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Clearing the way for reducing emissions from tropical deforestation

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ABSTRACT

Carbon emissions from tropical deforestation account for about 25% of all anthropogenic carbon dioxide emissions but cannot be credited under current climate change agreements. In the discussions around the architecture of the post-2012 climate regime, the possibility of including credits for reduced emissions from deforestation arises. The paper reviews two approaches for this, *compensated reductions* (CR) as proposed by Santilli et al. and the *Joint Research Centre* proposal that combine voluntary commitments by non-Annex I countries to reduce emissions from deforestation with carbon market financing. Both approaches have the clear advantages of simplicity and the possibility of fitting to an evolving greenhouse gas emission reduction regime. The authors consider the strengths and limitations of each proposal and build upon them to address several implementation challenges and options for improvement. Given the urgency of avoiding dangerous climate change, the timely development of technically sound, politically acceptable, cost-effective and practicable measures to reduce emissions from deforestation and forest degradation is essential. These two approaches take us a step closer to this goal, but they need to be refined rapidly to enable this goal to be realised.

1. Introduction and purpose of paper

The role of land use, land-use change and forestry in the global carbon cycle is significant: since the industrial revolution approximately 270 Gt C has been emitted as CO_2 into the atmosphere through fossil fuel burning and cement production, and about 136 Gt C as a result of land-use change, predominantly from forest ecosystems (IPCC, 2000). Tropical deforestation accounts for one-quarter of global carbon emissions, but under the Kyoto Protocol, reducing emissions

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from tropical deforestation cannot be credited in the first commitment period. However, several proposals have come forward recently, e.g. a joint proposal by Papua New Guinea and Costa Rica, and proposals by several other rainforest nations (UNFCCC, 2005) to include this option in future climate agreements, and some were discussed during the 11th session of the Conference of the Parties (COP11) of the United Nations Framework Convention on Climate Change (UNFCCC) in Montreal in November 2005. At this meeting, the COP established a 2-year process to review relevant scientific, technical and methodological issues and consider possible policy approaches and positive incentives for reducing emissions from deforestation in developing countries.

This signals the beginning of the international consideration of the inclusion of reducing emissions from deforestation as a serious climate change mitigation option. Apart from its potential role in the mitigation of climate change, reducing emissions from deforestation provides a means by which non-Annex I countries may increase their participation in the climate change mitigation effort and reach other important environmental goals. At this point, it is pertinent to take stock of the approaches so far proposed, with a view to strengthening the debate on methods that must follow.[1] Accounting and crediting systems need to be as simple and of low-cost as possible, but still guarantee the environmental integrity of any claim in the area of combating deforestation and, hence, climate change mitigation.

The paper starts by presenting the background and the context in which this mitigation option needs to be seen, that is to say, the possible outlines of a broader climate change regime of the future (Sections 2 and 3). In Section 4, we summarize briefly the salient characteristics of the *compensated reductions* (CR) proposal and the *Joint Research Centre* (JRC) proposal. In Section 5, we analyse a number of major challenges and options, using the two approaches as a means to illustrate these. We recommend directions in which methodological work should be undertaken to effectively operationalize policies aimed at reducing emissions from deforestation and forest degradation as a mitigation option.

2. Background

There are many reasons why reducing emissions from deforestation in non-Annex I countries was not included in the Clean Development Mechanism (CDM) under the Kyoto Protocol. At the time the policy was negotiated, there was resistance in some quarters to the inclusion of any land-use change elements, on the grounds that this would deflect efforts to mitigate climate change away from the energy sector. This position was strengthened by the fact that the emissions reduction and limitation commitments had already been negotiated without consideration of the possibility of forest interventions in non-Annex I countries as a mitigation option. There were also doubts about the methodologies to be employed, particularly to control leakage, and whether these would be robust enough to ensure real carbon benefits. This controversy finally led to the adoption of afforestation and reforestation as the sole eligible activities under the CDM in the first commitment period.

There is now growing interest in finding means by which reducing deforestation rates could be included in the post-2012 era (after the first commitment period of the Kyoto Protocol expires) by which past deforestation rates in non-Annex I countries could be used as the baseline against which future rates are compared, such that reductions in the rate of deforestation could be rewarded. The principle is being widely discussed and referred to (e.g. Viana et al., 2005; Jackson, 2005; Moutinho and Schwartzman, 2005). The difficulty is to design effective, environmentally sound and equitable accounting mechanisms for turning the principle into an operational system. Two approaches will be discussed in more detail in this paper. They are not mutually exclusive but could be employed side by side and even be mutually supportive.

The "CR" approach was first presented at a side event at COP9 by Brazilian researchers associated with the Instituto de Pesquisa Ambiental da Amazonia, (IPAM) (Santilli, 2003; Santilli et al., 2005). The submission by Papua New Guinea and Costa Rica (UNFCCC, 2005), based on the idea of the CR approach, received considerable attention, both positive and negative, in the international press (SciDev.Net, 2005; BBC News, 2005). Following this, at COP11, the Institute for Environment and Sustainability for the European Commission Joint Research Centre presented a method that is essentially a development and refinement of the approach proposed by IPAM (Mollicone et al., submitted for publication). We will refer to this as the JRC approach.

3. The context in which "reducing emissions from deforestation" should be placed

The term "reducing emissions from deforestation" first needs to be clarified. In the past, the term "avoided deforestation" has been used. This is often understood as referring solely to the establishment of national parks or conservation areas. However, forest conservation is only one of many possible options by which permanent land-use change may be avoided. A wide range of sustainable forest management practices could also be used. By careful design of the rules, modalities and guidelines, land-use practices such as shifting cultivation by indigenous peoples could still qualify as avoiding emissions from deforestation, as long as a sustainable rotation cycle can be demonstrated (Nepstad et al., 2006). The main objective is simply that CO_2 emissions caused by permanent loss of forest biomass should be reduced. We need therefore to be concerned not only with deforestation—the loss of area under forest cover, a two-dimensional concept—but also with degradation. Degradation is a three-dimensional concept and occurs when the forest cover is not entirely removed but thinned out, such that a significant amount of the carbon stock is removed.

