The Financial Costs of REDD:

Evidence from Brazil and Indonesia

Nathalie Olsen and Joshua Bishop

Full report

RioTinto

About IUCN

This publication has been made possible by funding from Rio Tinto

Published by: IUCN, Gland, Switzerland

Citation: Olsen, N. and J. Bishop (2009). The Financial Costs of REDD: Evidence from Brazil and Indonesia. Gland, Switzerland: IUCN. 64pp.

ISBN: 978-2-8317-1206-2

Acknowledgements: Special thanks go to Stuart Anstee, Rio Tinto, and David Huberman, IUCN for their constructive and insightful comments at various stages.

Cover design by: Nathalie Olsen

Cover photo: IUCN Photo Library © Johannes Förster

Layout by: Nathalie Olsen

Available from: IUCN (International Union
for Conservation of Nature)
Publications Services
Rue Mauverney 28
1196 Gland
Switzerland
Tel +41 22 999 0000
Fax +41 22 999 0020
books@iucn.org
www.iucn.org/publications

A catalogue of IUCN publications is also available.

Please send any comments to Nathalie.olsen@iucn.org

The Financial Costs of REDD: Evidence from Brazil and Indonesia

Nathalie Olsen

Opportunity costs of forest land

Compensating governments and/or land owners for the opportunity cost of conserving forest is likely to be the largest single cost component of any REDD scheme, assuming it is paid. The opportunity cost of forest conservation may be defined as the net income per hectare per year or net present value (NPV) sacrificed as a result of logging (or logging more sustainably) or not converting land to agriculture. Opportunity cost is

Implementation and transactions costs

The second major component of the costs of REDD is implementation and transaction costs. This paper considers these costs associated with search, negotiation, verification, certification, implementation, monitoring, enforcement and insurance. Implementation costs are affected by economies of scale and depending on whether REDD policies and measures are national or project-based. Implementation and transaction costs are expressed in terms of cost per tCO_2e and added to opportunity cost estimates (despite the fact that this may not be practical for project implementation which would operate on a per hectare basis).

Empirical estimates of the implementation and transaction costs of REDD presented here are based on experience with Payments for Ecosystem Services (PES) projects, other climate change mitigation projects, simulations and the observed costs of implementing Sustainable Forest Management (SFM).[2] Evidence suggests that there are significant economies of scale and that large projects and programmes have lower implementation costs per unit of emissions avoided (measured in tCO_2e). Transaction costs, on the other hand, are likely to be more fixed than variable. Experience suggests that transaction costs will be greater for smaller projects than for larger projects and also greater for a large number of small transactions versus a small number of larger transactions (Börner and Wunder, 2008).

Distributional issues and implications for costs

The distribution of the cost and benefits of REDD amongst different stakeholders will affect the net costs (and ultimate success) of investments in REDD. To date, the distribution of benefits of most PES schemes has been characterised as neutral, at best, with respect to poverty. For example, small landowners and the poor may be marginalised from PES due to high implementation and transaction costs, poorly defined land tenure, and lengthy, complicated administrative procedures. Moreover, there may be an equity-efficiency trade-off; for example, investment in the Clean Development Mechanism (CDM) has tended to focus on low cost emissions reductions through the adoption of cleaner technologies in China and India, with relatively limited benefits for local people. Although the unit costs of carbon abatement via REDD would most likely increase with efforts to integrate equity and poverty concerns, the increased costs need to be met in order to ensure the delivery of project or programme outputs and this expenditure is likely to be highly cost-effective.

This study adopts US$1/ton CO_2e as a rough global estimate of implementation and transaction costs. This estimate is derived in Boucher (2008) and is based on the aggregation of sub-sets of implementation and transaction costs from a range of studies: Antinori and Sathaye (2007) estimate of transaction costs (US$0.38/tCO$_2$e), Nepstad et al. (2007) implementation cost estimate (US$0.50/tCO$_2$e) and Grieg-*UDQ·V K L J K H V W D G P L Q L V W U D W L Y H F R V W H V W L P D W H* of US$1/ton$CO_2e$. While there is some overlap in the components of this sum, a small degree of double-counting ensures that the estimate is conservative. In parallel, in a ¶ E D F N R I W K H H Q Y H O R S H · F D O F X O D W L R Q 6 R K Q J H Q

[2] See Wunder and Alban, 2008; Mayet al., 2004; Cacho et al., 2005; van Kooten, 2008; Antinori and Sathaye, 2007; Grieg-Gran, 2006; Boucher, 2008

plantations, smallholder farming, internal migration and government-sponsored resettlement. Industrial timber plantations mainly supply the pulp and paper industry. Rising commodity prices have accelerated the conversion of forest for the production of cash crops, notably palm oil. Illegal logging is a significant problem while forest fires destroyed over five million ha of forest in 1994 and another 4-6 million ha in 1997-98.

There are also important indirect drivers of deforestation in Indonesia. Over the last few decades, rapid economic growth has seen the emergence of a powerful class of landowners whose interests are often in conflict with small-scale land users (Swallow et al., 2007). The fall in value of the Indonesian currency during the Asian financial crisis in 1997 provided additional incentive to convert forest to export tree crops, such as oil palm, rubber, cocoa and coffee. Competition between migrants, indigenous people and large investors accelerates deforestation on islands with greater population density, e.g. Sumatra. Logging is a powerful driver of forest degradation on other islands, e.g. Kalimantan.

Including incentives to reduce forest degradation in REDD is particularly important for Indonesia, where forest degradation may be a larger source of GHG emissions than forest conversion. Indonesia contains one of the world's [illegible] which [illegible] are extremely rich in carbon. In recent decades, these ecosystems have widely been cleared and converted to oil palm, fast-growing tree plantations for the pulp and paper industry, large scale irrigated rice and small scale agriculture. Large carbon emissions occur when peatlands are burned or drained. In a study of three provinces (East Kalimantan, Jambi, Lampung), Swallow et al (2007) find that the economic returns from conversion of peatlands are very low, while carbon emissions are very high. The conservation of peatlands is thus a very low opportunity cost carbon abatement option, which has attracted wide attention as a priority for REDD investment.

As opportunity cost estimates per ton CO_2e are highly sensitive to estimates of the carbon content of forest, this paper uses data from both the Alternatives to Slash and Burn (ASB) study (high carbon scenario) and the FAO Forest Resource Assessment (FRA) (low carbon scenario). Based on data from the ASB study, returns to land are adjusted by the net change in carbon storage per hectare that results from land use change. The net change in carbon is defined as the difference in the carbon content of undisturbed forest and the carbon content of the alternative land use (i.e. slash and burn farming) for the for high carbon content scenario. However, for the low carbon content scenario, carbon content data on alternative land uses is not available. In this case, it is assumed that the carbon content of alternative land uses is zero.

The highest opportunity cost of REDD in Indonesia occurs where forest conservation competes with palm oil production. Opportunity costs range US$6-49/ton CO_2e for small holder farming in Sumatra up to US$19.6/ton CO_2e for conversion of degraded forest land to palm oil. Most palm oil production generates returns equivalent to US$3-7/ton CO_2e. Logging (unsustainable) is the next most profitable land use. Assuming a carbon content of undisturbed forest of 300 ton/ha, opportunity costs range from US$1.65/ CO_2e for commercial logging in Sumatra to US$3.44/ton CO_2e for unsustainable commercial logging in Southeast Asia and the Pacific. Subsistence agriculture and cattle ranching have low rates of return in Indonesia, expressed as costs per ton CO_2e, most estimates are close to zero (and negative in some cases) due to low per hectare returns and the low carbon content of these land uses.

