas of high deforestation pressure would cut average annual cost to an estimated US$33.5 bn per year. This large difference in costs indicates the magnitude of costs to be saved by designing targeted incentive schemes.

Carbon tax schemes do not suffer as much from an information problem, as global earth observation systems can detect deforestation with some reliability already today. In tax scenarios, e.g. simulated introduction of a forest clearance tax, an average carbon tax of

US$9/tC would reduce emissions from deforestation by half if we assume deforestation by slash and burn. If the carbon from the harvested wood is assumed to be temporarily sequestered in a timber products pool, a timber sales tax of US$25/tC would have a similar effect. In practice these two taxes would be additional, i. e. a timber sales tax on top of a land clearance tax. Revenues from such carbon taxes on deforestation would result in annual revenues in the magnitude of US$5.9 bn in 2006 declining to US$4.2 bn in 2025 (Table 1 and Figure 1). Results from the scenario analysis show that almost independent of the financial mechanism (incentive payments or tax), more than half (53%) of the forest carbon would be saved in sub Sahara Africa 30% in Latin America and 16% in Asia.

Table 1 about here

The "Deforestation Baseline" in Table 1 shows the amount of forest biomass (GtC) lost through deforestation over the coming 20 years. Incentive payment and Carbon tax give the amount of avoided deforestation in GtC per 20years at the price/tax levels indicated. Slash-burn and timber sales assume that 100% of the biomass will either be burned on the spot or a harvested wood products pool respectively. Sale/burn is a more realistic and geographically differentiated combination of slash-burn and the wood products pool. The share is region specific, based on empirical evidence of region-specific deforestation drivers (FAO 2006, Geist and Lambin 2002).

Figure 1 about here

The upper figure in Figure 1 shows the geography of baseline deforestation up to 2025 assuming no carbon policy (no incentive payments, no tax) and the lower figure illustrates the carbon saved assuming a carbon tax of US$12/tC on deforestation. The lower figure shows that large areas could be saved from deforestation if a carbon price of US$12/tC is introduced, which would in effect cut deforestation in half .

Funding sources and tailored funding mechanisms

The model calculates that incentive payments needed to cut deforestation in half would require annual payments of at least US$33.5 billion. This would require funds that are more than double the total annual global investment in forestry, currently estimated at around US$18 bn (Tomaselli 2006). Only a small fraction of the current investment in forestry is non-domestic, i.e. private foreign direct investment or official development assistance (ODA) or official aid (OA). According to the United Nations on Trade and Development (UNCTAD, 2005), the worldwide foreign direct investment (FDI) in agriculture, forestry, hunting and fishing activities combined reached US$ 1.8 billion in the period 2001-03, i.e. US$ 600 million per year, most of which is dedicated to agriculture. Recent data from the Organisation for Economic Cooperation and Development (OECD, 2005) on the total ODA/OA commitments to forestry by OECD countries and multilateral agencies shows an annual average commitment to forestry of US$ 564 million between 1996-2004. Even if all current FDI and ODA funding for forestry combined would be redirected to reduce emissions from deforestation, this would reach only around 3.5% of the funding required to cut emissions from deforestation in half while around 40% of all ODA would be needed to achieve the same goal.

Financing "Avoided Deforestation" through the Clean Development Mechanism (CDM) or other climate policy related financing mechanisms seem unlikely to be sufficient to convince deforestation agents and their respective governments to curb deforestation. In fact, given current realpolitik, international financial flows are likely to remain below 10% of the US$33.5 bn needed to cut deforestation in half in the foreseeable future. For instance, in 2005 the overall value of the global aggregated carbon markets was estimated at over US$10 billion. Around 93.5 MtC (342 million tCO_2e), mainly of Certified Emissions Reductions (CERs), were transacted at a value of US$2.7 billion (with an average price of around US$1.8/tC (US$ 7.23/tCO_2e) in the same year)[2] (Capoor and Ambrosi 2006). Thus, even if half of the funds generated through CERs had been earmarked to avoid deforestation it would have covered less than 10% required to cut deforestation by the arbitrary figure of 50%.

