Estimating opportunity costs of Avoided Deforestation (REDD): application of a flexible stepwise approach to the Indonesian pulp sector

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SUMMARY

Developing countries are expected to contribute to climate change mitigation efforts by reducing deforestation, with financial compensations for associated economic losses. These losses are due to foregone revenues and limited economic development, all of these labeled "opportunity costs". Their accurate estimation is strategic for at least two reasons: to determine fair compensations, and to prioritize low cost strategies to reduce emissions. However, numerous interpretations of the opportunity cost concept coexist in the literature and in influential reports (e.g. Stern review), with differing estimated values for similar cases. This paper presents a framework to better identify relevant values to the calculations: profits / total national economic value, conservation site / downstream industries. When applied to the pulp sector in Indonesia, the framework yields contrasted opportunity costs. This contrast is due to several factors, including the heterogeneity of the pulp industry, or the availability of non-forested lands to displace activities. These values range from zero to one thousand dollars per hectare per year. To use such a framework would help gain credibility and achieve fairness in negotiations between host countries and other stakeholders, in particular those who fund activities to reduce deforestation.

Keywords: opportunity cost, avoided deforestation, REDD, pulp industry, Indonesia,

Estimation des coûts opportuns de la déforestation évitée (REDD): application d'une approche pas à pas flexible dans le secteur de la pulpe en Indonésie

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Il est prévu que les pays en voie de développement contribuent aux efforts d'atténuation du changement climatique en réduisant la déforestation, avec un octroi de compensations financières pour les pertes économiques résultantes. Ces pertes sont dues aux revenus perdus et au développement économique limité, tous labellisés: coûts opportuns. La précision de leur estimation est stratégique pour au moins deux raisons: déterminer des compensations justes, et donner priorité aux stratégies à coût bas pour réduire les émissions. Cependant, de nombreuses interprétations du concept de coût opportun coexistent dans la littérature associée et dans les rapports influenciels comme l'étude Stern, ayant chacune des valeurs estimées différentes pour des cas similaires. Cet article offre un cadre pour mieux identifier les valeurs importantes pour les calculs: profits/ valeur économique nationale totale, site de conservation/ industries en aval. Appliqué au secteur de la pulpe en Indonésie, ce cadre révèle des coûts opportuns contrastés. Ce contraste est dû à plusieurs facteurs, lesquels incluent la nature hétérogène de l'industrie de la pulpe, ou la disponibilité de terres non boisées pour déplacer des activités. Ces valeurs vont de zéro à mille dollars par hectare par an. L'utilisation d'un tel cadre aiderait à gagner une crédibilité et à obtenir davantage de justice dans les négotiations entre les pays hôtes et les autres parties prenantes, en particulier celles finançant des activités visant à réduire la déforestation.

Cálculo de los costos de oportunidad de la Deforestación Evitada (REDD): aplicación de un modelo flexible paso a paso en el sector indonesio de pulpa de madera

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Se espera que los países en vías de desarrollo contribuyan a los esfuerzos para paliar los efectos del cambio climático por medio de la reducción de la deforestación, y se proporcionan indemnizaciones financieras para compensar las pérdidas económicas asociadas. Estas pérdidas se deben a la pérdida de ingresos y la limitación del desarrollo económico, llamadas 'costos de oportunidad'. El cálculo exacto de estas pérdidas tiene una importancia estratégica por al menos dos razones: la determinación de una indemnización justa, y la prioritización de estrategias de bajo costo para reducir las emisiones. Sin embargo, existen numerosas interpretaciones del concepto del costo de oportunidad en el material publicado y en los informes importantes (p.ej. el informe Stern), y cada una postula valores estimados diferentes en casos similares. Este estudio presenta un modelo para mejorar la identificación de valores relevantes para el cálculo, como por ejemplo las relaciones entre beneficios y valor económico nacional global, y entre la zona de conservación y las industrias de río abajo. Al aplicarse al sector de

pulpa de Indonesia, el modelo demuestra un contraste en los costos de oportunidad. Este contraste se debe a varios factores, incluyendo la heterogeneidad de la industria de pulpa y la disponibilidad de tierras no forestales para reemplazar las forestales en las actividades. Estos valores oscilan entre cero y mil dólares anuales por hectárea. El uso de un modelo parecido ayudaría a establecer una mayor credibilidad y a lograr negociaciones más justas entre los países en vías de desarrollo y otros interesados, sobre todo los que financian las actividades para reducir la deforestación.

INTRODUCTION

The COP13 in Bali was an important step towards enhanced efforts for climate change mitigation. The Climate Convention (UNFCCC) resulted in the Kyoto Protocol a decade ago with legally-binding targets for Greenhouse Gas (GHG) emissions in industrialized countries. While focusing on fossil fuel emissions, this agreement did include carbon stocks in industrialized countries forests in national carbon accounts. Besides, the Clean Development Mechanism (CDM) allows industrialized countries to make part of their emissions reductions in developing countries. Regarding forestry projects under the CDM, agreements in 2001 limited eligible activities to afforestation/reforestation activities (Neeff and Henders 2007).