McKinsey & Company (2009) use global estimates to compare the cost-effectiveness of a range of carbon abatement opportunities across all sectors (see Figure 1.3). The estimates reviewed in this study (US$ estimates are converted into euro at the 2005 exchange rate of US$1=1.25 EUR) are consistent with McKinsey estimates for reduced slash and burn agriculture and reduced pastureland conversion at less than EUR 5/ton CO_2e. These abatement options appear to be more cost effective than many non-forestry sector abatement opportunities such as solar energy, wind energy, carbon capture and storage, etc. Moreover, abatement based on reduced slash-and-burn agriculture and reduced pastureland conversion is more cost-effective than all other forest sector abatement options, e.g. the restoration of degraded land, afforestation of pastureland, and reforestation of degraded forest. In line with this review, McKinsey find that the costs of abatement based on the reduced conversion of forest to intensive agriculture are higher and cannot compete with solar and wind power, for example. However, it must also be acknowledged that the data, and indeed many of the published estimates of abatement costs, do not measure risk consistently, i.e. the reliability of different abatement strategies.

There is a wide range of estimates of the costs of carbon abatement strategies in the forest sector and of REDD in particular. Much of the difference is due to the fact that micro-level estimates, based on particular local conditions, more accurately capture variation in local opportunity costs. This type of information is critical to guide public and private investors seeking to develop forest carbon projects and REDD activities in particular areas. For many stakeholders, global estimates and broad averages do not provide sufficiently accurate estimates of the relevant costs and risks.

The key findings of this review may be summarized as follows:

- There is significant variation in per hectare opportunity costs in Brazil and Indonesia, reflecting differences in local conditions, land use and proximity to transport infrastructure and markets. National, regional and global averages are of limited usefulness for determining where REDD is most cost-effective.
- There is significant variation in the carbon content of forest land at national, provincial and local level. Moreover, there is some inconsistency between published estimates of carbon content, based on the application of different methodologies. It is therefore essential to not only estimate local opportunity costs, but also to measure carbon content on a local basis.
- A review of empirical opportunity cost estimates suggests that REDD is competitive with most land uses in the Brazilian Amazon and many land uses in Indonesia at a carbon price of less than US$5/ton CO_2e. REDD is competitive with most land uses in Indonesia at US$10/ton CO_2e. Subsistence agriculture and most livestock production systems are characterized by very low returns in both Brazil and Indonesia, logging and cash crops generally exhibit higher opportunity costs.
- While implementation and transaction costs add roughly US$1/ton CO_2e to opportunity costs, these additional costs are not so large as to make REDD (or other forest carbon activities) financially unattractive relative to non-forest sector carbon abatement options.

List of Figures

The Financial Costs of REDD: Evidence from Brazil and Indonesia

Nathalie Olsen and Joshua Bishop, IUCN [3]

1 Context, rationale and analytical framework

1.1 Introduction

Opportunities to mitigate climate change by reducing emissions from deforestation and forest degradation (REDD), especially in developing countries, have risen to the top of the international climate policy agenda, attracting increasing attention and investment from environmental organizations, development assistance agencies and the business community. Deforestation is one of the largest sources of global greenhouse gas (GHG) emissions and produces about 17 percent of total emissions (IPCC, 2007). There is growing consensus that REDD may offer a large pool of relatively low-cost emission reductions, which could significantly reduce the costs of meeting GHG reduction targets (see Beinhocker et al., 2008; Stern, 2006; Grieg-Gran, 2008). However, proponents of REDD are still striving to win political endorsement for the approach as a compliance mechanism. The potential of REDD and other land-based carbon storage and sequestration opportunities as part of post-2012 climate change regime remains uncertain, in part due to lack of detailed information on the likely costs associated with forest carbon projects, and REDD programmes in particular.

This desk study reviews the financial costs of abating GHG emissions through REDD from the perspective of an institutional investor seeking cost-effective abatement options. The objective is to investigate the main factors that determine the costs of REDD and to assess the range of likely costs in countries and regions where the potential to deliver significant abatement through REDD is greatest. As such, this review seeks to contribute to the current debate on the design and costs of REDD by focusing on field-level empirical issues and data and on financial rather than economic costs, i.e. actual costs to individual investors.

A number of studies on the costs of REDD attempt to estimate the forest area which could be conserved or the volume of CO_2 emissions which could be avoided given a fixed global budget, i.e. how much carbon can remain fixed in existing forests at a carbon price of US$X/ton or how many tons of CO_2 equivalent (CO_2e) emissions can be avoided for a global budget of US$X million? The debate on REDD within the UNFCCC is working to determine the costs of nationally appropriate mitigation actions (NAMAs) for REDD that are measurable, reportable, and verifiable (MRV). However, micro-level analytical studies focusing specifically on national, sub-national and project level costs of REDD are not common. This paper attempts to begin to fill this gap by proposing a simple framework and reviewing data available for Brazil and Indonesia.

[3] Please send any comments to nathalie.olsen@iucn.org

The paper reviews empirical work which suggests that the costs of REDD lie in a range from US$2

REDD focus on the accounting level of an international financing mechanism for REDD, but the level of implementation is less important as a REDD scheme could include both nationally implemented projects and a national REDD strategy that credits projects implemented by others. Similarly, a sub/national project approach to implementation would benefit enormously from sound national REDD policies (Angelsen and Wertz-Kanounnikoff, 2008).

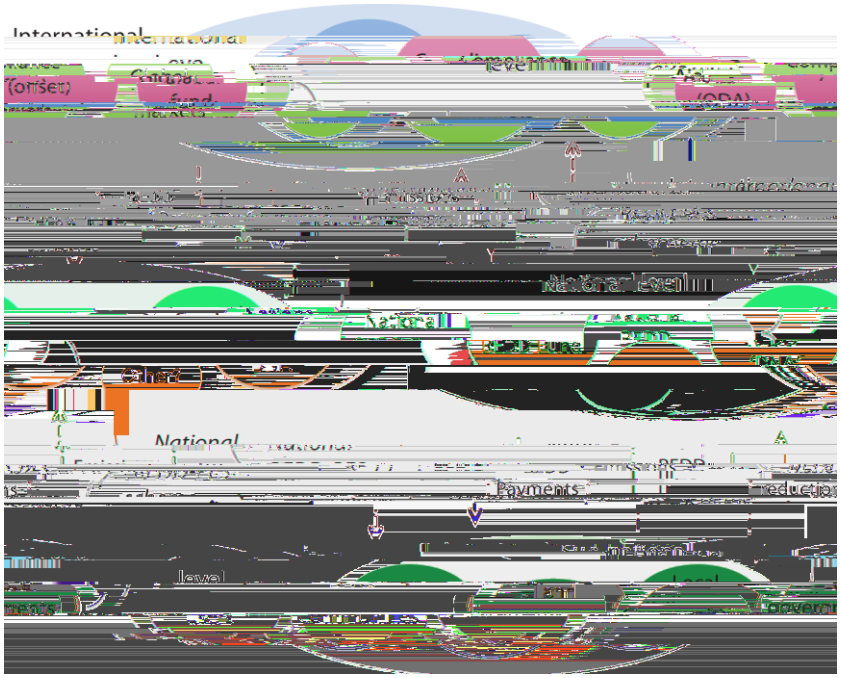
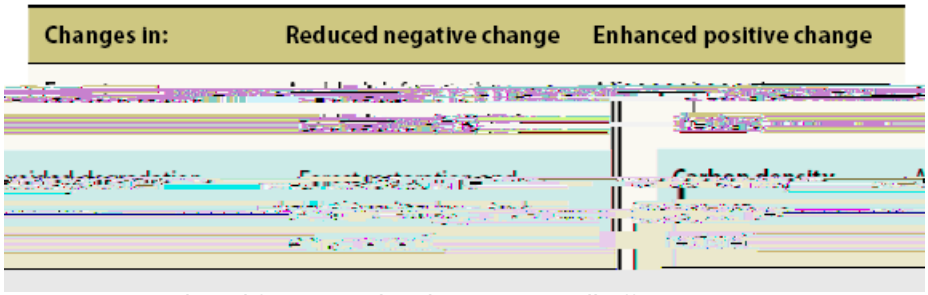


Figure 1: REDD as a multi-level Payment for Ecosystem Services scheme
Source: Reproduced from Angelsen and Wertz-Kanounnikoff, 2008.