It becomes apparent that existing international sources and mechanisms, including carbon trading, can only contribute to a limited extent to fund avoided deforestation. Thus, contrary to the expectations of many in the policy debate, climate policy will not be THE silver bullet that solves the deforestation problem. A wide range of existing and new instruments is needed, both international and domestic (Table 2). Given the magnitude of funding required compared to existing funding it is unlikely that the financial resources needed could be mobilized through the current international ODA system or that alternative international funding sources could be quickly identified and mechanisms established. Given that domestic investments are a magnitude higher than international investment flows in forestry, it seems that "bailout" hopes should not be pinned on international financial mechanisms– or at least not on the international mechanisms alone. Possibly the most important share of financial resources will have to be generated first and foremost from domestic sources. Obviously, developing countries cannot be expected to generate sufficient funding alone, particularly in Africa and parts of Asia. International funding will be needed, particularly to develop and support national mechanisms.

Table 2 about here

Domestic financial incentives need to be based on programs that target and are adjusted to diverse and often small-scale local and regional deforestation and forest degradation contexts. Such incentives need to address and reach people that drive forest cover changes because of subsistence needs such as food, energy or living space, be it legal or unauthorized. Decentralized and smaller-scale redistributive financial mechanisms that work on a national and sub-national scale and are supported through international funds pose many problems, including transaction costs and leakage of funds. However, a large pool of experience is available on how to address small-scale diversity and needs, such as through micro-finance infrastructures and payments for environmental services of forests (Maynard and Paquin 2004, Pagiola et al. 2005, see also section III).

Existing international incentive channels, including bilateral and multilateral ODA and specific funds, such as the GEF Trust Fund, can be used to fund baskets of national measures aimed to address local and regional drivers of deforestation. If the annual amount of total ODA spent on forestry were tripled from 2004 levels to US$1.6 billion, i.e. from 0.7% to

[2] European Union Allowances (EUAs) worth US$8.2 billion traded in 2005, which corresponded to 322 million tons of carbon dioxide equivalent (tCO2e).

2.1% of total annual ODA, the model calculates that this would result in 1.7GtC of saved carbon corresponding to an area avoided from deforestation of 26.5 million ha. In addition, existing and emerging carbon credit based transfer schemes with appropriate rules to channel funds from larger-scale (e.g. CDM-type) projects towards avoided deforestation could emerge, given appropriate policy signals (Victor et al. 2005).

Tax-type payments based on international agreements seem to be difficult to negotiate now and in the future. On the domestic (national) level, redistributive financial mechanisms, such as taxing land clearance and timber sales in combination with earmarked re-routing of revenues to promote financing of forest conservation and sustainable forest management programs, might turn out to be the most effective policy instrument to address deforestation. Given that in practice the by far largest part of forests is government-owned (FAO 2006), domestic taxes such as land clearance tax or timber sales taxes can be set up through voluntary budget allocation and balance mechanisms within different levels of government. In addition, tax income from private land clearance and timber sales could be channeled back to support keeping other forests to remain or targeted at the roots of deforestation.

Conclusion

Reducing emissions from deforestation, a major source of CO_2, could potentially be a highly cost-effective option for climate policy. Comparatively low amounts of financial flows could save millions of hectares from deforestation. Equally important is that, if appropriately spent, such financial flows would be a highly welcome tool to help reduce poverty by improving livelihoods of some of the hundreds of millions forest-dependent people in the developing world and secure many of the forests' ecosystem services. However, it appears that only a fraction of the funding needed, estimated in the magnitude of US$33 billion per year, can be realized in the context of climate policies. A basket of financial mechanisms will be needed to properly address the avoided deforestation challenge.

References

Angelsen A. and Kaimowitz D. 1999. Rethinking the Causes of Deforestation: Lessons from Economic Models; The World Bank Research Observer, vol. 14 No. 1, IBRD/World Bank pp. 73-98

Benítez P. C, Obersteiner M. 2006. Site identification for carbon sequestration in Latin America: A grid–based economic approach. Forest Policy and Economics 2006, 8:636-651.

Capoor K., Ambrosi P. 2006. State and Trends of the Carbon Market 2006, World Bank and International Emissions Trading Association, Washington D.C.

FAO 2006. Global Forest Resources Assessment 2005 Progress towards sustainable forest management; FAO Forestry Paper 147; Food and Agriculture Organization of the United Nations Rome

Fearnside P. M., 2006. in *Emerging Threats to Tropical Forests*, W. F. Laurance, C. A. Peres, Eds. (Univ. of Chicago Press, Chicago, Il, in press). Cited in Fearnside P.M. 2006. Tropical Deforestation and Global Warming; Letters, *Science* 26 May 2006: Vol. 312. no. 5777, p. 1137

Geist H. J. and Lambin E. F. 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation February 2002 / Vol. 52 No. 2 • BioScience pp. 143-150

Gullison, R.E, P.C. Frumhoff, J.G. Canadell,C.B. Field, D.C. Nepstad, K. Hayhoe, R. Avissar, L.M. Curran, P. Friedlingstein, C.D. Jones, C. Nobre. 2007. Tropical Forests and Climate Policy. *Science*. 316:985-986.