Tropical deforestation (broadly speaking) was responsible for emissions amounting to 15-35% of those generated by fossil fuels in the 1990s (Houghton 2005). Since ignoring such a source of emissions would affect climate change mitigation, the formal inclusion of "avoided deforestation" (REDD: Reduced Emissions from Deforestation and forest Degradation[1]) in the Kyoto Protocol recently became a source of discussion in international fora (Skutsch *et al.* 2007).

Influential proponents of avoided deforestation, e.g. Stern review (2006) or Chomitz *et al.* (2006), believe that the average cost of reducing tropical deforestation (usually equalled to the opportunity cost) is low compared to emissions reductions in industrialized countries. Simultaneously, developing countries argue that reducing deforestation generates high opportunity costs, mostly in terms of economic development. It is common that countries provide global figures, more or less based on previous studies, as did for instance Indonesia's environment minister: "*We will ask for a compensation of $5-10/ha*" (Reuters 8 October 2007[2]), or the Democratic Republic of Congo's president who claimed three billon dollars for protecting forests.

This issue is highly sensitive. If REDD takes the form of a Multilateral Fund that finances initiatives and measures to reduce deforestation, then tropical countries would *negotiate* compensations based on estimated opportunity costs. It is less relevant if REDD generates carbon credits fungible with the international carbon markets, because prices then will be *fixed* by the market. But in all cases opportunity costs remain strategic for determining the role that tropical forests will play in climate change mitigation efforts.

So far studies have focused on the costs of sequestration, i.e. mostly afforestation activities or forest management. Richards and Stokes (2004) provide an extensive review of carbon sequestration cost studies since the early 1990s, and conclude that results are hard to compare because of "*inconsistent use of terms, geographic scope, assumptions, and methods*". Their review in principle comprises three main types of activities: afforestation, forest management, and avoidance of conversion; yet most of the studies they quote relate to the first category and to North America area. These studies are hardly replicable to the conservation of natural forests in tropical developing countries for methodological reasons: illegal logging is a widespread phenomenon, unknown land prices with poorly recognized land ownership, informal markets are commonly favoured, etc.

This being said, the clarification of the concept of opportunity costs for tropical forest conservation is very much required for current negotiations on REDD. Calculations of these opportunity costs thus require methods that suit various contexts in order to avoid inequitable outcomes: inappropriate calculations potentially lead to inappropriate compensations. Referring to the proceedings of the international workshop on which is based this IFR special issue (Karsenty *et al.* 2008), it was noted that "*the reliability of* [opportunity costs'] *calculation has given rise to a debate on the relevance and use of such exercises*". By definition these methods tend to estimate low costs for subsistence agriculture and high costs for industrial activities, with the possible risk to "*stick poorest farmers into their current poverty levels*" (*ibid*) if compensations are based on simplistic calculations of farmers' revenues.

Next section analyses the concept of opportunity costs in relation to forest conservation. The third section presents a stepwise approach for making opportunity costs calculations more relevant. The fourth section applies the stepwise approach to the pulp sector in Indonesia. The last section draws conclusions.

OPPORTUNITY COSTS: WHAT DOES IT MEAN FOR CARBON SEQUESTRATION?

Basic notions and definitions

The opportunity cost is a concept which definition involves two core notions: (i) the notion of a foregone opportunity, meaning that an investment, activity, or use of a resource,

[1] At the COP13 it was decided to include « Degradation » during the preliminary phase at least until COP15 in Copenhagen.
[2] Available on www.reuters.com/article/environmentNews/idUSJAK10785920071008.

all prevent an alternative investment, activity or use of the resource; and (ii) the notion of a cost, meaning that the foregone opportunity would have provided benefits.

Alternatively named economic cost, it is "*the cost of something in terms of an opportunity forgone*" (Wikipedia, consulted 4 October 2007), as opposed to the accounting cost (operational, investment…) expressed in monetary terms. Some argue that the word "opportunity" is redundant, but useful in reminding that in economics "*the cost of using a resource arises from the value of what it could be used for instead*" (Concise Encyclopedia of Economics). Therefore, the sum of both costs assesses the true cost of any course of action. In the case of forest conservation, the accounting cost is limited to operational costs (salaries to security guards mainly), but the conservation might prevent people from generating value with agriculture.

The concept of opportunity cost is based on scarcity and exclusiveness, because a course of action prevents another one. Forest conservation could take place along with other land uses in a world without land scarcity, thus suppressing opportunity costs. But scarcity usually then translates into exclusiveness when two activities or land uses cannot take place simultaneously. They are *mutually exclusive*.