Within the UNFCCC, discussions surrounding REDD began in earnest in 2005 with RED, i.e. limited to deforestation only. Discussions expanded to REDD to include forest degradation and have since begun to consider forest conservation, sustainable forest management and enhancement of carbon stocks (REDD+). There is currently a general consensus that a REDD mechanism should cover all forests and only forests (Angelsen, Brown, et al., 2009) although disagreement over how to define forests renders this consensus somewhat tenuous. There is still disagreement over whether there should be a primary set of measures addressing deforestation and forest degradation, and a supplementary set of measures for other forest-based mitigation options. It is also not clear whether Parties to the UNFCCC can´enhancement of forest carbon stocks

Table 1: Possible scope of mitigation activities to be included in REDD mechanism



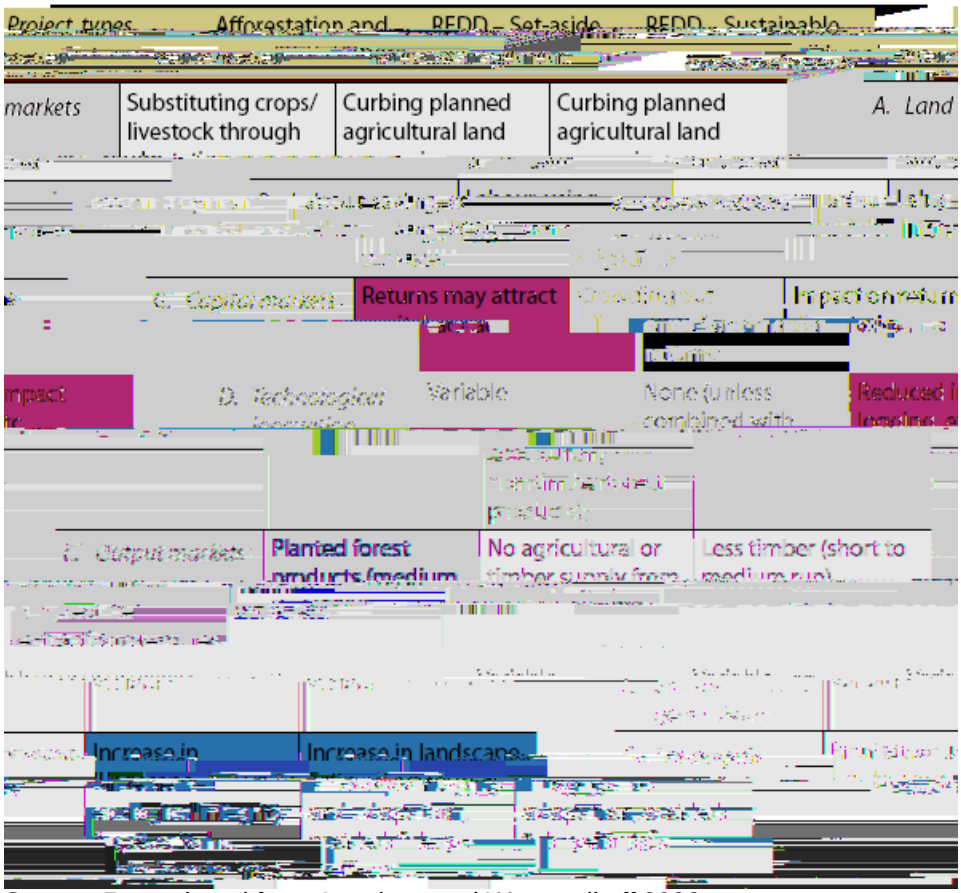
Source: Reproduced from Angelsen and Wertz-Kanounikoff, 2008

With regard to the scope of REDD, this paper focuses primarily on the cost of avoided deforestation and avoided degradation as this is the subject of most of the reviewed micro-level studies. Unfortunately, it is not always clear in empirical studies whether it is the costs of avoided deforestation or degradation that are being estimated. In this review, opportunity costs are generally estimated based on the conversion of primary forest to agricultural uses. Forest degradation is covered in a limited manner for Indonesia in the discussion on the conversion of peatlands to agriculture.

While forest carbon projects may fall within the scope of REDD, there are criteria which will determine the eligibility of forest carbon projects for REDD financing. Leakage is an important issue

8iue8 566.59 Tm [(a)ET BT 1 0 0 10 BT 1 0 0 1 4n4(E)-3(DD, t)] TJ ET BT101 0 0 10 BT 1 0 8.59 Tm [( )] T

Table 2: Potential leakage channels for REDD



Source: Reproduced from Angelsen and Kaimowitz 2008

In addition to leakage management, REDD programmes will almost certainly include a criterion for additionality. Additionality requires that evidence be provided that long term, measurable GHG emission reductions would not have occurred in the absence of the project, policy or activity. This implies that those who have already invested in conservation of forest land or restoration of degraded forest land will not be eligible for inclusion in a REDD programme. This may have implications for private investors, who will have to demonstrate a clear and verifiable threat to forest land selected for REDD relevant project activities.

In summary, due to issues of scope, leakage and additionality, many investors in forest carbon may find that their activities do not qualify for REDD financing. The degree of restrictiveness of a future REDD regime is currently taking shape, but many of the details remain to be fleshed out. However, it is likely that there are opportunities for receiving carbon credits for forest carbon activities outside of UNFCCC REDD discussions as witnessed by the expanding volume and value of forest carbon in the voluntary carbon market. Because it is currently difficult to know the precise future requirements for inclusion of forest carbon project in a REDD regime, this paper refers

specific to a region and reflect local conditions and costs; as a result, these estimates can vary significantly across localities and regions. A second approach is to derive estimates based on generic or average production costs per hectare or per ton agricultural output. Average costs may be calculated on the basis of data from other countries

ton carbon (US$/ton C) are converted to net per ton CO_2e (US$/ton CO_2e) using a standard conversion factor of 3.67. Expressing opportunity costs per ton of CO_2e enables comparison with other climate mitigation options and with prevailing carbon prices. All net present value estimates of opportunity costs have been converted to 2005 US dollars, for ease of comparison.

1.3.1.2 Primary commodity prices

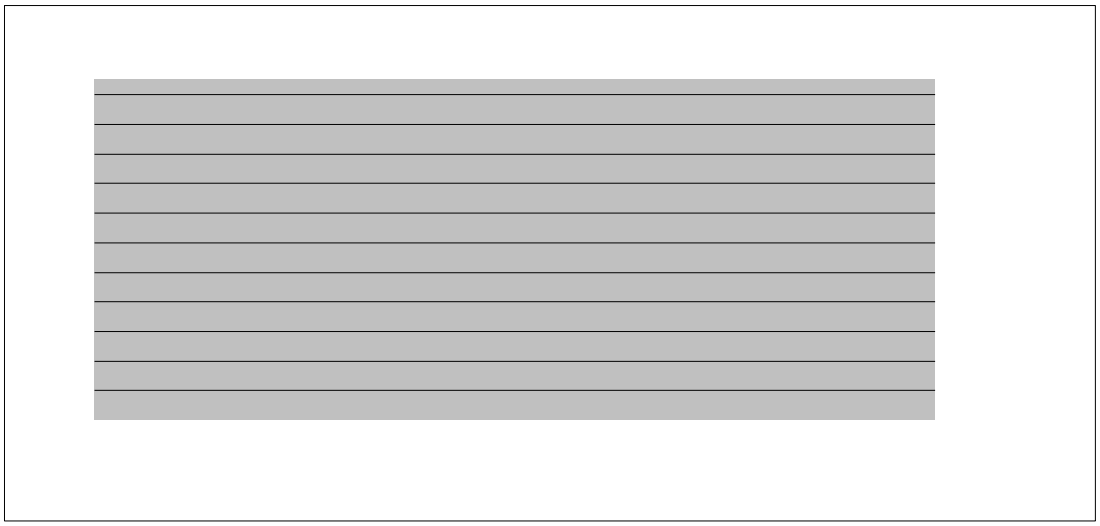


Figure 3 Selected primary commodity prices, 1980-2009 (nominal prices)
Source: Data from IMF primary commodity price database accessed March 2009