In order to examine what the contribution of approaches such as CR and JRC could be to international climate change mitigation, we will first consider the options for future

[1] An approach is understood as "a conceptual framework for estimating emissions and removals", in other words, *what* is to be measured while a method is the calculation framework within an approach, that is *how* they are to be measured (Cowie et al., 2005).

architecture of the climate change regime, so that CR and JRC may be placed in context. It is also necessary to consider the different spatial scales at which reducing emissions from deforestation could be implemented, and what methodological problems may characteristically arise.

3.1. The possible architecture of a future climate regime

Currently, we have the UNFCCC and its associated Kyoto Protocol with the first commitment period as agreed in the Kyoto Protocol and operationalised through the Marrakech Accords. What comes after 2012 is still subject to debate. Some parties argue in favour of a new regime under the Convention directly, others favour a second commitment period under the Kyoto Protocol, and some appear to want nothing except voluntary agreements in the realm of policies and measures.

Various quite different policy elements are being discussed and debated. The option of ''de-linking'', or separate targets for separate sectors (fossil energy and biocarbon) has been suggested, whereby the credits could be either fungible or non-fungible (e.g. proposals presented in Grassl et al., 2003). This would constitute a fourth kind of flexibility mechanism (in addition to joint implementation, the CDM and emissions trading) and boil down to a sectoral target. In addition, ideas have been launched whereby countries might participate in the climate regime through a multi-stage approach, such that their level of commitment increases gradually over time (Gupta, 1998). Depending on their development and economic circumstances, countries might for example move from no commitments, through commitments to reach energy intensity targets, to stabilization of emissions and finally to reduction of emissions (Berk and den Elzen, 2001; den Elzen, 2002). Some schemes propose that commitments in early stages could be made in terms of policies and measures whose effects cannot be measured directly or quantitatively in terms of carbon reductions, but which would be recognized as a more sustainable way of developing (Höhne et al., 2005). Benndorf et al. (2007) have brought together the concepts of separate targets and the multi-stage approach, including initial qualitative commitments, to provide a wide range of options. It is important to recognize that reduced emissions from deforestation, as a future measure, do not necessarily have to fit into the narrow box of what can be credited today, which is to say a regime in which there is a single target and single quantitative commitments, and the two approaches reviewed in this paper could fit into a variety of different options.

The two approaches propose voluntary targets for reducing emissions from deforestation with financial incentives reducing these emissions assumed to be coming from an elaboration of the Kyoto carbon market. Both approaches propose that the voluntary targets become more stringent over time. In a multi-stage approach, this could eventually lead on to a situation in which non Annex-I countries might adopt binding targets in future commitment periods including penalties for non-compliance. Of course, these steps would be subject to international negotiation and could improve access to the financial mechanisms of the UNFCCC.

The two approaches do not exclude the possibility of new systems of targets outside of, but in conjunction with the Kyoto carbon market. This would probably require more international negotiation, take more time to develop and may reduce the possibility of a strong financial incentive. Given the urgency of the need to reduce emissions, this option may not be as attractive as modifying the existing climate change agreement.

3.2. Different spatial levels at which reduced emissions from deforestation could be tackled

From the discussion above, it is clear that we should not be limited to consideration of project level activities such as now represented by the CDM. Commitments and interventions could also occur at the sub-national level: for instance, a state of Brazil, or one province or island of Papua New Guinea, as well of course as at national level. It is also possible to think in terms of regional levels such that countries that are part of, e.g., the Congo basin or the Amazon watershed could jointly take on commitments and initiate mitigation efforts. A global effort could lead for instance to one overall reduction target related to an average deforestation rate, which could then be divided between the countries participating in the regime. Each scale however brings its own problems. Leakage will be of greater concern at the project level, whilst accuracy will be a larger problem at the regional or global scale.

At all levels, a major challenge will be the distribution of the carbon benefits among the land and/or resource users: for instance, a sectoral or sub-national target may lead to income at government level when the credits for emission reductions are put into the system, but the efforts to reduce the emissions are always made at the local level and land or resource users will thus always be affected. A fair transfer of the benefits to the direct actors will be crucial to the lasting success of any emission reduction exercise. Hence, the design of a nested system of global benefits achieved through local action poses the real challenge. We may think globally, but must not forget that the action is always taken at the local level.

3.3. Different methodological issues to be addressed at different scales

At each level (project, sub-national, national/sectoral, regional) a different set of methodological and technical challenges will present itself. To some extent, the discussion will be a ''Kyoto revisited'' exercise because some of the challenges were already under discussion before 1997. For instance, the pros and cons of project-based, sectoral or regional baselines have been discussed at length in the literature at the time. Likewise, the debate on leakage has been fleshed out to a large degree already. So, for all the options and scales, the challenges should be assessed. But what are these challenges? Just to mention a few: baselines (how to project developments into the future), base year or base period (which level of emissions will be selected to assess improved performance against, and does that need to be the same for every participating country?), estimation and monitoring (what technology is available to estimate areas and carbon stocks), leakage (can we assess and quantify leakage? where should system boundaries be placed?), uncertainty (will we be able to quantify the baseline and improved performance with such accuracy that the environmental integrity is ascertained?), and permanency (what if deforestation rates go up again or if there is substantial loss or degradation of forest through climate feedback?). The significance of each of these methodological challenges needs to be worked out for each of the spatial levels individually.