IPCC. 2007. Climate Change: Synthesis Report, Intergovernmental Panel on Climate Change. Cambridge University Press.

Kindermann G., Obersteiner M., Rametsteiner E., McCallum I. 2006. Predicting the deforestation-trend under different carbon-prices; Carbon Balance and Management 2006, 1:15

Mayrand K., Paquin M. 2004. Payments for Environmental Services: A Survey and Assessment of Current Schemes. By Unisféra International Centre For the Commission for Environmental Cooperation of North America Montreal, September 2004

Moutinho, P., Santilli, M., Schwartzman, S. and Rodrigues, L. 2006. Why ignore tropical deforestation? A proposal for including forest conservation in the Kyoto Protocol. Unasylva. Submitted.

OECD 2005: OECD Journal on Development Development Co-operation - 2005 Report - Efforts and Policies of the Members of the Development Assistance Committee Volume 7 Issue 1, Organization for Economic Co-operation and Development, Paris

Pagiola, S., Arcenas A, Platais G. 2005. "Can Payments for Environmental Services Help Reduce Poverty? An Exploration of the Issues and the Evidence to Date from Latin America," World Development, Elsevier, vol. 33(2), pages 237-253, February.

Persson, U.M., and Azar C. 2006. Tropical Deforestation in a Future International Climate Policy Regime - lessons from the Brazilian Amazon. Environmental Conservation. Submitted

Schaeffer R., Rodrigues R. L. V.; Laurance W.F., Albernaz A. K. M., Fearnside P.M., Vasconcelos H. L., Ferreira L. V. 2005. Underlying Causes of Deforestation; Science 18 February 2005: 1046-1047

Schulze E.D., Mollicone D., Achard F., Matteucci G., Federici S., Hugh D. E., Valentini R. 2003. Climate Change: Making Deforestation Pay Under the Kyoto Protocol? Policy Forum; *Science* 14 March 2003: Vol. 299. no. 5613, p. 1669 (15) Capoor K., Ambrosi P. 2006. State and Trends of the Carbon Market 2006, World Bank and International Emissions Trading Association, Washington D.C.

Soares-Filho, B.S., Nepstad D.C., Curran L.M., Cerqueira G.C., Garcia R.A., Ramos C.A., Voll E., McDonald A., Lefebvre P. and Schlesinger P., 2006. Modelling conservation in the Amazon basin. Nature 440, 520-523.

Sohngen B, Mendelsohn R., 2003. An optimal control model of forest carbon sequestration. Am. J. Agric. Econ. 85(2), 448-457.

Tomaselli I. 2006. Brief Study on Funding and Finance for forestry and Forest-based Sector; Report to the United Nations Forum on Forests Secretariat, United Nations, New York

UNCTAD. United Nations Conference on Trade and Development. 2005. World Investment Report 2005. New York and Geneva.

Viktor D.G., House J.C., Joy S.. 2005. A Madisonian Approach to Climate Policy; Science Policy Forum. 16. September 2005. Vol. 309, p. 1820-1821.

Williams M. 2003. Deforesting the Earth – from Prehistory to Global Crisis, The University of Chicago Press, Chicago, 2003.

World Bank 2007. Governance matters 2007. Worldwide Governance Indicators: 1996-2006. The World Bank, Washington D.C.

Tables and Figures

Table 1: Scenarios of forest biomass saved according to financial mechanism.

Region	Deforestation Baseline	Incentive payment US$6/tC/5yr	Carbon tax US$9/tC (slash-burn)	Carbon tax US$25/tC (timber sales)	Carbon tax US$12/tC (sale/burn)
	GtC Deforested	GtC saved in 20 Years			
Pacific	0.00	0.00	0.00	0.00	0.00
Caribbean	0.02	0.02	0.01	0.02	0.01
Europe	0.02	0.00	0.00	0.00	0.02
Asia	2.19	1.49	1.50	1.41	1.32
Australia	0.22	0.06	0.03	0.12	0.17
Latin America	6.22	2.75	2.55	2.65	3.02
North America	0.04	0.00	0.00	0.00	0.00
Sub Saharan Africa	8.82	4.90	4.77	4.67	4.08
North Africa	0.00	0.00	0.00	0.00	0.00
Sum	17.54	9.22	8.86	8.85	8.63