To estimate the cost of preventing an activity, we need to define two values that explain its contribution to the national economy:

(i) The "total national economic value" is the sum of all expenses that an activity generates in the country: employment, machinery, taxes, etc. It does not include payments abroad, such as equipment imports. Its rationale is to estimate the total contribution of an activity to the national economy.
(ii) The "profit" is the "*redistributive share different from the returns to the productive services of land, labour, and capital*" to take the seminal definition by Knight (1921). It is the benefit to the entrepreneur after all expenses have been paid, included the cost of capital. Its rationale is to estimate the specific contribution of an activity compared to other investment opportunities in a country.

Identification of foregone opportunities: several issues to consider

To take the most valuable alternative as the opportunity forgone, assumes that no limited rationality for the decision-taker neither the presence of barriers would prevent its realization. But the real opportunity cost might better rely on the alternative option with the highest probability. This distinction finds an important application with "avoided deforestation", where the opportunity foregone is identified with the business-as-usual scenario (what would happen with deforestation). While host countries that participate to the mechanism have an interest to point to the most profitable land uses, these would not necessarily take place. It is difficult, to say the least, to determine the shares of each land use based on its profitability, notwithstanding the variability of output prices and resulting profits.

Second, scarcity of production factors relatively to investment opportunities determines opportunity costs. For instance, a capital-intensive pulp mill in a country with insufficient capital availability (like Indonesia) has high opportunity costs because it limits investments in other sectors. Reversely, labour-intensive industries (e.g. garment manufacturing) are appropriate in densely populated countries because they do not limit other activities from a labour perspective.

Related to the previous issue, any barrier to a project (e.g. not allowing forest conversion) is especially costly in a country with few investment opportunities, because it means that capital cannot be invested in any other project *instead*. Reversely, the cost would be low in a country with limited availability of capital because the investment might be simply *diverted* to another sector or geographical area with a contribution to the national income. Opportunity costs might be respectively the total national economic value of the project or just the profits it generates[3]. As an application to avoided deforestation: it is likely that logging companies in Central Africa would move to other countries if not allowed to log forests; on the contrary it is plausible that Indonesian conglomerates, if not allocated licenses to build pulp mills, would invest in other domestic sectors through their own active subsidiaries.

Land uses are frequently connected to various industries: oil palm plantations supply factories that process CPO into biodiesel, Acacia plantations supply pulp mills, etc. This justifies in some cases to include downstream investments in the opportunity cost of not deforesting. But it is not straightforward because, once again, scarce capital might be invested in other productive sectors instead of downstream industries.

Social *versus* Private opportunity cost

The opportunity cost can be viewed from a social or private perspective. The latter view is limited to the agents directly affected by forgone opportunities. It could be a worker who loses employment when a local project is cancelled.

But the social opportunity cost embraces the national economy and its estimation should theoretically include all collateral effects of a course of action. In particular, the alternative use of capital when specific investment options are suppressed is important (e.g. domestic use or investment abroad). In the case of forest conservation, the local impacts on labor and taxes are simple to measure. However, positive impacts in other geographical areas and sectors where capital and labour are used might be uneasy to measure, and impacts on the national economy might be hardly identifiable. If investments are displaced, impacts on the national economy

[3] The terms 'total national economic value' and 'profit' are defined in the Box 1.

could be equivalent overall, but some people will benefit from new opportunities to the detriment of others living in the area with conservation. This is less true in case rural migrations accompany the move of capital.

Lessons from carbon sequestration cost studies

Great efforts were done by Richards and Stokes (2004) to review carbon sequestration cost studies since the early 1990s. Reviewed studies make diverse assumptions for various parameters: carbon yield is an emblematic example of these discrepancies. Not only do the studies inconsistently use various terms as important as "ton of carbon" and refer to distinct geographical areas and scales, but they also base their calculations on different time horizons or discount rates. In addition, the methods belong to three distinct categories, which "*complicates direct comparison of study results*". These three categories are briefly presented below:

(i) Bottom-up engineering studies in their most simple form consider observable prices from agricultural land rental or purchase markets (e.g. de Jong *et al.* 2000). More sophisticated studies account for increasing marginal costs of land with some kind of elasticity (e.g. Richards *et al.* 1993), in order to include the effects of afforestation programs on the availability of agricultural lands. Estimations are labelled "rents" or "net returns", which is pretty close to the "profits" as defined in the present paper. The method has a limited scope because land prices are the only proxy for net returns.

(ii) Sectoral models add an important component to the first category with endogenous prices that orient the method towards spatial equilibrium models (e.g. Alig *et al.* 1997). Thus the studies can incorporate the leakage effects when afforestation in one place causes price increases in the agricultural markets and forest conversion in other places. While enabling on the one hand up-scaled cost estimations, on the other hand costs for specific projects and sites cannot be estimated.

(iii) Last, econometric studies basically model historic land uses as a function of market prices, but consider actual decisions rather than they model decision-making as a function of expected profits. This category is by nature more oriented towards predictions of the respective shares of land uses, rather than to an estimation of opportunity costs to divert land away from agricultural production. Yet one study attempted to indirectly estimate forest conservation costs in Costa Rica by comparing economic yields of forest clearance *versus* conservation scenarios with revenues from the sale of carbon credits (Kerr *et al.* 2001).

