The Financial Costs of REDD:

Evidence from Brazil and Indonesia

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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 from environmental organizations, development assistance agencies and the business community. Deforestation is one of the largest sources of global greenhouse gas (GHG) emissions, accounting for 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 total costs of meeting GHG emission targets (see Beinhocker *et al*., 2008; Stern, 2006; Grieg-Gran, 2008). However, proponents of REDD are still striving for 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 a 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 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 mitigation options. The objective is to identify 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 estimate the area of forest 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 would remain stored in standing 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 United Nations Framework Convention on Climate Change (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 the national, sub-national and project level costs of REDD are not common. This paper attempts to help fill this gap by proposing a simple framework and reviewing data available for Brazil and Indonesia.

The paper reviews empirical work which suggests that the costs of REDD lie in a range from US$2–10 per ton CO_2e, including implementation and transaction costs. As a portion of the market for voluntary carbon offsets, REDD and related projects are becoming more significant. In 2007, more than two million tons of CO_2e were generated from avoided deforestation projects at an average price of US$4.80 ton/$CO_2$e (Johns and Johnson, 2008). For comparison, the price of emission allowances in the EU Emission Trading System, in October 2008, ranged between EUR 18–25 (US$ 23–33) per ton CO_2e (Ecosystem Marketplace, 2008). Finally, compared to the cost of cutting industrial emissions, which can exceed US$50 per ton CO_2e, the costs of REDD seem quite competitive. In short, avoiding deforestation appears to provide cost-effective opportunities to reduce GHG emissions, particularly when forest land with the lowest opportunity cost is conserved.

Section 2 of this paper sketches out an analytical framework to assess the costs of REDD in different countries, provinces or project areas. Sections 3 and 4 apply this analytical framework to areas of Brazil and Indonesia. Section 5 compares estimates of the costs of carbon abatement based on REDD with other forest sector and non-forest sector carbon abatement opportunities.

2 Analyzing the costs of REDD

This paper looks at the two main cost components of REDD: (i) compensating the opportunity costs of forest conservation and (ii) implementation and transaction costs. There is a large degree of variation both within and between countries with regard to the opportunity costs of forest land, depending on the direct and indirect drivers of deforestation and the carbon content

1 This is an abridged version of a report prepared by IUCN and available at www.iucn.org/about/work/programmes/economics/. The authors gratefully acknowledge support from Rio Tinto for the preparation of this report. The views expressed in this report do not necessarily reflect those of IUCN or Rio Tinto. The authors remain responsible for any errors.

of forests. As a result, on-the-ground estimates of opportunity cost vary according to local conditions and land use and are often significantly lower than estimates produced using global economic models. This paper attempts to provide an analytical framework to quantify the full financial costs of REDD, in order to facilitate private and public sector investment.

2.1 Opportunity costs of forest land

Compensating governments and/or land owners for the opportunity costs of conserving forests 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 the net present value (NPV) that is sacrificed as a result of not logging (or logging more sustainably) or not converting land to agriculture. Opportunity cost is thus the profit gained from continuing 'business as usual'. Opportunity costs vary according to the drivers of deforestation in a specific region or country.

Grieg-Gran (2006) summarizes the factors that affect the opportunity costs of REDD, including methodological issues such as:

- How timber harvesting and land clearing costs are treated;
- What type of forest land is considered;
- How alternative land uses are modelled;
- Which carbon density estimates are used; and
- Whether cost curves or point estimates for carbon abatement are calculated.

And also various economic, social and geographical/physical factors, such as:

- Primary commodity prices;
- The suitability of particular forest lands for different uses;
- Soil and climate conditions which affect yields and hence returns to agriculture;
- Scale of operation – small, medium, large;
- Inputs and technology;
- Distance from market and the quality of transport infrastructure.

The case studies of Indonesia and Brazil presented below examine some of these factors for which data is available.