This paper does not review all these challenges but discusses how the two approaches respond to them.

3.4. *Fossil fuel versus reducing emissions from deforestation*

Even though emissions from deforestation constitute a significant portion of total global greenhouse gas emissions, the main cause of climate change is the emissions from the use of fossil fuels and cement production. There is a risk that introducing emission reductions from deforestation into a trading system could weaken incentives to reduce emissions from fossil fuels by lowering the price of carbon. However, there are high uncertainties over the opportunity costs of alternative land uses in the tropics, so it is still unclear whether the cost of carbon resulting from reducing deforestation will be very much lower than that from energy conservation or fuel substitution.

One of the questions that need to be resolved is whether credits for emission reductions resulting from reducing deforestation rates should be subject to a cap, as is the case with for example afforestation and reforestation (AR) projects under the CDM during the first commitment period. If a capping policy were to be adopted, the cap could be calculated based on preliminary targets for emission reductions from deforestation proposed by each country on the basis of an agreed methodology, as was done for forest management under Article 3.4 of the Kyoto Protocol. In order to ensure a balance with fossil fuel credits, there would have to be an agreed overall cap on the use of reduced emissions from deforestation for all participating countries together, which could then be shared among them by negotiation. However, any cap will inevitably limit market liquidity.

To avoid the necessity of a cap, global deforestation emission reduction targets would have to be negotiated alongside targets for other activities in future commitment periods. Establishment of long-term limits for GHG emissions (for example, up to 2050) together with short-term (5-year) commitment periods would provide a clearer context for the market, such that trade-offs between different mitigation options, including reduced deforestation, could be made.

4. Proposed approaches for crediting emission reductions from deforestation

4.1. *Compensated reductions*

CR as presented by Santilli et al. (2005) proposes that non-Annex I countries may, on a voluntary basis, elect to reduce their national emissions from deforestation. The original proposal suggests a baseline starting from 1990 or even 1980, but argues that exact periods will need to be negotiated to allow for country-specific situations as well as inter-annual variability. A historical baseline would be constructed on the basis of area of forest cover, according to locally specific definitions of forest based on canopy cover, as detected, primarily, from remote sensing, and extrapolated to the future. Reductions in emission from deforestation during the commitment period could then be credited and sold to governments or international carbon investors at the end of the relevant period. A country that has been credited for reducing emissions from deforestation would agree to stabilizing, or further reducing, deforestation rates in the subsequent commitment periods (Santilli et al., 2005)—the "once in, always in" clause. There could be various mechanisms to ensure compliance to this rule, for example some part of the credits could be banked till the subsequent commitment period, or an insurance policy could be taken out to ensure the permanence of the carbon credited.

Recognizing that the CR approach will most benefit those countries that have experienced high deforestation rates in the base period, Santilli et al. suggest that countries with low deforestation rates in the past might also enter voluntarily into a CR agreement, but negotiate baselines that are above their recent deforestation rates (allowing a "growth cap"). This would act as an incentive to maintain the forest (Santilli et al., 2005). Other proposals have argued in favour of country-specific base years or base periods to take account of the different dynamics in the forestry sector in the different countries.

Under the CR approach, claims could be made for forest areas which have been cleared already but are either replanted or allowed to regenerate, in contrast to what is allowed at present under CDM in terms of forestry options (afforestation and reforestation (AR)). The baseline could be adjusted downwards over time to motivate countries to continue reducing deforestation rates. Santilli et al. (2005) suggest that the carbon credits that would be generated by reducing emission from deforestation would be "similar to certified emission reductions (CERs)" and clearly envisage integration of the credits in the growing global carbon market.

4.2. *The JRC approach*

The *JRC approach* (Achard et al., 2005), which builds on the basic concepts of CR, also relies on baselines built on past deforestation rates but starts from a function of global average rate of deforestation (they suggest half the current average global deforestation rate, but other benchmarks could be argued). Countries, whose baseline deforestation rates are above half the global average, will be rewarded for any reductions in their national rate of deforestation during the commitment period, compared to the pre-commitment period baseline rate. Countries which in the past have had deforestation rates lower than half the global average would be credited if, during the commitment period, they do not increase their rate of deforestation over what it was in the pre-commitment baseline, thus rewarding the countries which have already taken strong measures to control forest destruction. As with CR, the baselines might be adjusted downwards periodically.

The JRC approach, like the CR approach, is based partially on forest area changes over time as detected from remote imagery, but also includes three land-use changes of interest;

from *intact forest* (pristine, untouched primary forest) to *non-intact forest* (forest which shows signs of human intervention); from *non-intact forest* to *non-forest* (defined on a canopy cover criterion), and from *intact forest* to *non-forest*. This resembles forest degradation—as against deforestation—to a limited extent. Carbon levels for intact forest would be determined per ecotype from the literature, and carbon levels in non-intact forest in the same ecotypes would be estimated at 50% of that in the intact forest.

Achard et al. (2005) suggest that the carbon benefits would be expressed as temporary certified emission reductions (tCERs) as defined at COP9 and would therefore be fully exchangeable on the world market. The benefit of temporary crediting would be that the liability for reverted deforestation rates in future commitments periods would fall back to the buyer, so that a ''host'' country commitment would not be needed.[2]

Obviously, there are a number of methodologies suggested here that could be debated. For instance, determining a reliable global deforestation rate for tropical countries is a daunting task. Furthermore, transition points from intact to non-intact forest are hard to determine, since the canopy may still appear closed to some forms of remote sensing, whilst the carbon stocks may well be reduced by 75%.

The validity and practicability of the distinction between intact and non-intact forest may need more consideration, since this simple dichotomy does not take into account the spatial variability of carbon densities between or within countries. Reducing deforestation in a low biomass density area but increasing deforestation in a high biomass density area may have a net negative effect on GHG emission, even if the total deforestation rate diminishes.

