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Content

Foreword and Acknowledgement

This report was commissioned by the Nordic Working Group for Global Climate Negotiations (NOAK), the Nordic Council of Ministers, to assess impacts of including REDD credits in global carbon markets and to provide improved knowledge and better understanding among key decision makers on the options and impacts of integrating REDD in global carbon markets.

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Political Summary

After years of intensive negotiations, COP19 in Warsaw in November 2013 finalized a significant set of decisions on ways to help developing countries reduce greenhouse gas emissions from deforestation and the degradation of forests (REDD+). These decisions will enable the REDD+ mechanism to evolve towards its final operative stage: results-based finance.

One of the Nordic priorities in climate negotiations during the recent years has been instruments for cost-effective reductions of greenhouse gas emissions, especially well-functioning market-based mechanisms. This report has reviewed and analyzed the implications of introducing REDD+ credits in a future global carbon market. The different options discussed in the report have each their merits and risks. A major challenge is to introduce REDD+ in such way that, on the one hand, sufficient funding is mobilized and the REDD+ potential realized, and on the other hand, the inclusion ensures that REDD+ becomes additional. Even though an inclusion of REDD+ credits in a global carbon market is unlikely to materialize in the short term, many of the conclusions are still relevant for a situation with more fragmented carbon markets.

The study has been carried out by Norwegian University of Life Sciences and PBL Netherlands Environmental Assessment Agency for NOAK, a working group under the Nordic Council of Ministers. The aim of NOAK is to contribute to a global and comprehensive agreement on climate change with ambitious emission reduction commitments. To this end, the group prepares reports and studies, conducts meetings and organizes conferences supporting the Nordic negotiators in the UN climate negotiations.

Helsinki May 2014

Harri Laurikka
Chair of the Nordic Working Group
for Global Climate Negotiations

Executive summary

Policy implications

A number of issues have to be addressed if REDD credits are to be included in a future global carbon market. This report focuses on a subset of these: the implications of different rules for REDD credit inclusion and global commitments on the carbon price, other mitigation efforts, and the magnitude and distribution of the financial flows to REDD action and the subsequent reductions in forest emissions.

A major conclusion is that we can do more in terms of climate mitigation if REDD credits are included. The risk of market flooding and crowding out can be minimized through several mechanisms, for example, a system of partial offsetting (discounted REDD credits). Simple and practical ways to minimize this risk therefore exist.

The model simulations also show that an inclusion without any adjustments in the overall cap will lead to significantly lower carbon prices. Even in the scenario of high pledges, a full inclusion of REDD credits will reduce the carbon price by almost 2/3 (USD 19 to 7 per tCO_2). The overall emission target must move towards the 2 degrees climate target if REDD inclusion is to maintain a high carbon prices and thereby strong incentives for domestic emissions reductions in Annex I countries (and elsewhere).

On the other hand, a 2 degrees target seems politically very challenging without fully utilizing the REDD potential. Even with full inclusion of REDD and no restriction on the share of emissions reduction to be done domestically, the carbon price is in the range of USD 63–72 per tCO_2.

In short, there are environmentally and economically sound ways of including REDD credits in a carbon market. Future discussions would be more meaningful if the assumptions and options are clearly spelled out, and the debate focuses on the design of mechanisms, rather than a polarized debate for and against inclusion.

Key messages

- Larger emissions reductions and lower overall abatement costs can be achieved by including REDD[1] credits in a global carbon market.
- Several factors influence the impact of an inclusion of REDD credits in the carbon market including the rules for emissions trading and domestic actions, commitment levels, and mitigation potential and costs from other sectors.
- Global emissions from deforestation are reduced by 22–62% below business-as-usual levels by 2020 under the various scenarios for including REDD credits in a carbon compliance market.
- Achieving the global greenhouse gas (GHG) emission levels by 2020 needed for a likely chance of meeting a 2 degrees target[2] is politically even more challenging *without* inclusion of REDD. Carbon prices would become very high compared to those obtained under the conditional pledges put forward by the countries under the Cancún climate agreements. Many countries will find these high prices unacceptable, while a 2 degrees scenario that includes REDD is still attainable from a cost perspective.
- A key challenge is to get a balanced introduction of REDD credits, that is, to ensure that inclusion of REDD is additional and thereby contributes to deeper cuts in global emissions (avoids crowding out of other mitigation efforts). This can be achieved through more ambitious global commitments that bring us closer to a 2 degrees scenario, which raise the demand for emission credits on the carbon market, and thereby reinforce the carbon price by balancing the increased supply by higher demand. REDD credits inclusion *without* tightening the global target will lead to significant crowding out of other mitigation efforts.
- One further option to achieve a balanced introduction is through *partial offsetting*, whereby one REDD credit offsets less than one credit of domestic reductions in Annex I countries.