This paper reviews empirical evidence of the per hectare financial returns (US$/ha) to alternative land uses in Indonesia and Brazil. Per hectare returns are converted to returns per ton of carbon (US$/ton C), based on local or regional estimates of the carbon content of forests. It is assumed that GHG emissions from deforestation equal the total carbon content of above-ground vegetation, expressed as tons of CO_2 equivalent (CO_2e), i.e. returns per ton carbon (US$/ton C) are converted to returns per ton CO_2e (US$/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.

2.2 Implementation and transaction costs

The second major component of the costs of REDD is implementation and transaction costs. This paper considers the costs associated with search, negotiation, verification, certification, implementation, monitoring, enforcement and insurance. Implementation costs are affected by economies of scale and vary depending on whether REDD policies and measures are national or project-based. Implementation and transaction costs are expressed in terms of cost per ton of CO_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), other climate mitigation projects, simulations and the observed costs of implementing Sustainable Forest Management (SFM)[2]. Recent studies suggest that there are significant economies of scale and that large projects and programmes have lower implementation costs per unit of emissions avoided (measured in tons CO_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 smaller number of large transactions (Börner and Wunder, 2008).

2.3 Distributional issues and implications

The distribution of the costs and benefits of REDD among different stakeholders will affect the net cost (and ultimate success) of investments in REDD. PES schemes may offer the closest parallel. To date, the distribution of benefits of most PES schemes has been characterized as neutral, at best, with respect to poverty. For example, small landowners and the poor may be marginalized 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.

Effective and equitable REDD requires clear identification and definition of property rights over forest land; this is likely to increase transaction costs. If forest carbon credits are awarded to land owners, through contracts with carbon investors, the lack of widespread land titling in many countries could pose a significant barrier to

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

forest carbon projects (May *et al*., 2004). However, recent empirical analysis of the costs of recognizing local and indigenous rights (Hatcher, 2008) suggests that this type of expenditure is highly cost-effective (although politically difficult in some contexts).

It is commonly accepted that REDD will not succeed without assurances that the rights of local and indigenous people are recognized and respected. The costs of doing so have been estimated using empirical data from Brazil's efforts to demarcate indigenous territory (US$0.05/ha), Mozambique's demarcation programme (US$0.18/ha), the creation of social reserves and protected areas in Brazil (US$0.50/ha) and World Bank estimates of the costs of land titling in Laos, the Philippines, Indonesia and Cambodia (Hatcher, 2008). The costs of recognizing community tenure and land rights range from US$0.05–9.00/ha (about US$0–0.2/ton CO_2e), with average costs of US$3.35/ha (US$0.08/ton CO_2e). Costs increase with the remoteness of the area, the level of political opposition, and the need for international expertise. Although the unit costs of carbon abatement via REDD would most likely increase with efforts to integrate equity and poverty concerns, these higher costs will need to be met in order to ensure the delivery of project or programme outputs – indeed 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's (2007) estimate of transaction costs (US$0.38/ton CO_2e), Nepstad *et al.*'s (2007) implementation cost estimate (US$0.51/ton CO_2e) and Grieg-Gran's (2006) highest administrative cost estimate (US$0.04/ton CO_2e) to derive a total 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 'back of the envelope' calculation, Sohngen (2008) calculates the potential transaction costs of REDD based on the budget of the USDA Conservation Reserve Program (CRP); coincidentally, he also estimates these costs at about US$1/ton CO_2e. While these costs are not negligible, they are likely to be significantly smaller than the opportunity cost component of most REDD programmes.

3 The Brazilian Amazon

Brazil is responsible for approximately half of annual global deforestation (Hansen, 2008) and is the second largest emitter of GHG from deforestation, accounting for roughly 2.5 percent of global greenhouse gas emissions. Roughly 75 percent of Brazil's total GHG emissions are from deforestation in the Amazon, and represent 8–14 percent of global emissions from land-use change.