Furthermore, the use of tCERs to credit the carbon benefits may turn out to be a political decision. From the atmosphere's perspective, an emission avoided from the combustion of fossil fuel is the same as an emission avoided from deforestation. But if reversal or liability issues are blocking an agreement, the tCER accounting option may well make the inclusion of this mitigation option more palatable. This point is further discussed in Section 5.7.

4.3. *Comparing the CR and JRC approaches*

The basic features common to the two approaches are as follows:

- The rewarding of interventions to reduce emissions from deforestation.
- The use of the carbon market as a source of finance for activities and policies which will reduce rates of deforestation.
- A national, sectoral approach to forestry in non-Annex I countries rather than a project approach as in CDM (although both approaches could in principle be applied at a variety of scales).
- Voluntary participation.
- The lack of penalties if deforestation rates are not reduced (carrots, not sticks).
- The assessment of historic and future deforestation rates based on detectable change in forest area using remote sensing imagery.
- The downwards revision of baselines over time.

The main refinements which are added in the JRC approach are as follows:

- JRC relates national baselines to a global rate and uses this to trade-off and compensate between countries, while CR leaves this open to negotiations.
- JRC attempts to reach a more detailed estimate of carbon in forest by distinguishing between intact and non-intact forest, thus conceptually including degradation as well as deforestation.
- CR proposes rewarding carbon with CERs, but ensuring permanence by committing countries to follow through in the subsequent commitment periods, or a system of banked credits and insurance. JRC resolves the permanence issue by proposing the use of tCERs.

The similarities and differences between the two approaches are summarized in Table 1.

The main advantage of both these approaches to accounting for reducing emissions from deforestation is that, if accepted, they would enable a major source of carbon emission to be included in the market mechanisms for mitigation and thus could contribute significantly to fight against climate change in accordance with the ultimate objective of the UNFCCC (Dutschke, 2007). There are other important potential benefits however.

At the level of global climate policy crediting, the reduction of emissions from deforestation would provide a means for non-Annex I countries with significant deforestation emissions but a limited industrial base to take on real, sectoral commitments and reduce emissions on a voluntary basis. Moreover, well-designed measures to reduce deforestation emissions may provide many additional environmental benefits such as the protection of biodiversity and watersheds, and societal benefits by offering a route for poorer, marginalized sections of society to strengthen their livelihoods through financial compensation for forest stewardship.

One of the major advantages of the approach to forestry proposed by models such as CR and JRC, over the project approach, relates to leakage. As noted in Section 1, this was a major concern during the earlier negotiations and was one of the main reasons why CDM forestry options were limited to afforestation and reforestation in the Marrakech Accords. The application of the approaches on a national scale for the detection of land-use change would mean that losses in one area could be balanced against gains in other areas. This does not entirely solve the leakage problem, since the issue of international leakage remains. However, it is clear that international leakage will diminish as more countries participate, and moreover global timber models (e.g. Songhen, 2001) become more robust and may be able to quantify expected leakage, and discount carbon credits appropriately.

[2] Indeed, for the case of reducing emissions from deforestation it will no longer be possible to speak of a ''host'' country as in the case of CDM.

Table 1 – Summary of design similarities and differences between CR and JRC

Design feature	Compensated reduction	Joint research centre
Emissions targeted	Deforestation	Deforestation and degradation
Unit of quantification	Area	Area
Carbon model	Simple, national average carbon stock	Simple, national average carbon stock for both *intact* and *non-intact* (degraded) forest.
Baseline	Based on national historical averages with a correction for countries which have already significantly reduced deforestation	Based on the global average deforestation rate. Countries with less than half the global average will be credited for not increasing deforestation.
Baseline adjustments	Downward (more stringent) targets over time	Downward (more stringent) targets over time
Units created for trade	Certified emission reductions (CERs)	Temporary certified emission reductions (tCERs)
Permanence	Addressed by a "once in, always in" clause	Addressed using tCERs
Voluntary	Yes	Yes
Scale	National or sectoral (not projects)	National or sectoral (not projects)

A further major advantage of the CR/JRC approach is that transaction costs should be significantly lower than for individual projects, noting, however, that income generated nationally may need to be redistributed to those actors involved "on the ground" that actually make the emission reductions happen (e.g. local governments that enforce the law, forest managers changing over to sustainable forest management, etc.).

An advantage of both approaches is that they leave much greater control and responsibility in the hands of the non-Annex I country than do CDM projects. Basically, both approaches have been designed to involve measures to be taken by the non-Annex I country without intervention from outside.

5. Implementation challenges and options for improvement

It is evident that crediting measures that reduce emissions from deforestation requires methodologies which are technically sound, politically acceptable, cost-effective and practicable to implement. The proposals on the table at present are founded on the idea that the changes in carbon emission rates over time can be gauged from changing forest areas and carbon stocks within forests, although the emphasis at this stage is still on area change. Around this, and other methodological matters, there are several issues to be resolved.

5.1. *What constitutes "deforestation" and what does not?*

As pointed out by a number of commentators (DeFries et al., 2005, 2007; Schlamadinger et al., 2005), the definition of deforestation needs to be tightened up. First of all, what types of forest disturbances count as "deforestation"? Deforestation is defined in the IPCC and UNFCCC documentation as "permanent removal" of forest. However, it is important to distinguish temporary removals, e.g. as part of cycles of timber extraction under forest management or shifting cultivation, from those that are permanent. The scale of forest clearance and what should be the minimum area for inclusion is also certainly a challenge, both in terms of definition as well as detection (does felling one tree constitute deforestation and can that be detected?).