Apart from telling us how fragmented and heterogeneous are the available cost estimations for carbon sequestration, this large review also provides key lessons regarding the opportunity costs of avoided deforestation. We understand that land prices are usually considered a prerequisite of any cost estimation, and that studies are mostly based on the conversion of agricultural lands (either pastures or cultivated fields) into forested lands. When studies address actively managed forests for timber production, the future economic benefits are pretty straightforward to model and predict. But these conditions are rarely satisfied for avoided deforestation. Not only might the natural forests not be exploited for commercial purposes, but land prices do not exist and future land uses are quite uncertain.

This very different context makes it unrealistic to base opportunity costs estimations on similar methods. Avoided deforestation in tropical developing countries will likely be a result of domestic policies such as stricter criteria for the allocation of forest conversion permits, the protection of forests from encroachment by surrounding populations, improved law enforcement, etc. (Pirard and Karsenty In press). Land uses after forest conversion are potentially diverse and investments are yet to be realized. Some are legal, some are not. Some take place on state forests, others on private or community lands. Some are small-scale and rely on local investors, but others are large-scale and based on foreign capital.

Contrasted assumptions in forest conservation cost studies

Although opportunity costs are the entry point to all studies on forest conservation costs, a succinct literature review shows how diverse are the definitions and methods of calculation. The Table 1 supports this point with a classification of five articles published in academic peer-reviewed journal with impact factor (except for the influential Stern review). This limited number of cases provides interesting insights regarding methods and assumptions:

- Some studies follow a total national economic value approach that equals opportunity costs of conservation to the various economic benefits provided by an alternative land use (employment, taxes mainly); while other studies follow a profit-oriented approach that equals opportunity costs to investment returns
- Scale is local, regional or national
- All studies take costs and prices at current values, thereby assuming no evolution in time (although up to 30 years time horizon). One study only points to the implication in terms of poverty alleviation in the long run
- Investor's alternative strategies are investigated in two cases (domestic / foreign)
- Only activities on site are addressed, except for one study that includes downstream effects (transportation and mill processing)
- Various time horizons and discount rates
- One study only used the classical (yet modified) approach with land prices as a proxy for land value

TABLE 1 *Characteristics of various published methods of calculation for opportunity costs for forest conservation*

Reference	Business-as-usual land use*	Scale of analysis	Basic value for cost calculation	Analysis of downstream effects	Analysis of investor's alternative strategies	Inclusion of timber harvesting benefits before conversion	Inclusion of conservation benefits	Specifics
Naidoo and Adamowicz (2006)	Past conversion rates for each land use	Regional	Profit/ha estimated as weighted-mean of net benefits (regional estimates) based on past conversion rates	No	No	No	No	Discount rate 20%
Stern (2006), based on Grieg-Gran (2006)	Past conversion patterns or "subjective assessment drawing from qualitative statements"	National	Profit/ha taking average national land productivity	No	No	Yes / No	No	Time horizon 30 years, discount rate 10% (for most of cases)
Kremen *et al* (2000)	(i) Land use with highest alternative return at national level (industrial logging) plus subsequent rice field after forest damage due to poor law enforcement (ii) Same with assumption that only one-third due taxes are paid (iii) only industrial logging with full law enforcement	Local (employment), and national (employment, taxes, infrastructure development)	Taxes and employment (logging), "value" for rice fields (not further specified)	No	Alternative investment abroad	-	Estimated separately	Use market values and shadow prices; 10 and 30 years time horizon; 3-10-20% discount rate.
Karsenty (2007)	Concession allocation plans	Site of conservation plus sectoral impacts	Taxes (government and population) and revenues from employment	Transportation and processing activities related to timber logging	Alternative investment abroad	-	No	Stresses need to assume increasing revenues with logging operations

Chomitz *et al* (2005)	Related to land characteristics (soil quality, soil quality, slope, climate, road proximity, land cover)	Regional	Land price estimated with regressions on land characteristics	No	No	Yes (indirectly as forest cover is one explanatory variable for land value)	No	No business-as-usual land use

* What would happen without conservation.

PROPOSAL FOR A FLEXIBLE STEPWISE APPROACH

Building on the diversity of views, methods and contexts as showed in previous sections, a general framework is provided for the calculation of opportunity costs of avoided deforestation. This stepwise approach is flexible in the sense that it derives formulae that suit key characteristics of each case. The following operational definition is proposed:

"*The social opportunity cost of avoided deforestation is the financial loss for a country when one hectare of forest prevents another land use as determined by the business-as-usual scenario. This financial loss also considers the most obvious alternatives for investors, and impacts on downstream industries*".