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[1] We use REDD rather than REDD+ in this report, as the discussion and model scenarios focus on avoided deforestation and to some extent also degradation, but not "enhancement of forest carbon stocks".
[2] Meeting a 2 degree target not only depends on the 2020 emissions, but more on the emissions budgets for the period 2000–2050, and 2000–2100.

- Setting reference emission levels below the business-as-usual baseline can also ensure that REDD inclusion yields additional cuts in global GHG emissions.
- An inclusion of REDD credits have distributional impacts, and different consequences for Annex I and non-Annex I parties. Among non-Annex I parties, REDD are likely to crowd out some CDM credits and thereby create both winners and losers of REDD credit inclusion.

The challenge of a balanced introduction of REDD credits

Including certified emissions reduction from Deforestation and Forest Degradation (REDD credits) in a future global carbon market remains one of the controversial issues in the REDD and climate debate. Such inclusion can mobilize the funding needed to realize the REDD potential. Since REDD is a low cost mitigation option, larger global emissions reductions can be achieved when including REDD in the carbon market. Many fear, however, that including cheap REDD credits may crowd out mitigation efforts in developed countries by depressing the carbon price, reducing or eliminating the global additionality of any REDD credits inclusion; as well some fear that no early investments in clean technology will take place and long-term ambitions will not be met due to inertia in the system. This report assesses different options for REDD credits inclusion, and proposes ways to balance the different concerns expressed in the debate.

We stress the importance of ensuring a balance between demand (global mitigation commitments) and supply for REDD credits (rules for inclusion of REDD credits in the market). Achieving such a balance between the demand and supply is needed to keep a stable and "not too low" carbon price, which will ensure sufficient flows of REDD funding, limit crowding out and increase the extent of additionality. These elements are essential to ensure political acceptance of inclusion of REDD credits in a future global carbon market.

Six different options of ensuring a balanced inclusion of REDD credits are discussed: (i) REDD inclusion along with tighter global caps on emissions, (ii) rules which adjust the overall cap depending on the carbon price, (iii) partial offsetting through REDD credits, (iv) restrictions on the demand and/or supply of REDD credits, (v) banking of REDD credits (to encourage early reductions and ensure a more stable carbon price path), and (vi) tighter reference levels for REDD (some initial cheap reductions cannot be traded and thereby not used as offsets).

The option of *partial offsetting* (or discounted REDD credits) is an innovative proposal, and is in this report analyzed empirically. This system will ensure that REDD credits used as offsets in the market automatically increases the global emissions reductions. For example, a developed country may be required to buy 2 REDD credits (tCO_2) in the market to offset 1 credit of domestic emissions. The net effect of that transaction will be to cut global emissions by 1 tCO_2.

Scenarios analyzed

From the six discussed options for including REDD in the carbon market we dive into options i, iii and iv in ten different scenarios. We do not create scenarios to analyze flexible caps (option ii), banking of credits (option v) and tighter reference levels (option vi). Scenarios are constructed by varying demand and supply assumptions. On the demand side, we consider three mitigation scenarios (commitment levels): (i) the low reduction pledges (scenario 1), (ii) the high reduction pledges by 2020 put forward by countries in the Cancún Agreements (scenarios 2, 3a, 3b, 4), and (iii) the global emissions targets by 2020 compatible with meeting the 2 degrees target with a likely chance (higher than 66%, scenarios 5, 6, 7). On the supply side, we consider three alternatives for REDD inclusion: (i) no inclusion (scenarios 1, 2, 5), (ii) partial inclusion (scenarios 3a, 3b, 6), and (iii) full inclusion (scenarios 4, 7). The option of partial offsetting of REDD credits is analyzed in the partial inclusion scenario. We also analyze two additional scenarios where the aim is to keep the carbon price or the overall abatement costs constant after an inclusion of REDD credits into the market (scenarios 8, 9).

The scenarios are analyzed using the FAIR model of the PBL Netherlands Environmental Assessment Agency. The model integrates baseline emissions and information on marginal abatement costs by sectors and regions and based on this, calculates regional and global abatement costs given regional GHG emission targets. The implications are assessed for the year 2020 in the form of: (i) the abatement cost for Annex I (developed) and non-Annex I (developing) countries, (ii) price of carbon credits, (iii) the emissions trade flows, (iv) global GHG emissions, and (v) reductions in deforestation CO_2 emissions and the additionality achieved by including REDD activities, overall and by groups of countries.