More important is the fact that the definition of forest in the Marrakech Accords is in terms of canopy cover (a minimum of 10–30%), not biomass content. This means *degradation* of forest, i.e. activities which reduce the amount of biomass in the forest without reducing the area below 10–30% canopy cover, will not be picked up if "deforestation" is defined as "forest removal", as measured in spatial terms. As pointed out in Section 3, forests can be thinned or selectively logged, with huge losses of stored carbon, although the area under forest is not reduced. This is a very strong argument to insist on "ground truthing" of any remote sensing imagery result to link area to carbon contents. This problem, not addressed in the CR proposal, might be resolved by establishing deforestation indices that incorporate degradation factors as well as area measures (Penman et al., 2003; Schlamadinger et al., 2005; Achard et al., 2005). The JRC approach proposes recognizing two grades of forest—intact and non-intact, with the carbon value of non-intact forest set at 50%, thereby bypassing the country-specific Marrakech definition of forests.

Change in national carbon stocks as a result of deforestation and forest degradation, rather than the area of deforestation alone, should be the ultimate goal. In reality, of course there will be considerable variation in the actual carbon value depending on the intensity and type of forest use, as well as by ecotype. Ultimately, a deforestation definition and quantification methodology will need to be established that can be operationalised without excessively high cost, and that provides an acceptable level of confidence in creditable carbon stocks: it requires an acceptably accurate means of translating changes in hectares of forest into tonnes of carbon, which takes into account the real changes in carbon in all pools and in all land-use types.

5.2. *Accuracy in establishing changes in forest area using remote sensing*

Much faith is put by the authors of CR and JRC in the availability of remote sensing technology to detect changes in forest area, both for the construction of the historical baseline and for monitoring change in the commitment period. However, even many Annex I countries do not have a national system capable of meeting an appropriate level of accuracy using remote sensing. In addition, the resolution of remote sensing imagery is such that small cleared areas are difficult (and more expensive) to detect. There is some disagreement among experts about what can and cannot be obtained from remote sensing technology. The very best systems such as Quickbird give a resolution down to centimetres, but at a prohibitive cost. A resolution of 0.3 ha is easier to obtain, but is still rather expensive (DeFries et al., 2005).

Methods to discriminate between forest and other land-cover types using satellite images work well when the contrast between the forest and the surrounding land-cover types is large; accuracies of 80–95% may be expected with high-resolution images, and there is good coverage available; data sources exist to determine base periods in the 1990s as reference points (DeFries et al., 2007). Problems arise when those other land-cover types are themselves green vegetation, perhaps even trees. When more forest parameters need to be determined from the imagery, such as canopy cover and degradation, remote sensing technology quickly reveals its weaknesses. It is clear that any approach that proposes to rely primarily on remote sensing technology to monitor change in carbon stocks will have to take cognisance of these limitations. Ground truthing is essential (DeFries et al., 2007); the main question is, how much ground truthing is needed, and at what scale.

5.3. *Accuracy in establishing changes in biomass stocks*

Recent developments in remote sensing technology may address some of the challenges associated with the determination of carbon stocks. Of particular interest are radar imagery, which gives higher accuracy in estimating biomass and which works under cloudy conditions, and lidar (laser) soundings, which yield a detailed three-dimensional picture of the forest. Both are useful for determining levels of forest degradation (Lefsky et al., 2005). However, these techniques require expertise for the analysis (not generally available in most developing countries) and, particularly lidar, are currently too expensive to be applied over large areas. However, in many countries, it may be possible to rely on inventories based on good old-fashioned fieldwork, sampling large forest areas to derive carbon stock values, since labour costs are low compared to the significant installation and management costs of high-technological remote sensing technologies and associated staff training.

Modelling could be employed to increase accuracy and reduce costs of estimation of carbon stock. Over the last two decades, many biophysical models of forest growth dynamics have been developed, many of them with the specific objective of using data from satellite imagery as input to drive the models (for a review of many such models, see Porté and Bartelink, 2002). Apart from remotely sensed imagery, these models can be driven by using field observations of parameters such as species composition, age/size distribution, Leaf Area Index (LAI), etc.

5.4. *Determining the business as usual (BAU) scenario: the baseline*

The deforestation baseline describes the emissions related to land-use change during the commitment period that would be expected in the absence of a reduction target. Santilli et al. (2005) propose to determine the BAU scenario based on historic rates, such as the period since 1980 or 1990. Both the CR and JRC approach propose that baselines should be adjusted downwards in the future, to allow for generally improving management practices, and Tipper and de Jong (1998) have suggested a time-step approach to cope with periodic variation.

The use of historic rates to establish baselines is similar to the Annex I base year determination, but it bears the same risk, namely the creation of excess emission allowances (''hot air'')—particularly if there is evidence that deforestation is likely to decline in any of the large remaining tropical forest areas. For example, the rate of deforestation may be related to the amount of forest remaining and its location: a slowing down of deforestation rates may reflect nothing more than the increasing cost of reaching what is left.

5.5. *Modelling as an option for baseline determination*

On the regional scale, modelling is proving successful for predicting future deforestation, once the drivers were correctly factored in. Various models are already available and others are under development, with a view to identifying the vulnerability of forest areas to deforestation. Factors that have been identified as important in terms of deforestation are accessibility (closeness to roads, rivers, settlements, agricultural areas and slope) and pressure on land (population density, markets, tenure, among others). Various studies found a close relationship between deforestation and one or more of these factors (see special issue of *Agriculture, Ecosystems & Environment*, 2001, Vol. 85 (1–3)). If these relationships can be expressed spatially in maps, the degree of correlation between deforestation and its drivers can be analysed (Castillo-Santiago et al., in press). With these tools, a vulnerability index could be created for each forest area (de Jong et al., 2005; Castillo-Santiago et al., in press). Brown et al. (in press) compared various modelling approaches and found that they gave comparable results over short time scales (5–10 years) and that spatially specific models could improve the prediction of *where* deforestation would take place (Brown et al., in press). Soares-Filho et al. (2006) have used such a model to estimate future deforestation rates over the whole Amazon Basin under different management scenarios, including not only traditional conservation measures, but also different levels of enforcement of environmental legislation, the paving or non-paving of major roads, etc., and from this have estimated carbon emissions per scenario (using the approximation that 85% of the carbon contained in forest trees is released on deforestation). This demonstrates the enormous carbon gains that can be made through different management regimes, but more particularly, the value of such modelling as a tool for making predictions.