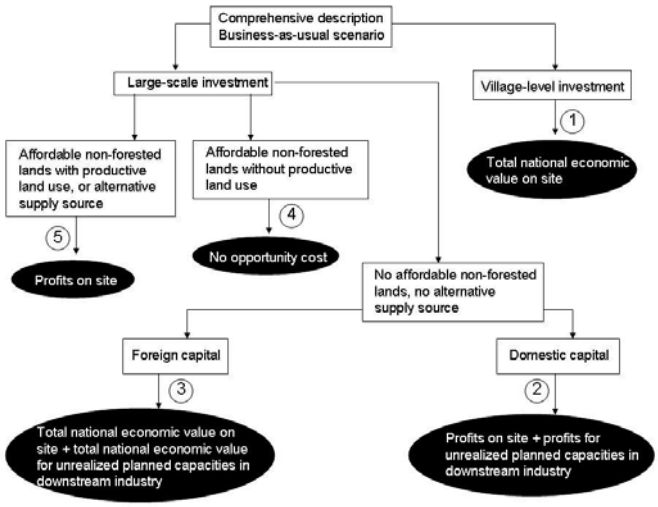
A flexible stepwise approach requires simplicity for being operational while guaranteeing fair and credible cost estimations. This trade-off translates in the necessity to be context-specific and inclusive of the most significant side effects (e.g. downstream industries) of avoided deforestation, while not using costly and time-consuming methods (e.g. exhaustive cost-benefit analyses). Moreover, cost estimations are likely to be more useful in classifying high / low costs rather than refining estimations. Precise estimations are indeed most justified for determining individual compensations to land users (e.g. *private* opportunity costs).

Therefore this approach merely intends to orient the calculation in the right direction in order that decision-makers do not miss the real low cost strategies for reducing deforestation. Once a direction is chosen, the choice of assumptions like discount rates and time horizons is as debatable as for any other opportunity cost calculation.

Several pathways appear in the Figure 1 and each of them is detailed below as a matter of clarification. An important assumption is that no leakage occurs, i.e. avoided deforestation does not generate forest conversion elsewhere. Note that pathways are mutually exclusive.

Pathway 1: Avoided deforestation prevents village-level investments, i.e. on a small-scale basis and without external financing. The opportunity cost is equal to the total national economic value on site generated by the business-as-usual land use. The rationale is that villagers do not have alternative opportunities for investments because of limited access to lands and productive sectors of the economy. It follows the logic of the Payments for Environmental Services

FIGURE 1 *Flexible stepwise approach*



whereby villagers earn revenues from forest conservation without alternative opportunities. Ex.: Shifting cultivators or smallholders of coffee plantations do not engage in alternative activities and might lose all economic value generated by land uses following deforestation.

Pathways 2 and 3: Avoided deforestation prevents large-scale investments that cannot be displaced to non-forested lands (physical or economic reasons), and which production for domestic industries (if any) cannot be substituted by alternative supply sources at affordable prices. Consequently downstream industries (if any) will not be realized. The question is whether investments in business-as-usual land uses and downstream industries will be diverted to other activities within the country or abroad. We assume that this relates to the capital origin: domestic investors find other opportunities within the country, but foreign investors look for opportunities abroad. Ex. pathway 2: A domestic group invests in palm oil plantations and mills that process fresh fruit bunches into crude palm oil. If not allowed to establish the plantation, the investor finds with alternative investments in the country. Ex. pathway 3: a foreign group invests in forest concessions to supply plywood mills located nearby. If not allowed to manage the forest concession, the investor looks for alternative investments abroad.

Pathway 4: In specific contexts forest conversion takes place although non-forested lands are available with similar

land characteristics except for forest cover. Among the reasons for such a situation, the forested lands might be close to the markets, or forest conversion generates substantial benefits with timber sales. In this context, avoided deforestation does not generate opportunity costs to the country because land uses are simply displaced to non-forested lands. Yet the necessary condition for opportunity costs to be low or nil is that no competition takes place among productive land uses on non-forested lands. Ex.: A pulp and paper (P&P) group lobbies the government for controlling tree plantation concessions close to the pulp mills with rights to clear-cut remaining natural forests for pulpwood production. As barren lands are located further, the government might decide to relocate tree plantation concessions.

Pathway 5: The difference with pathway 4 lies in the competition among productive land uses on non-forested lands with the consequence that land uses are mutually exclusive to some extent. In this context, we assume the opportunity cost to be equal to the profits generated after forest conversion on site. Also relevant to pathway 5, the case where alternative supply sources exist within the country or abroad to supply downstream industries. Ex.: Example is similar with pathway 4, but the P&P group needs to compensate right-holders to the land (villagers, smallholders, or the State) in proportion to foregone opportunities.

The stepwise approach has limitations for application that are due to somehow indeterminate thresholds. To take an example, it is debatable and certainly not straightforward to classify lands as "affordable". But the approach is merely intended to provide guidance in the choice of data and calculation formulae, in order to match local contexts, and thus flexibility in its application is a logical outcome.