#	Scenario name	Carbon Price in 2020 (USD[3]/ tCO_2)[4]	Global GHG emissions in 2020 ($GtCO_2$)	Reduction of CO_2 deforestation emission in % below business-as-usual levels in 2020 (% below 2005 levels)			Global Abatement Costs in 2020 (USD billion and % of GDP)[5]
				World	Brazil	Indonesia	
1	No REDD inclusion/ Low pledge	6	52.7	8 (32)	20 (32)	20 (50)	53 (0.07)
2	No REDD inclusion/ High pledge	19	51.2	10 (33)	25 (37)	25 (54)	71 (0.10)
3a	Discounting REDD/ High pledge	9	50.5	32 (50)	50 (58)	8 (43)	73 (0.10)
3b	Price REDD/High pledge	19	50.7	22 (42)	52 (59)	95 (97)	77 (0.11)
4	Full REDD inclusion/ High pledge	7	50.7	27 (46)	42 (51)	4 (41)	74 (0.10)
5	No REDD inclusion/ 2 degrees	108	45.7	10 (33)	25 (37)	25 (54)	247 (0.34)
6	Discounting REDD/2 degrees	72	45.2	62 (71)	82 (85)	95 (97)	163 (0.23)
7	Full REDD inclusion/ 2degrees	63	45.6	61 (71)	82 (85)	95 (97)	157 (0.22)
8	Full REDD inclusion at equal price	19	47.5	52 (39)	79 (67)	72 (44)	91 (0.13)
9	Full REDD inclusion at equal costs	16	49.2				71 (0.10)

The business-as-usual global emissions levels including land-use CO_2 emissions reach to 56 $GtCO_2$ by 2020, and the mitigation efforts of the scenarios vary between 4 and 11 $GtCO_2$. We also present specific results on Brazil and Indonesia given their relevance as REDD countries. In all pledge scenarios we assume that all Annex I countries excluding the US must meet 2/3 of its emission reduction target by domestic reductions, based on countries' statements on international offsets during the climate negotiations (e.g., the maximum allowed use of international offsets of 9% for the EU 30% target). For the US 100% domestic reduction is assumed, based on official statements that the 17% reduction target for 2020 will be

[3] USD in 2005 value.
[4] In the model calculations CO_2eq are used, but in the report we simply use CO_2.
[5] GDP uses Market Exchange Rate.

implemented through various national policy instruments, and as there is currently no legal basis (federal law) for emissions trading or international offsets. Mexico and South Korea achieve their respective targets domestically, and after doing so they can trade additional reductions in the carbon market. We also assume for the no REDD inclusion scenarios, based on the pledges of Brazil and Indonesia, a REDD realization of 20 to 25% below business-as-usual emission levels.

Modeling results

The scenarios and their results on key variables are presented in the table. In line with earlier studies, we find that there is a large potential for further reducing emissions by including REDD credits in the global carbon market. When allowing REDD credits to be traded in the global carbon market, emissions from deforestation are reduced by 22–62% compared to business-as-usual levels (i.e., 42 to 71% compared to 2005 levels) by 2020, depending on the scenario. The highest reduction is achieved in the 2 degrees scenario when REDD credits are fully included.

For any given global target, the carbon price decreases following an inclusion of REDD credits in the market. When REDD credits are allowed to be traded fully in the market and we keep the same commitment levels for comparison, the global carbon price is reduced from USD 19/tCO_2 (scenario 2) to USD 7/tCO_2 (scenario 4) for the high pledge assumption. This effect is less (USD9/tCO_2) when REDD credits are discounted, i.e., more than one REDD credit is needed to offset one credit in an Annex I country (scenario 3a).

An alternative option for REDD inclusion in the carbon market, is to keep the carbon price constant at the level of the high pledge scenario (scenario 2) after REDD credits are included. Global emissions are reduced from 51.2 to 47.5 GtCO_2 (scenario 2 vs. scenario 8). Under the assumption to keep global abatement costs constant, emissions are reduced to 49.2 GtCO_2 (scenario 9) although this depends on the allocation of emission reductions among regions. In comparison, the 2 degrees scenario has global emissions of 45.7 GtCO_2 in 2020, and REDD inclusion brings us approximately 2/5 of the way towards that target at no increase in global costs, as compared to the high pledge scenario. With the constant price assumption we are 4/5 on the way towards the 2 degrees target.

The model results also suggest that reaching the 2 degrees target without inclusion of REDD (scenario 5) will be substantially more expensive than a scenario with full REDD inclusion (scenario 7) where global abatement costs are 57% higher in the former case, while the carbon price is 71% higher and goes above USD 100 per tCO_2.