Baseline emission scenarios created by these models involve two steps: first the future deforestation trend is estimated based on comparison of historical land-use maps separated by a number of years, using either the annual percentile rate of deforestation or simple linear estimates (the difference may be significant, as shown in Fig. 1). The next step is to estimate the carbon densities of the forests predicted to disappear in the future. The biomass densities of these forests are estimated from the most recently available inventory data,

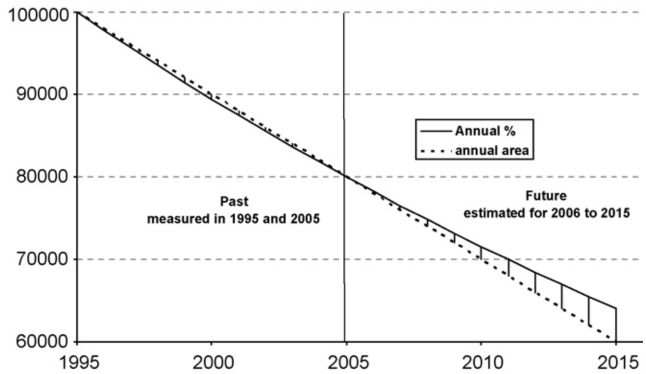

Fig. 1 – Baselines constructed on annual area of forest loss versus percent of remaining forest lost.

particularly for the case of non-intact forests which have been subject to recent degradation. In this way, historical deforestation trends are used to construct the deforestation baseline and recent statistics on biomass densities on forests expected to disappear are used to calculate the emissions of future deforestation. Factoring in differential biomass densities at different locations is an important step.

Regional modelling approaches have the potential to provide more accurate baselines, but they also have several limitations relative to the historic baseline approach proposed by Santilli et al. (2005). These include limited current availability of data and model projections for many tropical regions and limited expert agreement on model validation. One option might be for historic baselines to be used initially, with a transition to regional models as they become more readily available and standardized.

To cater for a sub-national scale or to reduce the risk of too much generalization and loss of detail, sub-national baselines, reflecting local biomes and local levels of economic activity influencing deforestation rates, could be applied.

Neither CR nor JRC proposes the use of an approach which models drivers of deforestation; they treat the reasons behind both current and future as black boxes. Although the benefit to the atmosphere of modelling the drivers is immaterial, a good understanding of these drivers is useful for national or sub-national governments and societies to design effective policies and measures to reduce deforestation. In addition, the ability to model "cause and effect" improves the accuracy, transparency and credibility of the emission reductions generated. As shown, methods are already available to remedy these kinds of problems, and as science continues to develop new and better methods for the construction of baselines in the long run, this challenge should not be difficult to overcome.

In parallel, it is worth recalling that currently Annex I Parties are required to submit national forest inventories which will be used for additions and subtractions to their assigned amounts to assess compliance with commitments for the first commitment period. In these reports, which undergo expert review by the UNFCCC, the base year emissions are fixed. A similar construct could be envisaged for "newcomers": non-Annex I Parties aiming to participate in the climate regime through the reduction of emission from deforestation. The level of ambition relative to the baseline could be on the basis of participating parties' analysis of their situation, including maps of forest area changes anticipated under BAU and under the intervention scenario. It would be reasonable to expect the predictions to be justified on the basis of an analysis of deforestation drivers and of measures to be taken to counteract these.

5.6. *Base year or base period and crediting those with low deforestation rates*

Choosing a base year or base period is obviously of great importance. Deforestation dynamics and the timing of deforestation greatly differ amongst countries and even within countries. It will therefore make a great difference to the level of commitment which base period is chosen in order to estimate a baseline. Nabuurs (2004) clearly illustrates this with reference to the historic functioning of the biosphere per continent, for example. If one particular base year or base year period was set for all countries that wish to participate, one group of countries will always be put at a disadvantage: those that had low deforestation rates in the base year or base period.

The CR proposal suggests that countries with low current rates of deforestation might negotiate targets above their current rates (analogous to hot air), thus allowing them "room to increase emissions" or alternately offering an incentive not to deforest, while JRC explicitly proposes to credit countries whose deforestation rates are low, provided they do not raise their deforestation rates above those of the pre-commitment period. This suggestion, though attractive from an equity point of view, brings with it major problems. First of all, it would appear that some countries will be credited for business as usual, which is counter to environmental integrity. Perceived inequality of this kind may lead to difficulties in reaching international agreements. In any approach to crediting of reduced emissions from deforestation, this is an issue which will have to be taken on board and dealt with by negotiation.

5.7. *Non-permanence*

Both approaches recognize that efforts to reduce deforestation in one period may be reversed in the future leading to losses of carbon stock. Similarly, losses may occur from climate feedbacks. Santilli et al. (2005) propose addressing permanence by (a) requiring participating countries that increase deforestation above their baseline to take the increment as a mandatory target in the subsequent commitment period, (b) allowing carbon credits to be "banked" for use in the subsequent commitment period and (c) establishing (unspecified) carbon insurance mechanisms.