APPLICATION OF THE STEPWISE APPROACH TO THE PULP SECTOR IN INDONESIA

In this section the stepwise approach is applied to the pulp sector in Indonesia. This sector has several important characteristics:

1. By 2005 the country's installed pulp production capacity reached 6.3 million tonnes per year (tpa), making the country the ninth world producer. The expansion was extremely rapid, with only 706 000 tpa in 1989.
2. Very specific to Indonesia, the major pulp producers have used Mixed Tropical Hardwood (MTH, natural forests) for production and plantations have remained a minor supply source until recently.
3. Pulpwood plantations were established after forest conversion, and new concession permits are still distributed on forested areas mostly. No regulation so far has been drafted to prevent producers from converting natural forests.

Baseline scenario for deforestation related to the pulp sector

Among the most influential factors for future deforestation related to the pulp sector: (i) rules and their enforcement, and (ii) available domestic plantations with low cost supplies to the pulp mills. Each of these is discussed below. Pulpwood plantation establishment has traditionally been motivated by domestic fibre needs, with the exception of several plantations in Kalimantan that might possibly export chips (Pirard and Cossalter 2006). Therefore the baseline scenario used in this paper is based on the domestic demand for pulpwood.

Note that figures are intended to be illustrative. While these figures are based on previous analysis and research by the author, they should not be given too much importance. The focus is on qualitative analysis and conclusions.

Regulations and their enforcement

The conversion of natural forests has been subject to changing regulations in Indonesia. The word "conversion" is not used by Indonesian authorities in the case of subsequent tree plantation establishment, because it officially refers only to the excision of lands from the forest domain to the non-forest domain (e.g. oil palm). Instead, the Ministry of Forestry (MoF) introduced the concept of "productive / unproductive forest" that justifies conversions of degraded forests (unproductive) into tree plantations (productive).

Since1986 HTI concessions (large-scale tree plantations) must be allocated on unproductive forests, but the definition of "productive forests" has varied with a criterion ranging from 5 to 20 m^3 commercial timber per hectare (among other criteria). Yet, a key regulation was issued in 2004 that allows pulp mills to convert natural forests up to 2009 and whatever the standing volume. The criteria for the period after 2009 are in the process of elaboration, but will likely be flexible to allow the distribution of conversion permits on primary forests in the Papua province that enjoys a large autonomy.

The Table 2 recapitulates some key regulations with their impact on forest conversion depending on enforcement.

Next, what about the size and localization of the plantation estate? Official targets for plantation development have been repeatedly well above effective implementation since the early 1980s (Iskandar *et al.* 2003), so we question the relevance of latest MoF targets. The report drafted by senior advisors to the MoF (Departemen Kehutanan 2007) announces 5 million hectares plantations in HTI concessions by 2009, and 5.4 million hectares of community tree plantations in the decade 2007-2016. The MoF "Strategic plan" for 2005-2009 (Departemen Kehutanan 2006) provides slightly different figures.

Availability of low cost pulpwood plantations

Official figures on standing pulpwood plantations are poorly reliable, not only because of deficient data management at the MoF, but also because the pulp sector in Indonesia is opaque with large financial amounts at stake and controversial

TABLE 2 *Regulations for pulpwood plantations: likelihood, implementation and impact*

Regulation	Likelihood of issuance	Assumed degree of enforcement if issuance	Resulting deforestation if issuance, based on degree of enforcement
Lax criteria for forest conversion in Papua	High	High	High
No conversion on peat soils	Medium	Medium	Medium
Strict criteria on remaining timber stocks for conversion	Low	Low	Medium
Ban on wood chip exports	Low	High	Uncertain
Match allocation of concessions to domestic pulp capacities	Low	Low	Uncertain
Ban on MTH use for pulpwood	Low	High	Low
Increasing requirements for set-asides within concessions	Medium	Medium	Medium

management. The two main groups APP and APRIL are those on which we concentrate our efforts, because they represent a majority of the domestic wood pulp capacities (> 80%) and the two other significant pulp mills are not engaged into forest conversion. The mill Toba Pulp Lestari fully relies on plantations and is thus not addressed.

The latest complete assessment available shows that planted areas will not be sufficient to fully supply pulp mills up to 2010 (Pirard and Cossalter 2006). The authors estimate that about 300 000 hectares of natural forests are going to be converted in 2006 and afterwards to supply the gap. With the expansion at APP and APRIL planned for 2008, the forest conversion would cover about 600 000 hectares (*ibid*). They express their doubts on the possibility that ambitious plans for plantation establishment will achieve targets due to the majority of plots on peat soils.

Among the planned pulp mills for the coming years, one will fully rely on affiliated plantations in Central Kalimantan (Korindo), and another one (UFS) is hard to assess due to contradictory assessments so far on the standing stocks in the affiliated plantation (Pirard and Cossalter 2006). In a conservative stance, it is assumed that none of their supply will originate from forest conversion.