While overall abatement costs are reduced following an inclusion of REDD credits, some non-Annex I countries will lose out, in particular the countries with low REDD potential. This is due to the lower carbon price (also for CDM payments), and this more than outweighs the REDD transfers they receive. In addition, the results are influenced by assumptions of restrictions of the share of emissions reduction to be done domestically in non-Annex I and Annex I countries (as specified in the conditions of the countries' submitted reduction pledges); domestic costs dominate over the financial flows due to emissions trading. Under more stringent commitment levels, full trade and no domestic restrictions for both Annex I and non-Annex I, the financial flows due to emissions trading and CDM (offsetting) would be enhanced, resulting in a more clear financial benefit for both Annex I and non-Annex I countries, from including REDD in the market.

1. Introduction

1.1 Background

Stabilizing the level of atmospheric greenhouse gases (GHG) is critical to avoid harmful climate change, and forestry related emissions are responsible for about 17% of net global GHG emissions (IPCC, 2007). Due to the relative low mitigation cost, and the possibilities for quick action, reducing emissions from deforestation and forest degradation (REDD) can play an even larger role in the short-medium term global mitigation efforts. Mobilizing international funding is considered a prerequisite to harness the REDD mitigation potential. One alternative is to include certified emissions reductions from REDD ("REDD credits") as an offset in global compliance carbon market(s). Options for and implications of inclusion are discussed in this report.

Since 2007, when REDD became an integral part of the UNFCCC negotiations through the COP 13 decisions in Bali a number of mechanisms to achieve REDD has been established. The bulk of the funding so far has come from developing countries' own effort, and public sources in developed countries in the form of official development aid (ODA) through both bilateral and multilateral channels. REDD credits are also being transacted in voluntary carbon markets, albeit in small volumes compared to the public funding (World Bank, 2011). However, most REDD pilot projects (demonstration activities) aim to sell verified emissions reductions (VER) in this market (Sunderlin and Sills, 2012). REDD credits are currently not included in any compliance markets, notably they are not part of European Union Emission trading system (EU-ETS) or the Clean Development Mechanism (CDM) under the Kyoto Protocol.

There are, however, some early steps being taken towards an inclusion of forest carbon in offset carbon markets. Australian carbon credit units (ACCUs) issued under the Carbon Farming Initiative (CFI) may become eligible for compliance under international agreements, even if carbon credits from reforestation and avoided deforestation activities are a non-Kyoto compliant (Australian Government, 2011). The Australian government has also proposed a carbon price mechanism that came into force on 1 July 2012. The Australian Government and the EU has announced that its two carbon trading schemes will link from as early as 2015. This will allow Australian emitters to buy carbon credits for compliance from the EU. The New Zealand government has taken steps to include forest carbon in a carbon trading market. Forests entered the New Zealand Emission Trading Scheme on 1. January 2008 (NZ ETS, 2011).[6]

The development of a global carbon market hinges on the progress in the UNFCCC negotiations, including an agreement on new targets after the first commitment period of the Kyoto protocol expires. In the UNFCCC negotiations urgent action to limit global warming to 2°C has been called upon, as described in the Cancún Agreements (UNFCCC, 2010a), and voluntary pledges to reduce greenhouse gas emissions by 2020 have been made by both developed and developing countries. If all countries fully implement their higher conditional reduction pledges and strict accounting rules, there is an average gap of 6 $GtCO_2$ between emission levels resulting from the submissions in 2020 and emissions necessary to place the world onto a trajectory that will keep global temperature rises to less than 2°C with a likely chance, according to the UNEP Bridging the Gap Report (UNEP, 2011). This underscores the need to look beyond current mitigation sources as well as sources of funding, including funding from carbon markets.

1.2 The debate on REDD credits in carbon markets

The issue is highly contested among UNFCCC Parties, NGOs, private sector and researchers. The key arguments for and the main concerns about any inclusion of REDD credits into carbon markets can be summarized as follows:

Forest emissions and potential for mitigation

Forest carbon pools are the third largest source of GHG emissions. Including this source in a global climate agreement will reduce the overall GHG emissions substantially (Eliasch Review, 2008). Skeptics to such a proposal argue that the creation of a global carbon market with the potential to use REDD as an offset, implies that rich countries can buy re-

[6] Owners of post-1989 forested land can choose to enter the scheme and earn New Zealand Units (NZUs) as their forests grow, but they do not receive allocations of NZUs as there are no mandatory obligations. Owners of pre-1990 forested land will on the other hand face obligations under the scheme if they deforest. These owners also receive a one-off allocation of NZUs to help reduce the decrease in land value due to the limitations of land-use flexibility. New Zealand has not included old-growth indigenous forests in their emissions trading scheme (NZ ETS, 2011).

ductions outside their national borders and substitute them for domestic reductions. They rise both to ethical arguments to the idea of offsetting, as well as questioning the realism of such a market being created and/or being able to work effectively.