JRC proposes use of tCERs to deal with this problem, which means that the onus is on the buyer of the carbon credits to renew them on a regular basis. If the forest is depleted, the buyer has to purchase carbon elsewhere to make up for the shortfall. Temporary credits however have an uncertain value (the only certainty being that they will be worth less than CERs (Dutschke et al., 2005)). Use of tCERs would mean that emission reduction from deforestation would result in another Kyoto-type mechanism and would not lead to any further commitments by non-Annex I countries. However, as stated before, temporary crediting schemes have proven essential to reach political consensus in the past with respect to the inclusion of land use, land-use change and forestry (LULUCF) activities in the CDM, and may prove to be indispensable again.

In this context, it is perhaps worth mentioning that the question of whether the carbon saved through reduction of deforestation should be considered permanent or temporary is still under debate. The idea of temporary credits was developed to deal with the creation of AR sinks, which remove carbon from the atmosphere but which are inherently vulnerable. They are seen as simply holding back carbon for a while, which is already in the biospheric cycle. In contrast, carbon saved by reduction of fossil fuel use is seen as permanent, since in the particular year in which the saving is made, less fossil fuel is used than would otherwise be the case. But conceptually, it can also be argued that reducing rates of deforestation operates similarly to reducing rates of exploitation of fossil fuels, in the long run.

An important point related to the debate is the understanding that re-release of carbon from forests in the future may not be, as it is for the case of fossil fuels, simply a function of direct human control (Schlamadinger et al., 2007), since forest itself will respond to global warming in ways which we are not yet entirely sure of. A choice for temporary credits may therefore be seen as precautionary in this regard. Moreover, temporary crediting for deforestation may be useful as a pragmatic policy element to enable Annex I Parties to gain some relief in the short run as they struggle to reduce the energy intensity of their economic growth, and also to cover for the problem of the "once in, always in" accounting discussed in Section 4.1. It is however essentially an accounting fix, rather than a scientific conclusion on the permanency issue.

5.8. *Practicability*

Clearly, there are barriers to overcome for non-Annex I Parties that wish to increase their participation in the international climate change agreements.

5.8.1. *Lack of capacity for baseline determination and monitoring*

Although countries like Brazil and India have strong Global Information System/Remote Sensing (GIS/RS) capacity, and well-developed forest inventories, this is much less the case in many other countries. This will be a serious challenge if the baseline requirements are stricter than first proposed by Santilli et al. (2005).

To develop the institutional capability to estimate baselines, design policy and monitor progress, financial investment is required. This may create financial barriers to participation for some countries. These barriers may be overcome by the determination of the initial baseline and conduction of the initial forest inventory in a fashion similar to the current "enabling activities" for non-Annex I Parties under the UNFCCC. This would assist interested non-Annex I Parties in laying the ground for taking on a sectoral target, whilst at the same time building capacity and the institutional framework required to continue with monitoring and other requirements.

Payment for the credits themselves is likely to be post-certification rather than when the investment is needed. Raising financial credit to cover the costs on the basis of carbon credits in the future might present difficulties, although some investors (World Bank, some of the re-insurance companies) have expressed interest in providing some up-front payment.

At the same time, some Annex I countries are at risk of not meeting their Kyoto targets and may not be able to obtain sufficient JI or CDM credits to cover themselves (World Bank, 2004). Currently, countries that fail to meet their commitments can "borrow" from the next commitment period at a 30% premium. Applying the same logic to deforestation, one could envisage a policy that allows Annex I Parties to fund the development of baselines and forest policies designed to reduce emissions from deforestation in non-Annex I countries. In return, the Annex I countries could use the resulting emission reduction at, say, a 15% premium. Instead of borrowing from future commitment periods, this solution would compensate Annex I excess emissions with a lower emissions level from deforestation achieved during the same commitment period. An alternative would be to install a new multi-lateral funding mechanism for forest inventories and baseline preparation, to be administered possibly by FAO or another appropriate agency.

5.8.2. *Over-estimation of ability to control deforestation*

Countries may over-estimate their ability to control deforestation, since the available instruments (law enforcement, incentives) may not be effective. History has shown that deforestation is a hard nut to crack. Existing land tenure and traditional law (usufruct), in this regard may make the implementation of state-based measures difficult. Land tenure has been the cause of much civil disruption in the past. Furthermore, the system of allocating concessions in some developing countries may promote over-exploitation of natural resources or stimulate short turnover times of concession. Fiscal systems may not be conducive to law enforcement, for example where local government is responsible for law enforcement but forest revenues are to be transferred to the state government.

However, if positive changes are rewarded and negative ones not punished, as in the CR and to a major degree in the JRC proposals (the "carrots, not sticks" principle), this should not represent a discouragement for countries wishing to participate in agreements on emission reductions from deforestation. The corollary will always be that credits generated as a result of such agreements can only be issued at the end of the relevant commitment period. As noted, it is possible that some investors may be willing to put up part of the finance in advance, for example in exchange for (lower priced) credits.

5.8.3. *Design of internal rewards system and dealing with internal equity*

Neither CR nor JRC specifies which measures should be taken by the participating country to bring about the reduced rates of deforestation. However, it is reasonable to suppose that some measures might be government-based, while some might be based on incentives or payments to individuals or groups to reward a change in behaviour with regard to forest. It has been well documented that command-and-control policies alone do not guarantee successful results on decreasing deforestation. Therefore, it is necessary that policy makers think about a system that compensates those who always protected their forests as well as those who will protect under a structure of incentives (Moutinho and Schwartzman, 2005). Any such schemes will create dilemmas for policy makers when designing a policy which is acceptable to all stakeholders. For example, logging companies might be paid incentives not to log, while indigenous peoples who have always lived in a sustainable way in the forest, and who have never logged, receive no compensation. It is to be anticipated that certain groups—in particular marginalised, forest-dependent people—are less likely to benefit from any such initiative.