So what baseline scenario?

Predictions based on previous points are recapitulated in the Table 3. Most important among these, the expected lax criteria for Papua would make further forest conversion related to pulp capacities' increase very likely, with the exception of Korindo and UFS pulp mills (i.e. 2012 increase in pulp capacities). Figures are largely based on most recent study of the sector (*ibid*).

Avoided deforestation and the strategies of pulp and paper groups

To stop pulpwood plantations' establishment on forested lands is the most obvious direct policy for reducing deforestation with the pulp sector. Large P&P groups have traditionally targeted forested areas to benefit cheap pulpwood supplies, and this practice continues owing to lax regulations and the intense lobbying of Indonesian authorities (Pirard and Irland 2006). Moreover, these authorities argue that forest conversions are desirable from an environmental perspective owing to reforestation. If such conversions are stopped, P&P groups will have four different alternatives that are discussed

TABLE 3 *Evolution of pulp capacities and related forest conversion*

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pulp Capacity (10^6 ADt/yr)	6.3	7.5	7.5	7.5	7.5	8.6	8.6	8.6	10.1
Fiber needs (10^6 m^3)	27.1	32.25	32.25	32.25	32.25	36.98	36.98	36.98	43.43
Plantation area needed (10^6 ha)	1.41	1.68	1.68	1.68	1.68	1.93	1.93	1.93	2.26
Expected forest conversion for plantation establishment (ha)	600 000 (expansion up to 7.5 million ADt/yr) + 0 (expansion from 7.5 to 8.6 million ADt/yr) + 330 000 (expansion from 8.6 to 10.1 million ADt/yr) = 930 000 hectares								

Source: For 2008-2011 based on company information. For 2012 we assume that Korindo and UFS pulp mills will start production but rely on affiliated plantations. For 2015 onwards we assume the construction of an additional 1.5 million ADt pulp mill based on plans by APP and APRIL, with associated forest conversion.

Assumptions: One ADt pulp requires 4.3 m3 wood. Mean Annual Increment 24 m3 in pulpwood plantations. 25% losses from site to processing: fires, harvest, transport, chipping.

briefly before application of the stepwise approach.

First, they rely on non-forested areas in two ways: large-scale HTI concessions or smallholder plantations. In the first case, local claims are likely to arise with only 10% of the total Forest Estate being delineated (Contreras-Hermosilla and Fay 2005). But appropriate compensations could help solve these conflicts as P&P groups have done very little financial effort in this direction so far. In the second case, limited access to cheap pulpwood from forest conversions is an incentive to develop smallholder plantations in order to fill the fibre gap. In all cases the access to non-forested lands for pulpwood plantations will face competition with other productive land uses.

Second, the P&P groups look for standing plantations. Pirard and Cossalter (2006) showed that in early 2005 Indonesia had an aggregate area of close to 250 000 hectares of standing industrial tree plantations in the Kalimantan province that could supply more than 20 million m^3.

Third, the groups buy chips in the Asia Pacific market. This significantly increases the production costs so that it is an alternative to fill the supply gap for installed pulp capacities, but certainly not for new capacities in Greenfield projects.

Fourth, the groups take the decision to reduce pulp production. This is unlikely because of extremely high fixed costs and the possibility still to import chips.

Opportunity costs according to the stepwise approach: great differences in value

Pulpwood plantations and pulp mills generate large-scale investments in the business-as-usual scenario. There are non-forested lands all over the country, with limited use at the moment, but with expected development of more productive land uses such as oil palm or rubber plantations. In Indonesia even *alang-alang* fields are potentially useful for pasture, hunting, houses, etc. The extent of non-forested lands is debated: according to MoF data approximately one fifth (1.5 million ha) of the area allocated to HTI concessions was without forest cover in 2003. These figures need cautious interpretation because plantations have been established at a rapid pace since 2003, and information does not exist on the availability of these lands four years later. However it is assumed that forest conversion for pulpwood plantations' establishment could be partially compensated with these non-forested lands within the HTI concessions. This is the pathway 4, for which the opportunity costs are nil.

At the country level, MoF data for 2003 disclose 22.5 million ha of lands without tree cover in the Forest Estate (World Bank 2007). With exclusion of lands located further than maximum commercial distance to pulp mills (about 150 km) and lands under more competitive land uses (especially oil palm with the "Bio Diesel New Deal"), then these non-forested lands could only partially compensate reduced forest conversion for pulpwood plantations' establishment. The program for smallholder plantations goes in this direction. This is the pathway 5, for which the opportunity costs are the profits on site because plantation establishment prevents other land uses.

As surprising as it might be in a context of overcapacities for the timber industry, the plantation estate in Indonesia is under-utilized with the presence of standing plantations without production. These plantations have been progressively purchased by the main P&P groups in Kalimantan in recent years (for chip exports mainly) and appropriate regulations could help to increase supplies to domestic pulp mills. It was estimated that such a policy could avoid deforestation on 100-200 000 ha in the short term (Pirard and Cossalter 2006). Other plantations may exist although with poor maintenance and scattered all over the archipelago (especially those of public ownership). Presumably these would be identified and fully used by the pulp mills if forest conversion is halted. This is also the pathway 5, for which the opportunity costs are the profits on site.