The opportunity cost estimates in this review are based on data collected between 1997 and 2008, expressed in 2005 US$. To take account of changes in commodity prices, opportunity cost estimates are adjusted. Certain commodities exhibit a high degree of price volatility (soybean, palm oil). In these cases, commodity prices in the year opportunity costs were estimated are compared to long term average prices. If there is a significant difference, i.e. 10 percent, opportunity cost estimates are adjusted by the percentage price difference (palm oil, beef, rubber). While beef prices are stable, the average 1997 price is roughly 20 percent lower than the long term (2003-2009) historical average price. If prices at the time opportunity costs were estimated were higher than the long term average commodity price, no adjustment made (soybean, logging). Estimates for non-traded sectors, i.e. subsistence agriculture were also not adjusted.

Future primary commodity prices will undoubtedly affect the costs of REDD. Investors face this uncertainty along with the risks associated with other uncertain factors which generally affect investment decisions, which involve decisions today based on current conditions and uncertain returns in the future. However, investments in REDD and other carbon abatement opportunities may actually be subject to less price volatility as governments may be more likely to take action to stabilise carbon markets or take indirect actions to support the carbon market than more traditional commodity markets.

1.3.1.3 One-off timber harvesting

When forests are converted, the harvest of timber has costs and benefits. If timber resources are commercially valuable (this depends on the species, quality and proximity to markets) there are significant net profits in the first year of forest conversion.

Grieg-Gran (2006) addresses this issue in detail. Her estimation of the opportunity costs of land is based on three different scenarios: 0%, 100% and a country specific share of returns to one-off timber harvesting which have to be compensated as part of land conversion. The issue of whether to include timber harvesting and pasture establishment costs depends very much on country specific drivers of deforestation and land use trajectory following deforestation. For example, studies in tropical Africa (Kaimo-Same et al., 2000; Osafo, 2005; cited in Grieg-Gran, 2006) do not include timber revenues because deforestation is primarily driven by smallholder agriculture, timber rights belong to the State and smallholders are only allowed to harvest for own use, timber is frequently burned rather than sold. A similar situation is found in parts of Indonesia (Tomich et al., 1998; in Grieg-Gran, 2006) although, with the recent significant expansion of large-scale palm oil monocultures, smallholder agriculture may no longer be the main source of deforestation. On the other hand, in Brazil, timber harvesting is sometimes included (Börner and Wunder, 2008a; Nepstad et al. 2007) and sometimes excluded (Börner and Wunder, 2008b; Vera Diaz and Schwartzman, 2005; Margulis, 2003 cited in Grieg-Gran, 2006) depending on land uses and land use trajectories analysed for particular regions. The ASB study for Indonesia excludes returns to one-off timber harvest from its calculations simply because the returns to timber harvest dwarf the returns to land uses that follow timber harvest which makes it difficult to compare the returns of alternative land uses (Swallow et al., 2007).

1.3.1.4

For investors who hold property rights over forest land, the level of threat facing a forest may not be directly relevant. However, for investors seeking to obtain access to forest land the level of threat will be important and will move in line with opportunity costs. Forest land with climatic and soil conditions suitable for agriculture would be

calculated based on the difference in the carbon content of forests and the carbon content of the alternative land use.

1.3.1.7 Cost curves versus point estimates

An increasing number of studies estimate supply curves (prices) and cost curves which reflect changes in prices and costs as the amount of emission reduction changes, rather than calculating point estimates of cost/ton CO_2e avoided. Unit costs are not single constant values but differ for each quantity of reduction. It is therefore useful, when possible, to estimate a supply curve which graphs the quantity of CO_2e supplied against

various stages of REDD would be useful to complete the table with quantitative estimates (US$/ha), but there is currently little empirical data available to do so.

Table 3: Typology and distribution of implementation and transaction costs

Implementation and transaction cost	Description	Fixed/ variable cost*	Cost incurred by carbon seller	Costs incurred by carbon investor
Search	Costs incurred in seeking project partners	Fixed	-cost to find buyers	- E U R N H U · V I H H V -charges for information services -cost of advertising willingness to invest - baseline
Negotiation	Costs of partners reaching an agreement	Fixed	-legal costs -costs of project design -distribution of responsibilities -delays -assignment of benefits (payment in cash, carbon credits, etc)	

1.3.2.2 National versus project-based REDD implementation and transaction costs

Implementation and transaction costs for project level REDD activities borne by individual groups are a subset of the costs for national and international REDD programmes.

1.4 Empiri lementation and transaction costs of REDD

1.4.1 Proje

Little data is ayments for Ecosystem S quently been inaccurate W s for a large number of small volume trans immature markets (Börner and V Brazil and Bolivia experienced ver he uncertain market environment and Other studies (Cacho et al. 2005 in a stud large start up costs relatively low recur

Some research s uarter of the costs of providing ecosyste Kooten, 2008). Other studies (Börner and forest conservation are exclude these costs nature of includ empirical estimat available empirical Payments for Eco

Table 4: Summar for PES proje

Project					Administr ation		
11 forestry offset projects							Antinori and Sathaye (2007). Transaction costs.
Pimampiro watershed protection	Peru		76	7			Wunder and Alba (2008)
PROFAFOR carbon sequestrati							

implementation of SFM projects which could potentially provide empirical and country specific estimates of transaction costs for forestry type projects.

1.4.3 National capacity building and implementation costs

Hoare et al (2008) look at the costs of building institutional capacity in rainforest nations and define three types of governance interventions (with associated costs) needed for these tropical countries to participate in REDD.

- Mechanism costs include costs associated with calculating baselines, development of monitoring and measuring capacity, and issuing credits. The Hoare study cites a number of empirical estimates for mechanism costs:
  - Based on experience in India and Brazil, the cost of setting up national monitoring systems is estimated at US$500,000 to US$2 million per country.
  - IPCC estimates the cost of establishing national vegetation carbon inventories at between US$0.05-0.6 per hectare (2000 prices).
  - In Cam6

Table 5: **Estimates of costs of ñreadinessò for REDD**

Activity	Lower estimate	Upper estimate

biodiversity on a regional basis and for six countries. In the Neotropics high carbon high biodiversity forest covers more than three percent of total land area and contains more than 4 percent of the total regional carbon stock. The Oceania and Asia region shows a particularly high coincidence of carbon and biodiversity with more than ten percent of total carbon stock located in high carbon high biodiversity forests. This coincidence is especially marked in the island archipelagos and the Western Ghats (Kapos et al. 2008).

1.7 Distributional issues and REDD design

The distribution of the costs and benefits of project based REDD will depend on local conditions, institutions, community equity, the status of land tenure, and other socio economic characteristics of the project area. While there is little practical experience of REDD and hence little is known of the distributional implications, the experience of PES schemes implemented in the last decade provides some insights into potential distributional issues (Huberman, 2009; Pesket et al. 2008). There is concern that REDD would exacerbate unequal power relations in countries and regions with weak governance institutions. In particular, there is a concern that indigenous peoples who are often the de facto guardians of tropical forest, would lose out as forest resources become relatively more valuable under REDD. The rights of local and indigenous people need to be strengthened in face of government measures to restrict access and harvesting of forest resources so that local livelihoods are not negatively affected by REDD.