The main drivers of deforestation in the Amazon are cattle ranching, soybean production and logging. Extensive, low-yield cattle ranching accounts for roughly 70 percent of deforestation, despite low rates of return, due to fiscal incentives and land speculation (Vera Diaz and Schwartzmann, 2005). Although cattle-ranching is identified as the proximate cause of deforestation, the expansion of soybean cultivation is the underlying economic force behind most deforestation in Brazil. Economic returns to soybean cultivation are high, although its expansion is more constrained by soil and climatic factors than is cattle ranching. Traditionally, the establishment of new soybean farms occurs in areas of established pasture; cattle-ranching is thereby displaced to more remote forested areas and thus soybean is a powerful albeit indirect driver of deforestation. Soybean is increasingly grown in areas with easy access to ports and highways in the Amazon.

Estimates of the per hectare opportunity cost of forest conservation are adjusted by the carbon content (ton carbon/ha) of alternative land uses to derive an estimated cost/ton CO_2e. While there is significant variation in carbon content both between and within provinces and regions, most studies use either averages by province (Börner and Wunder, 2008) or for the Amazon as a whole. For the carbon content per hectare of primary forest in Amazonas, values range from 110 tons C per ha (Houghton *et al.*, 2001 cited in Börner and Wunder, 2008) to 155 tons C per ha (based on estimates ranging from 121 to 397 tons C per ha (Brown and Lugo, 1992; Fearnside, 1997; Houghton *et al*., 2001 cited in Vera Diaz and Schwartzman, 2005).

Empirical estimates of opportunity costs are low and the studies reviewed here suggest that, at current carbon prices in both voluntary and compliance markets, carbon sequestration can compete with most prevalent land uses in the Amazon. Expressed in terms of cost per ton CO_2e, the opportunity cost of cattle-ranching ranges from zero for traditional pasture to US$2/ton CO_2e for small-scale and traditional ranching. As roughly 80 percent of recently deforested land is used for ranching, the scope for achieving cost-effective reductions in CO_2 emissions through avoided deforestation seems promising.

REDD is somewhat less competetive with soybean production, which has opportunity costs ranging from US$2.5 to US$3.5/ton CO_2e. Nepstad *et al*. (2007) calculate that to eliminate deforestation completely in the Brazilian Amazon would cost US$1.49/ton CO_2e, but that to reduce deforestation to 94 percent of projected levels would cost only half that amount at US$0.76/ton CO_2e. The difference is largely attributable to the high opportunity costs of foregoing soybean production. Similarly, Vera Diaz and Schwartzman (2005) estimate the cost of eliminating deforestation at US$5.44/ton CO_2e including soybean production and US$2.34/ton CO_2e excluding soybean production.

Adding an estimated US$1/ton CO_2e in implementation and transaction costs to the opportunity cost estimates reviewed above increases the total costs of avoided deforestation significantly. For the highest opportunity cost estimates reviewed, i.e. high-productivity timber harvest followed by ranching and soybean production, the addition of implementation and transaction costs increases the costs of REDD to US$7.1/ton CO_2e.

4 Indonesia

In 2007, Indonesia became the third largest emitter of GHGs globally. Roughly 85 percent of Indonesia's emissions are due to deforestation, forest degradation and forest fires. Indonesia is the world's top emitter of GHGs associated with the draining of peatlands, which is responsible for over five percent of annual global emissions of GHGs from human activities (Joosten, 2009). The rate of deforestation has increased in recent years from 1.61 percent per year (1990–2000) to 1.91 percent per year (2000–2005) while the annual loss of primary forest has increased by 25 percent over the same period. Clearly, Indonesia's extensive tropical forest cover is threatened with rapid degradation and conversion.

The direct causes of deforestation and forest degradation in Indonesia include logging for timber, the establishment of large-scale tree crop estates and industrial timber 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 hectares 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 private 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 incentives to convert forest to export tree crops, such as oil palm, rubber, cocoa and coffee. Competition between migrants, indigenous people and large-scale investors accelerates deforestation on islands with greater population density, e.g. Sumatra. Logging is a powerful driver of forest degradation on some 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-half of the world's tropical peatlands, which are extremely rich in carbon. In recent decades, these ecosystems have been widely cleared and converted to oil palm, fast-growing tree plantations for the pulp and paper industry, large scale irrigated rice production and small scale agriculture. Large carbon emissions occur when peatlands are burned or drained. In a study of three provinces (East Kalimantan, Jambi and 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 of 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 estimates) and the FAO Forest Resource Assessment (FRA) (low carbon estimates). Based on data from the ASB study (Swallow *et al.*, 2007), 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 between the carbon content of undisturbed forest and the carbon content of the alternative land use (i.e. slash and burn farming) for the high carbon content estimates. However, for the low carbon content estimates, 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 from US$0.49/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 in Indonesia. 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/ton CO_2e for commercial logging in Sumatra to US$3.44/ton CO_2e for unsustainable commercial logging in Southeast Asia and the Pacific. Both 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.