However, if subsistence activities of these marginalised groups are responsible for part of the deforestation, instruments will be needed that provide financial incentives for precisely this kind of stakeholder. Instruments will only work if the opportunity costs and subsistence risks of the people responsible for deforestation are covered by the financial benefits from the carbon credits. So, although both CR and JRC are based on the idea of a sectoral approach, in reality, within that framework, a participating government may need to create a project-based approach internally in order to deal with incentive-based payments, which will be made more complicated by the fact that carbon density and forest growth rates vary naturally within the country. The country will then be faced at the national level with the problems of a project-based approach such as leakage and free-riders, in addition to those related to the design of an institutional system to cope with monitoring and internal verification.

This is, however, a matter for the participating country itself to resolve: prescribing how a country should deal with the questions of internal reward systems and internal equity is not something to be solved in the international negotiations arena. That said, the greater the openness of a participating country regarding the policies and measures it proposes to use in its attempts to reduce deforestation rates, the greater the transparency of the process. Likewise, the better the nested system of the transfer of national benefits to local actors, the more acceptable the credits will be to the international community. This in turn will have a positive impact on the marketability of the credits generated, since buyers generally prefer credits which have social and broader environmental characteristics over those which lack such characteristics.

6. Conclusions

The current climate change regime does not allow for rewarding reduction of emissions from deforestation, and given that this source is responsible for a significant portion of global emissions, it is clear that a post-2012 climate regime must be different. We are now entering a new round of negotiations related to future climate regimes and the interest of the international community to include reducing emissions from deforestation in their considerations has increased significantly.

If a multi-stage approach is adopted, in which countries can enter using a wider range of options than allowed at present, including policies and measures which may not be fully measurable in terms of carbon, as well as sectoral carbon targets and non-binding emission ceilings, the opportunities for including deforestation are considerable. A voluntary national sectoral approach to reduction in emissions from deforestation, such as proposed by CR and JRC, would fit nicely into such multi-stage approach. It could work equally well in a future regime in which assigned amounts are set as at present (though at higher levels to reflect the potential of reduction of emissions from deforestation) or one in which they are "delinked" (with one target for biocarbon and another for fossil fuel reductions), although there would be no obvious source of financing for implementing reductions of emissions from deforestation if unlinked to the emissions trading market. It would open many possibilities for non-Annex I Parties to increase their level of participation, as well as broadening the range of options open to Annex I Parties to meet their own targets. National targets for reduction of emissions from deforestation might have to nest within an overall global maximum limit for such credits, and as such they would have to be negotiated. Clearly, this would need to be done in conjunction with negotiations for the national assigned amounts (for all sectors).

A number of approaches to deal with reducing emissions from deforestation at a national, sectoral level have been launched and two, CR and JRC, have been discussed in detail in this paper. They both have the advantage of being simple and straightforward in their conceptualization. The area deforested is seen as a single variable, which goes up or down and carbon transfers would follow the downwards movement. The costs of assessing achievements are often assumed to be low using primarily remote sensing technology, but this may be optimistic.

In this paper, it has been argued that much more information than just forest area is required to determine the emission from deforestation. Carbon content of the forest cannot be ignored. To determine a baseline it may necessary to use a more disaggregated approach (local-level baselines) as deforestation patterns and carbon densities within one country vary. As we have shown, there are ways of tackling this from a technical point of view. In particular, practical implementation of deforestation-reducing policies and measures may require the identification of drivers and causes of deforestation (including forest degradation) and the use of sophisticated land-use modelling.

An apparent advantage of a sectoral approach, such as proposed by CR and JRC, is that it helps to avoid problems that occur on project level (CDM-type projects), such as leakage and high levels of uncertainty. Countries choosing a sectoral approach may however still be faced with project-type problems, since reducing deforestation rates domestically may still require action on the ground in a project-like setting. The interaction between central and local organisations becomes crucial, since

1. the actual activities to reduce deforestation are implemented at the local level, but may be driven by "top-down" sectoral targets and negotiations; and

2. income generated nationally may need to be redistributed to the local organizations ‘‘on the ground’’ that actually make the emission reductions happen.

A closer look at the approaches reveals many challenges that still need to be addressed. In addition to the structural problems already mentioned, there are other issues to be resolved such as the determination of the base period, accuracy level of carbon stock estimation, monitoring methodologies and uncertainty. These are technical issues to which undoubtedly technical solutions can be found, but which urgently need attention.

Financial support and institutional capacity building will be needed in many non-Annex I countries. The instrument is therefore by no means as simple as appears at first glance. However, bi- and multi-lateral development assistance to the forest sector to support these activities would have multiple benefits for the forest sector and the environment in general.

Finally, a large unknown is whether payments for reduced emissions from deforestation will be sufficient to off-set the opportunity costs of local land users. This will depend on the monetary value of the credits generated, the transaction costs involved (which clearly need to be kept as low as possible) and the number of credits that could be generated. Both the transaction costs and the number of credits that can be claimed will be largely determined by the technological options and infrastructure available to obtain acceptable levels of accuracy in estimating emission reductions from deforestation.

The urgency of the global warming situation anno 2006 is such that this potential area of emission reductions needs to be embraced by the international community. In addition, creating sufficient incentives to achieve large-scale reductions in deforestation will have benefits for the stability and permanence of forests far beyond the value of carbon credits (e.g. water cycling, regional rainfall, fire resistance). Approaches of the type proposed as CR and JRC are very much needed and welcome, but they need to be refined rapidly to enable this major leak in emission reduction policy to be filled.

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