While the objective of PES schemes is generally not poverty alleviation, poverty alleviation is regarded as a desirable potential co-benefit. However, the distribution of benefits from PES schemes has in some cases been considered inequitable and there appears to be a strong efficiency-equity trade-off. For the efficient delivery of ecosystem services, it is not necessarily

investing in carbon offsets for the investor and lowers benefits to stakeholders. Alternatively, payment after verification significantly reduces risks for carbon credit purchasers; however, lack of access to credit would prevent local communities from making necessary investments in the absence of upfront financing. In some cases, governments would take on these liabilities. Other options include holding geographically diverse portfolios (to reduce the impact of forest fires on investors), temporary credits as used in CDM afforestation and reforestation projects, repayment of revenues/fines

- Spatial scale – national versus project based approaches has important implications for how emissions reductions are accounted for and how they are credited. Important distributional issues related to spatial scale include how finances and authority are distributed between government (central and sub-national) and non-governmental actors. The greater the degree of fiscal decentralisation, the greater the likelihood that financial benefits reach the local level and the lower the chances of elite capture (Peskett et al. 2008).

- Private investors are likely to prefer large-scale projects due to the lower transaction costs due to economies of scale. It is likely that there will be fewer opportunities for local communities to benefit from large-scale projects than from small-scale projects (Cosbey et al. 2006 cited in Dutschke et al. 2008).

- Efficiency-equity trade-offs are prevalent in the selection of project investments. For example, in the CDM there has been a great deal of investment in projects regarded as bearing 'low hanging fruit', i.e. low cost of emissions reduction, particularly in China and India. These types of projects which include the introduction of cleaner technologies into industrial processes generally have fewer benefits for local people (Peskett et al. 2008). Combined with private sector preferences for large scale projects, the equity-efficiency trade off will affect private investment in REDD; private sector investors are generally less concerned with distributional issues. That being said, some private investors are interested in projects with social or other (e.g. biodiversity) co-benefits as these projects attract higher prices and boost corporate reputation. There are already some standards schemes which provide premium credits from projects with high sustainability (Peskett et al. 2008). Standards which reward investment in projects with benefits additional to carbon increase the interest of private sector investors who would benefit financially in receiving higher prices for carbon credits and in promoting their 'license to operate' by being seen to operate in a responsible manner.

- Reference levels/scenarios are used to judge performance in reducing emissions related to deforestation. The baseline approach defines a scenario of projected

2 Case study 1:

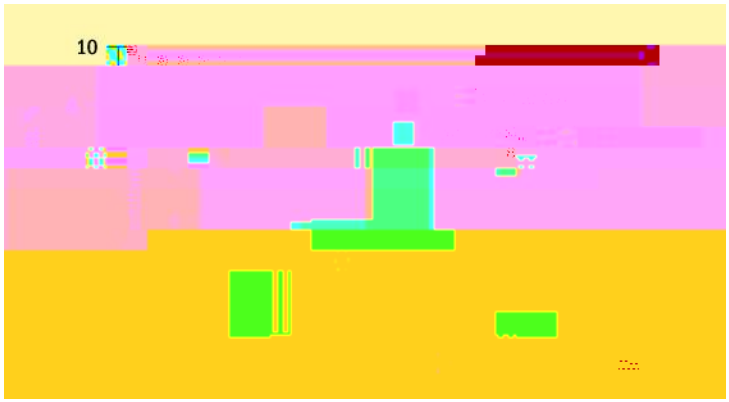


Figure 5: Deforestation in the Brazilian Amazon, Rainfall and Beef Prices, 2001-03
Source: Reproduced from Chomitz et al. 2007

Chomitz and Thomas (2003) provide evidence that almost half of

Another approach (Nepstad et al. 2007) looks at the foregone profits from forest-replacing agricultural and livestock production systems on all currently and potentially forested lands under all kinds of ownership. This approach is based on the argument that protected areas and forest concessions can be undone to permit forest-replacing agriculture. This study argues that continuous positive economic incentives are needed to maintain forests and prevent leakage within countries. Filters are used to limit the potential of soybean expansion

in spatial maps, these results are not directly comparable to other estimates and are presented separately below.

Appendix 1, Table A1.1 presents detailed information on opportunity cost estimates for the Brazilian Amazon. Cattle ranching has very low levels of profitability; small scale and traditional ranching produces profits between US$2 to /ha. Medium and large scale ranching, extensive ranching and improved pasture ranching are more profitable at US$461 to 1033/ha. Animal grazing density is between 0.5 (Pfaff and Thomas, 2005) and 0.8 animal units per hectare and profits are generally less than $50 per hectare (Hyde et al, 2007). In future, disaggregating livestock activities to look at dairy farming versus ranching

2.5 Carbon content

Estimates of the opportunity cost of forest conservation are adjusted by the carbon content (ton carbon/ha) of the landscape to derive an estimated cost/ton carbon or CO_2e. Assuming carbon dioxide emissions from deforestation equal the total carbon content of above-ground vegetation, the opportunity cost per ton of avoided carbon dioxide emissions is equal to per hectare opportunity cost divided by average carbon content. While there is significant variability in the carbon content between and within provinces and regions, most studies use either averages by province (Börner and Wunder, 2008) or for the Amazon

Figure 6: Forest carbon stocks of the Brazilian Amazon
Source: Reproduced from Nepstad et al. 2007

2.6 Opportunity cost per ton CO_2e avoided

Combining per hectare opportunity costs and carbon content data, estimates for cost/ton C and cost/ton CO_2e are derived for a specific locality. As some studies express opportunity cost in terms of cost per hectare (e.g. Grieg-Gran, 2006; Tomich, 2005), this study has converted these estimates by using the lowest per hectare carbon content

Table 7: Opportunity costs by land use in the Brazilian Amazon (US$2005)

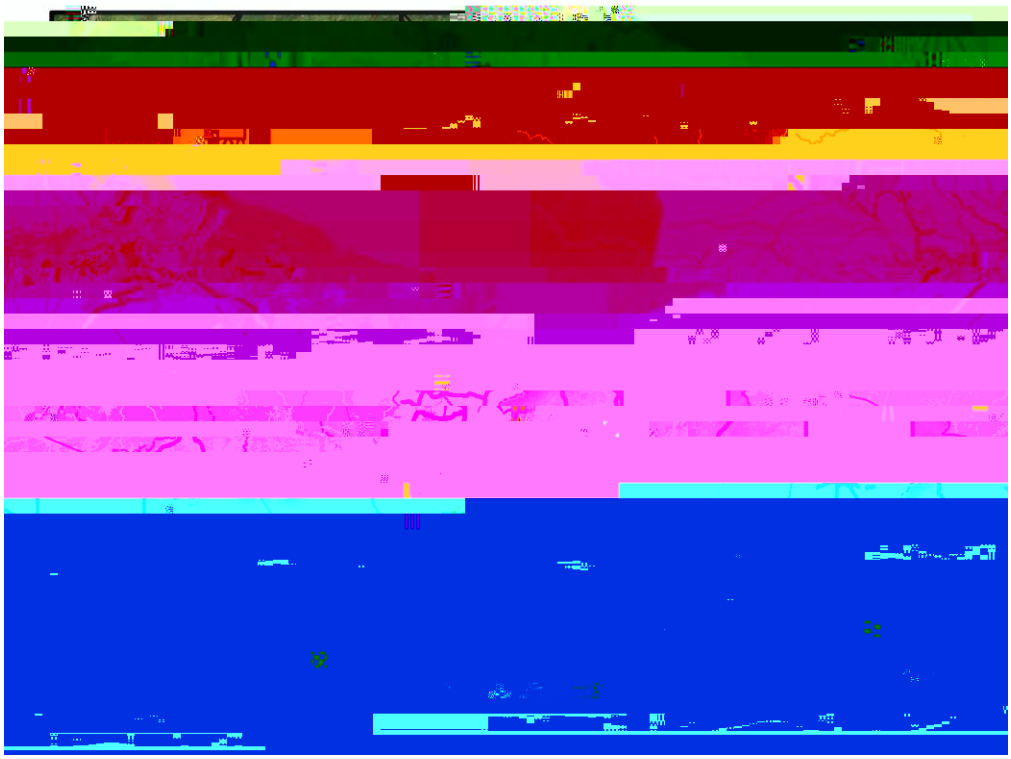
Land use	Opportunity cost $/ton CO_2e		
	Low	High	Share in area of deforested land (%)
Subsistence agriculture	0	1.1	4
Ranching	0	2.6	77-85
Soybean	2.5	3.4	5-8
Tree plantations	1.1	5.9	1
Timber harvest	0.3	2.5	na
Timber+ranching+soybean	3.9	6.1	na

Sources: See Table A.1 in Annex, various sources, Grieg-Gran (2006).