The sensitivity of the results with regard to the carbon content of both undisturbed forest and the land use following deforestation underscores the need to assess carbon stocks at a local level as there is significant variation even within forests. Adding US$1/ton CO_2 in implementation and transaction costs to the opportunity cost estimates reviewed above increases the costs of avoided deforestation significantly. However, the cost of abating carbon emissions based on REDD in Indonesia remains below US$10/ton CO_2e for most land uses and below US$5/ton CO_2e for many land uses (see Table 1).

5 REDD versus other emission abatement opportunities

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_2e, 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 low-return agricultural uses.

Table 1 summarizes the range of estimates of the opportunity costs of REDD, based on different sources and methodologies. The estimates reviewed in this paper are compared to those provided in the Stern Review (2006) and those of global partial equilibrium models of the forest sector, which simulate the dynamics of the world economy. Three major global partial equilibrium models have been used to assess the costs of REDD: GTM, DIMA and GCOMAP[3]. All rely on the same underlying data as more micro-level models, but differ in which sectors are included, how dynamics are simulated, assumed 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, in part because the models take into account the overall level of emissions abatement (Boucher, 2008). Implementation and transaction costs are not included in the table.

McKinsey & Company (2009) use global estimates to compare the cost-effectiveness of a range of carbon abatement opportunities across all

Table 1: Opportunity cost estimates of REDD from different sources

Approach	Land use	Opportunity cost estimate US$/ton CO_2e		
		Average	High	Low
Global models (various)		11.26	17.86	6.77
Stern Review (2006)		5.52	8.28	2.76
Regional, empirical (various)		2.51	4.18	0.84
This review:				
Brazil	Ranching		3.0	0
	Soybean		3.4	2.5
	Subsistence agriculture		1.1	0
	Timber+ranching+soybean		6.1	3.9
Indonesia – high carbon estimates (FAO)	Palm oil		4.29	0.18
	Subsistence agriculture		0.47	0
	Logging		3.44	1.65
Indonesia – low carbon estimates (ASB)	Palm oil		19.6	0.5
	Subsistence agriculture		1.53	0
	Logging		7.96	3.82

Source: Adapted from Boucher (2008), including estimates from this review

3 For GTM see Sohngen and Sedjo (2006). For DIMA see Kindermann *et al.* (2008). For GCOMAP see Anger and Sathaye (2008).