Investments in new pulp capacities might decrease if cheap fibre supplies from forest conversion are not available, as this has been a key argument for attracting large investments in the past (Barr 2002). Both Indonesian conglomerates and foreign groups are planning investments: Sinar Mas (APP) and Raja Garuda Mas (APRIL) for the domestic side, UFS and Korindo for the foreign side. In the former case, this is pathway 2, for which the opportunity cost are the profits on site and for unrealized pulp expansion. In the latter case this is pathway 3 with the highest opportunity costs: Indonesia loses the total economic value generated on site and in pulp mills.

CONCLUSIONS

The cost of avoided deforestation (REDD) in developing countries is usually approximated with the opportunity cost of the associated (business-as-usual) activity. Setting the cost of avoided deforestation is strategic for at least two reasons: it will influence decisions to dramatically increase the role of tropical forests for climate change mitigation, and serve as a basis for setting the level of financial compensations to countries that reduce deforestation.

Numerous studies were written on the matter. These studies fall broadly into two categories: national studies based on land prices to model the opportunity costs of sequestering carbon or conserving forests, and more detailed studies on specific sites and conservation activities. This paper argues that these methods might fail to identify real costs, and commonly lack sound justifications regarding the methods used. Although opportunity cost is merely a concept and might not be measurable with a high degree of accuracy, it is important to enable stakeholders (host countries, donors, buyers of credits, etc.) to identify activities or projects with extremely high / low costs. Relevance should be prioritized over precision in opportunity cost calculations.

To identify high / low cost avoided deforestation, this paper proposes a flexible stepwise approach that is aimed to enable analysts identify most relevant values for the calculation of opportunity costs. Depending on cases, these relevant values could be the total economic value of a given activity, or its profits only; they could be limited to the site,

TABLE 4 *Opportunity costs for each pathway related to the pulp sector**

	Pathway 2	Pathway 3	Pathway 4	Pathway 5
Description	Main Indonesian conglomerates that control P&P groups (e.g. APP and APRIL) cancel expansion of pulp capacities because of reduced profitability if low cost fibre is not available from forest conversion. Conglomerates invest in other sectors of the economy through their national industrial groups.	Foreign pulp and paper groups cancel their investments in Greenfield pulp mills in Indonesia (e.g. UFS and Korindo) because of reduced profitability if low cost fibre is not available from forest conversion. Groups invest in other countries instead.	The suppression of conversion permits forces P&P groups to plant on non-forested lands available in plantations concessions (HTI).	The suppression of conversion permits forces the pulp and paper groups to look for alternative supply sources (standing plantations or chip imports), or concessions / local partnerships in non-forested lands where they compete with other productive land uses.
Values to consider	Profits generated by pulpwood plantations after forest conversion + profits for unrealized pulp capacities	Total economic value generated by pulpwood plantations after forest conversion + total economic value generated by unrealized pulp capacities (only operational costs nationally)	-	Profits generated by pulpwood plantations after forest conversion
Estimation of opportunity costs (per ha)	$120/ha/yr (plantation profit) + $200/ha/yr (pulp mill profit)	$720/ha/yr (total economic value plantation) + $400/ha/yr (total economic value pulp mill)	0	$120/ha/yr (plantation profit)

Assumptions: One ADt pulp requires 4.3 m^3 wood. Mean Annual Increment 24 m^3 in pulpwood plantations. 25% losses from site to processing: fires, harvest, transport, chipping. Plantations generate profits $5/$m^3$ on site, with production costs $30/$m^3$. Pulp mills generate profits $50/ADt pulp, with operational production costs $100/ADt pulp (chemicals, energy, labour, maintenance, other mill costs).
* Pathway 1 is not represented because the sector is specifically large-scale and does not rely on village-level investments.

or expanded to downstream industries. The identification of relevant values is crucial because resulting estimations differ significantly, with consequences in terms of policy design and fair distribution of compensations. The flexibility of the stepwise approach is intended to match local contexts, and to provide guidance rather than to impose calculation methods.

The stepwise approach was applied to the pulp sector in Indonesia with interesting results. Indeed it showed that opportunity costs could be calculated in different ways with contrasted values ranging from zero to more than one thousand dollars per hectare per year. This supports the view that negotiations between host countries and other stakeholders, in particular those who fund activities to reduce deforestation, would gain in credibility with the use of a similar framework. To do so could help to allocate financial resources to developing countries in a fairer way. It could allow contributors to wisely use their resources and to prevent ultimate beneficiaries from being inappropriately compensated. Yet, as for any other method, transparency is a requirement in order to ensure that the right assumptions are applied.

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