As roughly 80 percent of recently deforested land is used for ranching, the scope for achieving cost-effective reductions in CO_2e emissions through avoided deforestation seems promising. Figure 7 illustrates how opportunity costs vary significantly between provinces in the Brazilian Amazon. More remote Amazonas which has little transport infrastructure and hence much less land under soybean production has far lower opportunity costs than Mato Grosso. Börner and Wunder (2008) estimate a supply curve which shows that more than a third of deforestation in Amazonas could be compensated for less than US$1/ton CO_2e, and there is no land use that could not be compensated for less than US$3/ton CO_2e. In Mato Grosso, opportunity costs are higher, but it is still possible to avoid half of deforestation for less than US$3/ton CO_2e; the supply curve is relatively flat but increases steeply to completely avoid deforestation (maximum of US$12/ton CO_2e).

Figure 7: Opportunity cost $/ton CO_2e in Amazonas and Mato Grosso
Source: Reproduced from Börner and Wunder 2008a

Not all the estimates discussed are directly comparable. In particular, Naidoo (2007) estimate net NPV; the NPV of timber production is subtracted from each model since timber production maintains most of the carbon stock of a forest. The net opportunity cost is calculated by dividing the difference in NPV (soy or cattle minus timber) by the difference in the carbon stock of agriculture/livestock versus timber. The study assumes sustainable logging is implemented and decreases carbon stock by 15 percent while soybean and pasture production reduce carbon stock by 85 percent. The results for soy, cattle and logging are presented in Figures 8, 9 and 10.



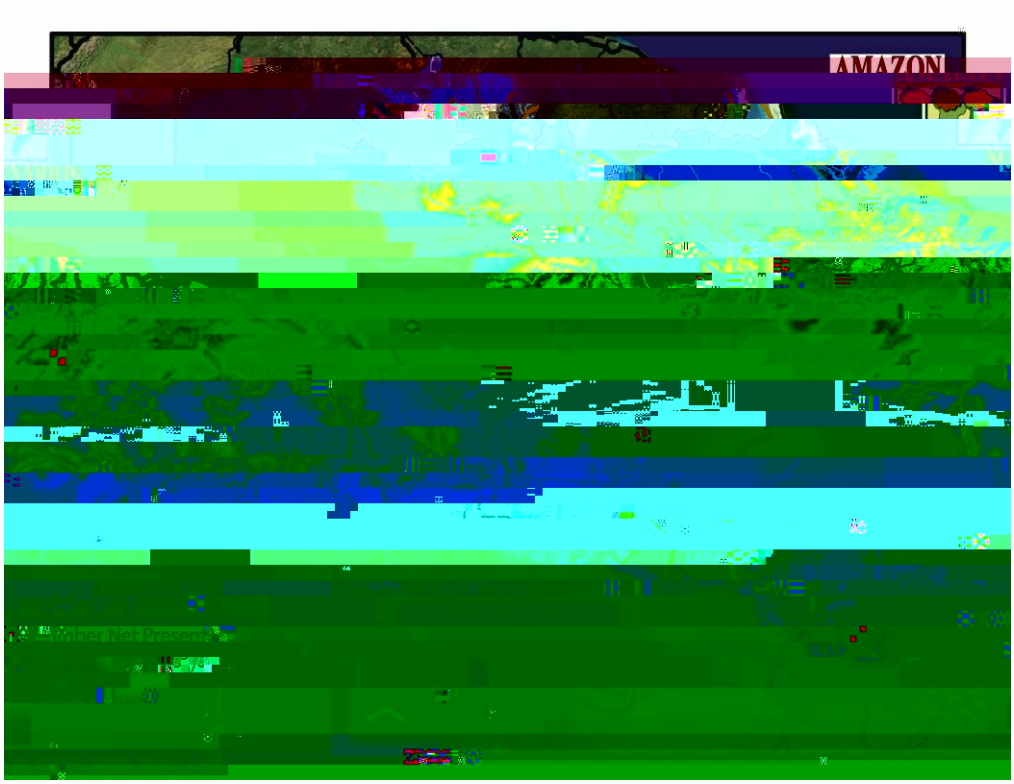


Figure 10. The potential net present value (2002–2037) of sustainable timber production in the Brazilian Amazon
Source: Reproduced from Nepstad et al. 2007

Chomitz et al. (2007) contrast different types of agricultural or agroforestry land use with the maintenance of secondary forest, sustainable use of primary forest and community forestry. The study shows how deforestation would be unprofitable in some parts of many countries and farming systems at very modest (US$3/ton CO_2e) carbon prices. Figure 11 provides a

Figure 11. Deforestation would be unprofitable in many land systems at modest carbon prices
Source: Reproduced from Chomitz et al. 2007

To sum up, the studies reviewed here suggest that at current carbon prices in both voluntary and compliance markets, REDD can compete with most

Adding US$1/ton CO_2e

3.3 Opportunity costs

3.3.1 Carbon content estimates

Table 9 presents empirical data from the Alternatives to Slash and Burn Partnership (ASB) study of above-ground carbon content by land use in Indonesia. According to this study, undisturbed forest contains 300 tons above-ground carbon per ha. However, according to WKH)$2 · V)RUHVW 5HVRXUFH $VVHVVPHQW 3URJUDP), WKH biomass in undisturbed forest in South and South East Asia is 89 tons/ha. The ASB estimate is more than three times the FAO estimate for Asia and is at least double the estimates used in the Brazilian Amazon (between 110 and 155 ton carbon/ha). There is no clear explanation why these estimates should be so different other than the ASB estimates are site specific for three provinces. Both estimates exclude soil carbon, but include carbon contained in living biomass, dead wood and litter.

Table 9: Above-ground time-averaged carbon stocks by land use in Indonesia

	Land use type	Time averaged carbon stock (tonC/ha)
1	Undisturbed forest	300
2	Logged over forest: high density	250
3	Logged over forest: low density	150
4	Undisturbed mangrove	200
5	Logged over mangrove	100
6	Undisturbed swamp forest	200
7	Logged over swamp forest	200
8	Home garden	21.8
9	Coconut	90.7
10	Damar agro-forest	114.8
11	Fruit-based agro-forest	116.1
12	Rubber agro-forest	62.1

Table 10 Opportunity cost estimates in Indonesia by land use

Land use		Opportunity cost $/ton CO_2e			
		Low carbon content(a)		High carbon content (b)	
		Low	High	Low	High
Oil Palm	Large scale		6.3		2.1
	Supported growers		5.1		1.7
	High yield independent		4.4		1.5
	Low yield independent		1.8		0.6
	Smallholder		0.5		0.2
Rubber		0	4.2	0	1.6
Subsistence agriculture		0	1.53	0	73.19] TJ ET

assuming 89 ton carbon/ha forest increases the opportunity cost for rubber plantations with improved planting material to US$ 4.18/ton CO_2e which is higher than logging in Indonesia.