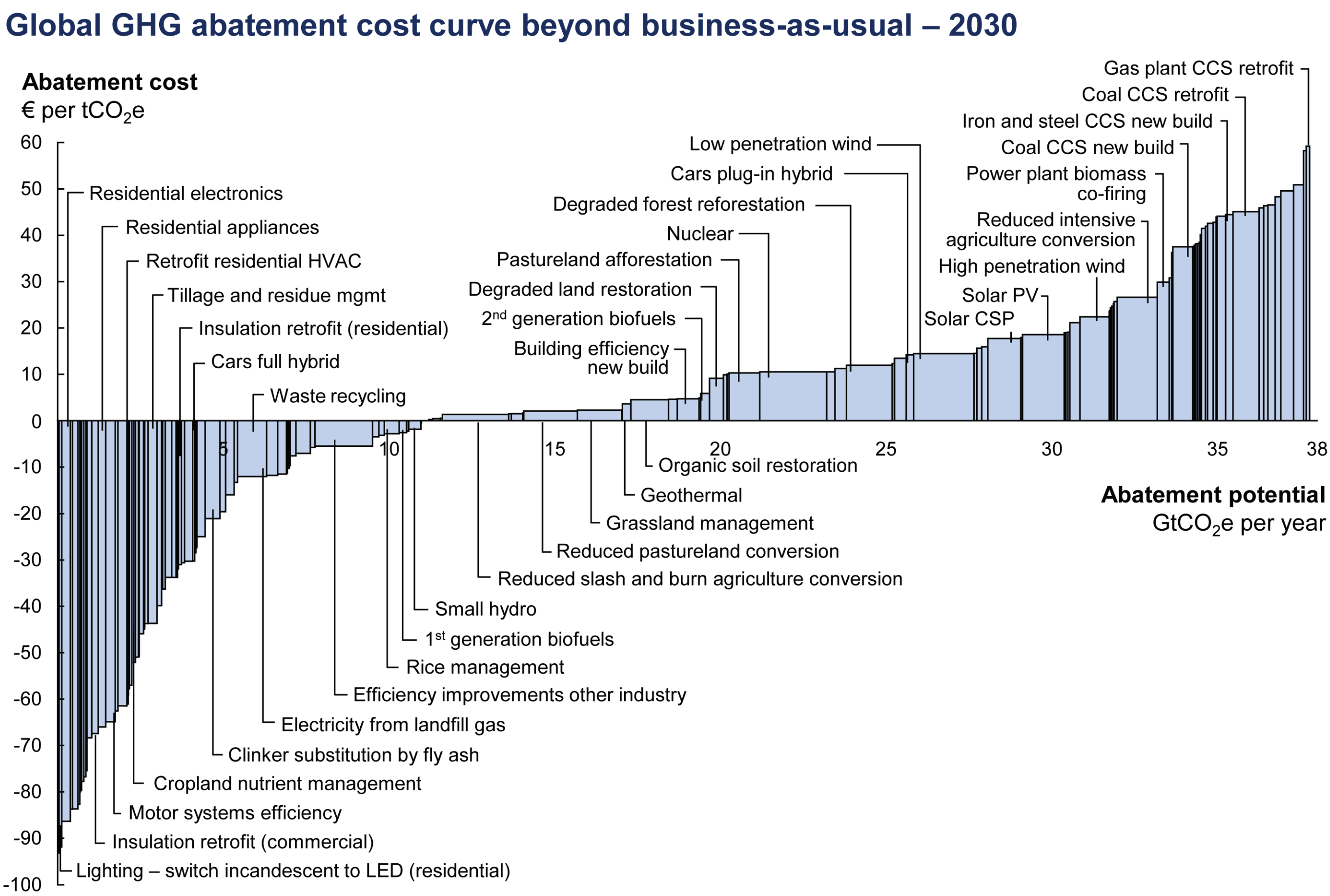
sectors. Figure 1 presents a cost curve of abatement options. The estimates reviewed in this study (converting US$ estimates into euros at the 2005 exchange rate of US$1=1.25 EUR) are consistent with McKinsey & Company's estimates for reduced slash-and-burn agriculture and reduced pastureland conversion at less than EUR 5/ton CO_2e. These abatement options appear to be more cost effective than many non-forest 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 & Company (2009) find that the costs of abatement through the avoidance of forest conversion to intensive agriculture are higher and cannot compete with solar and wind power, for example. However, it must also be acknowledged that the data in Figure 1, 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 regional 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

Figure 1: Cost curve of abatement opportunities



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: McKinsey & Company, Global GHG Abatement Cost Curve v2.0, 2009

Indonesia, reflecting differences in local conditions, land use and proximity to transport infrastructure and markets. National, regional and global averages are of limited usefulness in 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 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 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 other non-forest sector carbon abatement options.

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Rio Tinto

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Rio Tinto is one of the world's leading mining and exploration companies. Collaboration with IUCN will help Rio Tinto move closer to its goal of achieving a 'net positive impact' – which means minimising its impacts on the environment and ensuring that biodiversity conservation ultimately benefits from Rio Tinto's presence in a region. The collaboration with IUCN also aims to help both organizations address emerging issues such as the management of protected areas and ecosystem service provision.

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