Figure 1: Carbon loss and avoided carbon loss in forests caused by deforestation until 2025

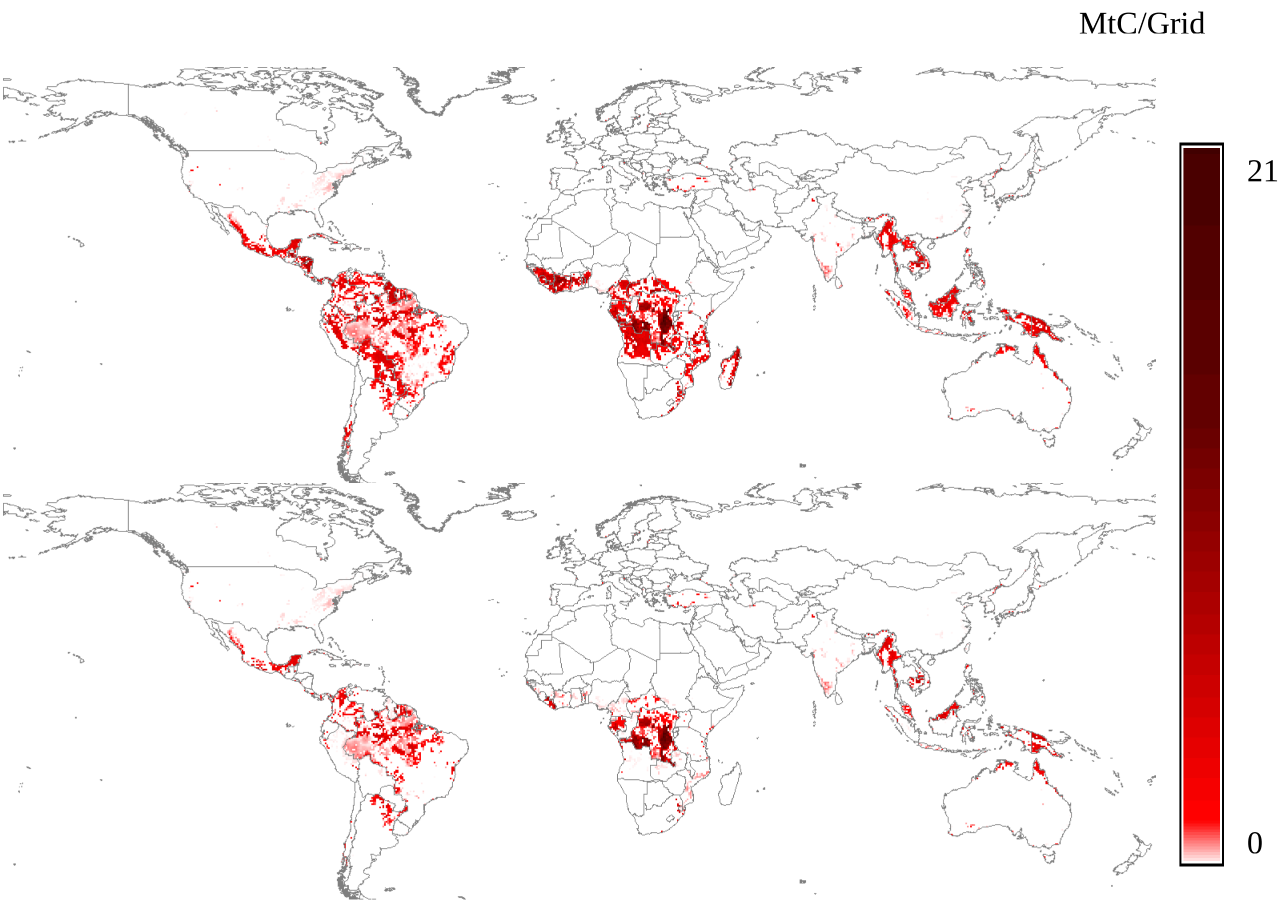

Table 2: Domestic and international financial policy instruments targeting deforestation. Incentive type instruments provide greenhouse gas (GHG) related revenues while tax-type instruments would create costs to potential deforestation agents.

	Incentives type	**Tax type**
International funding	• ODA funding support to national "avoided deforestation" policies • Carbon credits trading	• International agreements: payment above negotiated "accepted" deforestation rates
Domestic funding	• "Avoided deforestation" policies financed through subsidies • Redistributive budget schemes • Environmental services payment	• Land clearance tax • Timber sales tax • Non-renewable energy tax • Emission tax