3.3.3.1

3.3.3.3 Lampung Province

Lampung province in southern Sumatra has only eight percent of its area still under forest due to government sponsored and spontaneous migration from Java and large scale commercial logging in the 1970s followed by conversion to industrial plantations of sugar cane and pineapple. Cassava is the main crop in the lowlands and in the foothills, coffee has increased along with international coffee prices. Indigenous Lampung people still cultivate semi-permanent food crops on flooded river banks. Shifting cultivation is no longer practised. Migrants grow rice, but due to drought and soil erosion, people are leaving the area.

Figure 4.4: Summary of land use change in Lampung Province, Indonesia for 1990, 2000 and 2005

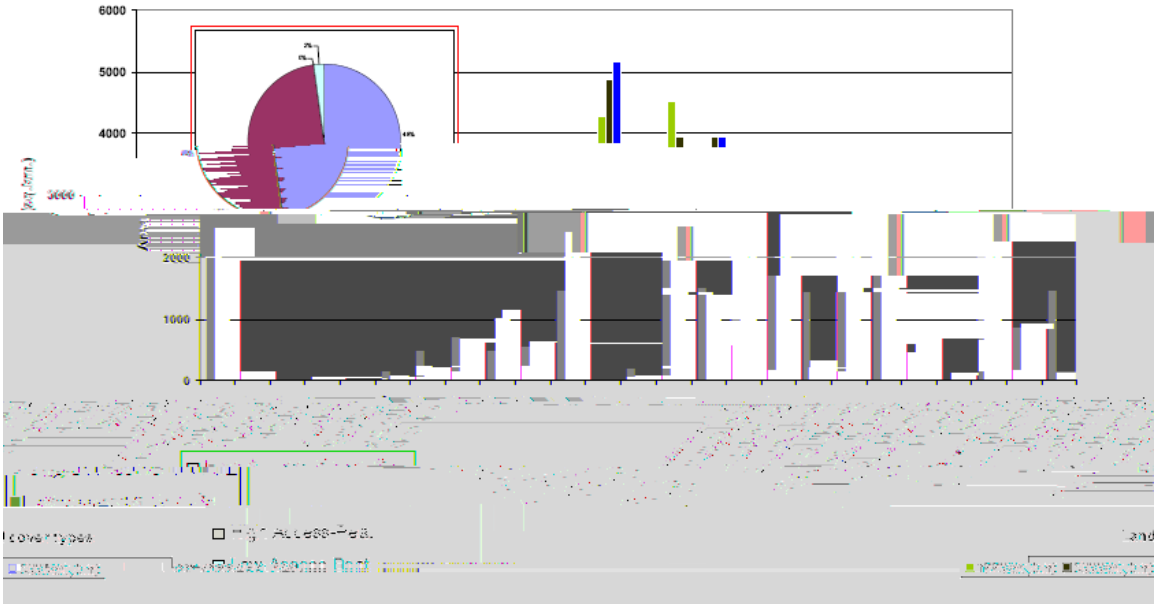


Figure 16: Summary of land use change in Lampung, Indonesia, 1990, 2000, 2005
Source: Reproduced from Swallow et al. (2007)

Figure 17 below presents the results for Lampung where the main source of deforestation is logging and conversion to multistrata coffee. Opportunity cos

4 Costs of REDD and other climate mitigation options

Empirical evidence on the financial returns to alternative land uses on recently deforested land in Brazil and Indonesia suggests that avoiding emissions from deforestation may provide a cost-effective climate mitigation option. The financial returns to a number of land uses, expressed in terms of net profits per ton of CO_2, are below current market prices for carbon. In other words, forest carbon can provide attractive investment opportunities simply from a financial perspective. Moreover, due to the large variation in opportunity costs within forest-rich countries, there appears to be significant scope to achieve efficient outcomes by allowing trade in REDD obligations across land users, while focusing REDD interventions on avoiding the conversion of forest to-high return agricultural uses.

However, there are a number of studies that have estimated the abatement costs of REDD to be higher than the estimates reviewed here (Beinhocker et al. 2008; McKinsey & Company (2009); UNFCCC, 2007). A number of these studies are based on global partial equilibrium models of the forest sector which simulate the dynamics of the world economy. There are three major global partial equilibrium models: GTM, DIMA and GCOMAP[4] which use the same underlying data as more aggregate models, but differ in which sectors they include, the dynamics simulated, interest rates and data on carbon content and deforestation rates. These models produce unit costs of abatement that are significantly higher than the on-the-ground empirical estimates reviewed here. These global models take into account the level of emissions abatement (Boucher, 2008).

Table 11 summarises average opportunity costs estimates from different sources using different methodologies. The table is adapted from Boucher (2008) who provides average opportunity costs as well as the range of estimates. We provide only a range of estimates reviewed in this paper as these estimates should be compared only very loosely due to different methodologies and assumptions in the calculations of NPVs by land use (discount rates, assumptions regarding carbon content of competing land uses, etc.). The Boucher study obtained the raw data from regional/empirical studies and redid the analysis in a standardised manner. It then compared the results to those of the Stern Review and the three main global models. Implementation and transactions costs are not included here

[4] For GTM see Sohngen and Sedjo (2006), Sohngen and Mendelsohn (2007). For DIMA see Kindermann et al. (2006) and Marland and Obersteiner (2007, 2008). For GCOMAP see Sathaye et al. (2006) and Anger and Sathaye (2008).


Iron and steel CCS new build
Low penetration win
Cars plug
Power plant biomass

Figure 18

is therefore critical not only to estimate local opportunity costs, but also to measure carbon content on a local basis.

- A review of empirical opportunity cost estimates suggests that REDD is competitive with most land uses in the Brazilian Amazon and many land uses in Indonesia at a carbon price of less than US$5/ton CO_2e. REDD is competitive with most land uses in Indonesia at US$10/ton CO_2e. Subsistence agriculture and most livestock production systems are characterized by low returns in both Brazil and Indonesia. Logging and cash crops generally exhibit higher opportunity costs.
- While implementation and transaction costs add roughly US$1/ton CO_2e to opportunity costs, these additional costs are not so large as to make REDD (or other forest carbon activities) financially unattractive relative to most forest sector carbon abatement options.

e of less than U

Bibliography

Angelsen, A., Brown, S., Loisel, C., Peskett, L., Streck, C. and Zarin, D. 2008. REDD: An Optio

Cacho, O., Marshall, G.R., and Milne, M. 2005. Transaction and abatement costs of carbon-sink projects in developing countries. Environment and Development Economics 10(5): 597-618.

Chomitz, K. M. and Thomas. 2003. Determinants of land use in Amazônia: a fine scale spatial analysis. American Journal of Agricultural Economics 85(4) November 2003.

Chomitz, K. M., Buys, P., DeLuca, G., Thomas, T.S., and Wertz-Kanounnikoff, S. 2007. At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests. World Bank Policy Research Report. The World Bank, Washington D.C.

Dutschke, M., Wertz-Kanounnikoff, S. with Peskett, L., Luttrell, C., Streck, C., and Brown, J. 2008. Mapping potential sources of REDD financing to different needs and national circumstances. Draft CIFOR Working Paper.

Enkvist, P.A., Naucler, T. and Rosander, J. 2007. A cost curve for greenhouse gas reduction. http://www.epa.gov/air/caaac/coaltech/2007_05_mckinsey.pdf accessed 18.02.09

Food and Agriculture Organisation, 2005. Forest Resource Assessment 2005. FAO, Rome. ftp://ftp.fao.org/docrep/fao/008/A0400E/A0400E00.pdf

Geist, H. J., and Lambin, E. F. 2002. "Proximate causes and underlying driving forces of tropical deforestation". Bioscience, 52(2): 143-150.

Grieg-Gran, M. 2008. The cost of avoiding deforestation: Update of the report prepared for the Stern Review of the Economics of Climate Change: IIED, London, UK.

Grieg-Gran, M. 2006. The cost of avoiding deforestation: Report prepared for the Stern Review of the Economics of Climate Change: IIED, London, UK.

Hansen, M. 2008. Humid tropical forest clearing from 2000 to 2005 quantified by using multi-temporal and multi-resolution remotely sensed data. PNAS, July 8, 2008, vol. 105, no. 27.

Hatcher, J. 2007. Securing rights as a mitigation measure: the costs of recognising tenure rights and carbon benefits. Presentation to the Conference 'Rights, Forests and Climate Change' convened by The Rainforest Foundation, Norway and the Rights and Resources Initiative, Oslo, 17-19 October 2008.

Hoare, A., Legge, T., Nussbaum, R., and Saunders, J. 2008. Estimating the cost of building capacity in rainforest nations to allow them to participate in a global REDD mechanism. Report produced for the Eliasch Review by Chatham House and

Moutinho and Schwartzman (eds.) 2005. Tropical Deforestation and Climate Change. Para, Brazil: IPAM (Instituto de Pesquisa Ambienta de Amazonia); Washington, D.C.: Environmental Defence Fund.

Nepstad, D., Veríssimo, A. Alencar, A., Nobre, C. Lefebvre, P., Schlesinger, P. Potter, C Moutinho, P. Lima, E. Cochrane, M., Brooks, V. 1999. Large-scale impoverishment of Amazonian forests by logging and fire. Nature, 398:505-508.

Nepstad, D., Soares-Filho, B., Merry, F., Moutinho, P., Rodrigues, H.O., Bowman, S., Schwartzman, S., Almeida, O. and Rivero, S. 2007. The costs and benefits of reducing carbon emissions from deforestation and forest degradation in the Brazilian Amazon. Woods Hole Research Centre, Falmouth, MA, USA.

ONF International 2008. Reducing emissions from deforestation and forest degradation (REDD): Analysis of seven outstanding issues for the inclusion of tropical forests in the international climate governance. ONF, Paris.

Pagiola, S. 2008. Payments for environmental services in Costa Rica. Ecological Economics 65.4 (2008).

Pagiola, S. and Bosquet, B. 2009. Estimating the costs of REDD at the country level. Version 1.0 – 24 February 2009. Forest Carbon Partnership Facility, World Bank.

Peskett, L., Huberman, D., Bowen-Jones, E., Edwards, G. and Brown, J. 2008. Making REDD work for the poor. A Poverty Environment Partnership Report, IUCN and ODI.

Sohngen, B. 2008. Paying for Avoided Deforestation: Should We Do It? Choices, 1st Quarter 2008, 23(1).

Sohngen, B. and Sedjo, R. 2006. Carbon sequestration in global forests under different carbon price regimes. Energy Journal 27: 109-126.

Stern, N. 2006. The economics of climate change. Cambridge University Press.

Strassburg, B., Turner, K., Fisher, B., Schaeffer, R. and Lovett, A. 2008. An empirically derived mechanism of combined incentives to reduce emissions from deforestation. CSERGE Working Paper ECM-08-01, Centre for Social and Economic Research on the Global Environment, University of East Anglia, Norwich, UK.

Swallow, B., van Noordwijk, M., Dewi, S., Murdiyarso, D., White, D., Gockowski, J., Hyman, G., Budidarsono, S., Robiglio, V., Meadu, V., Ekadinate, A., Agus, F., Hairiah, K., Mbile, P.N., Sonwa, D.J. and Weise, S. 2007. Opportunities for Avoided Deforestation with Sustainable Benefits. An Interim Report by the ASB Partnership for Tropical Forest Margins. ASB Partnership for the Tropical Forest Margins, Nairobi, Kenya.

Tomich et al. 2005 in Palm, C., Vosti, S., Sanchez, P., Ericksen, P. (eds) Slash and burn agriculture: The search for alternatives. Columbia University Press.

UNFCCC, 2007. Investment and financial flows to address climate change.

Van Kooten, G.C. 2008. Biological Carbon Sinks: Transaction Costs and Governance. Working Paper 2008-12, University of Victoria, Department of Economics, Resource Economics and Policy Analysis Research Group.

Vattenfall, 2007. Global mapping of greenhouse gas abatement opportunities. http://www.vattenfall.com/www/ccc/ccc/Gemeinsame_Inhalte/DOCUMENT/567263vattenfall/P0273261.pdf accessed 18.02.2009.

Vera Diaz, M.C. and Schwartzman, S. 2005. Carbon offsets and land use in the Brazilian Amazon. In Moutinho and Schwartzman (eds.) 2005. Tropical Deforestation and Climate Change. Pará, Brazil: IPAM (Instituto de Pesquisa Ambienta de Amazoni), Washington, D.C.: Environmental Defence Fund.

Vermeulen, S., and Goad, N. 2006. Towards better practice in smallholder palm oil production. International Institute for Environment and Development. London.

Wetlands International 2006.

Wunder, S. and Alban, M. 2008. Decentralized payments for environmental services: The cases of Pimampiro and PROFAFOR in Ecuador. Journal of Ecological Economics, Vol. 65, Issue 4, 1 May 2008.

Appendix 1

Table A1.1: Opportunity cost estimates by land use for the Brazilian Amazon

Region	Land use	Total net return US$/ha	NPV in 2005 US$/ ha A	Adjusted (2) NPV in 2005 US$/ha C=A*(1+ B)	Carbon content ton C/ha D	OC per ton C US$/to n C E=C/D	OC US$/ ton CO2e (1) F=E/ 3.67	Source/methodology	Year of estima te	Commo dity price in year of estimat e, $ G	Long term avg price 2000 2009 $ H	Change in price from baseline year (%) B=(H - G)/G
	Beef cattle											
Amazon												

Region	Land use	Total net return US$/ha	NPV in 2005 US$/ha	Adjusted (2) NPV in 2005 US$/ha	Carbon content ton C/ha	OC per ton C US$/ton C	OC US$/ton CO2e (1)	Source/methodology	Year of estimate	Commodity price in year of estimate, $	Long term avg price 2000 2009 $	Change in price from baseline year (%)
			A	C=A*(1+B)	D	E=A/D	F=E/3.67			G	H	B=(H - G)/G
Amazon												

Country or region	Land use	NPV in 2005 US$	C in baseline scenario ton C /ha (b)	C in new land use ton C /ha (b)	Net change in carbon ton C /ha	OC per ton C US$/ton C (c)	OC US$/ton CO2e (a)(c)	C in baseline scenario ton C /ha (b)	OC per ton C US$/ton C (c)	OC US$/ton CO2e (a)(c)	Source/methodology
			high carbon scenario					low carbon scenario			
	Subsistence Agriculture										
SE Asia and Pacific	Small-scale agriculture/shifting cultivation	499	300	12	288	1.73	0.47	89	5.61	1.53	Robledo and Blaser, 2008. Mix of small scale agricu with market access and shifting cultivation, $1/day income per day (CIFOR)
Indonesia	Rice fallow	26	300	1	299	0.09	0.02	89	0.29	0.08	Grieg Gran 2006 using Tomich et al 1998 (ASB Indonesia) Soil prices, 20% discount rate.
Indonesia	Cassava monoculture										

INTERNATIONAL UNION
FOR CONSERVATION OF NATURE

WORLD HEADQUARTERS
Rue Mauverney 28
1196 Gland, Switzerland
mail@iucn.org
Tel +41 22 999 0000
Fax +41 22 999 0002
www.iucn.org