Mitigation targets

Including forest carbon credits in the global carbon market will enable the international community to take on more ambitious mitigation targets. However, to the extent that the overall reduction targets are not adjusted, an inclusion of REDD credits may crowd out other mitigation efforts (through a lower carbon price), which is needed to move to a low-carbon economy in the medium-long term.

Cost Savings from REDD (costs efficiency)

Any given global emission target can be achieved at lower overall mitigation costs by including REDD in carbon market. However, there are secondary effects that also need to be factored in: lower current carbon prices may delay the development of cleaner technologies, which have impacts on the long term costs of reaching emission targets.

Role of market mechanisms in engaging the private sector

Market-based instruments are perceived to play a vital role to help meet ambitious GHG emission reduction objectives by incentivizing the deployment of private capital (World Bank, 2011). However, uncertainties relate to the creation of marketable REDD credits: establishing reliable systems of to measure, report and verify (MRV), changes in forest carbon and setting appropriate reference levels, with associated issues of additionality, permanence and leakage (Obersteiner *et al.,* 2009). There are also concerns on the equity aspect of allowing rich countries to buy relatively cheaper offsets abroad.

Forest conservation and technology transfers

In addition to the climate benefits of avoiding deforestation emissions, carbon markets would create opportunities for financing sustainable forest management (SFM) and forest conservation, and support technology transfers.

Co-benefits
To the extent that carbon markets contribute to "more REDD", the associated co-benefits in terms of biodiversity conservation and support to local livelihoods, should also increase.[7] However, the requirement of REDD credits and market transactions may prevent poor groups/ countries to participate, and also lead to a too strong focus on emissions reductions relative to co-benefits.

The positions in the debate reflect various weighting of the above arguments. Some parties (like the European Union) emphasize the need to keep the carbon price at a level that provides continuous incentives for the private sector to develop and adopt low-carbon solutions (and not penalize early movers). A related argument by many parties (e.g., Brazil) and NGOs is the concern for *additionality*; any inclusion of REDD credits must come on top of existing commitments.[8] Developing countries are also interested in a mechanism designed to ensure substantial transfers to them, although the proposed REDD mechanisms vary between these countries. Other developed countries, see the opportunity of REDD offsets as an opportunity to contain costs and/or take on stronger commitments.

1.3 Purpose, scope and outline of report

This report does not attempt to assess all arguments and positions, but will explore and simulate a subset of the arguments by quantifying the implications of including REDD in a future carbon market. The overall objective of the project, commissioned by the Nordic Council of Ministers is: "to provide improved knowledge and better understanding among key decision makers on the options and impacts of integrating REDD in global carbon markets."

The existence of a global carbon market is taken as given, and the steps needed towards its establishment are not discussed. Then implica-

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[7] Another discussion concerns to what extent REDD funding though markets viz-a-viz other sources of funding are likely to yield a different baskets of co-benefits (e.g., Vatn and Angelsen, 2009). Our point here concerns the overall level of REDD (i.e. reduced emissions though avoided deforestation and degradation).
[8] In this report, we apply the term "additionality" to mean that a mechanism for including REDD credits in the carbon market should lead to lower emissions (higher emissions reductions), and not just be an emission shifting mechanism. This is in line with Chung (2009), who argues that the "project additionality" (of a CDM project) should be less important compared to the additionality of overall carbon emission reductions, although one can argue that they are linked.

tions of a partial or full inclusion of REDD credits are explored in terms of equilibrium carbon price and crowding out effects, cost savings and potential for higher emissions reductions. We stress the importance of simultaneously considering: (i) the overall global cap on emissions or commitment levels (demand), and (ii) the degree and forms of REDD inclusion (supply). The scenarios developed are preliminary variations of key demand and supply side variables.

The regional scale in the FAIR model used for the analysis is countries (or groups of countries). We do not discuss a host of issues related to *how* REDD countries are to supply international REDD credits and the domestic REDD institutions and policies. These are clearly key issues for REDD to become an effective mechanism (Angelsen, 2009), and these issues will influence the amount of REDD credits that can be supplied. The different degrees of readiness are incorporated in the modeling scenarios, but several critical issues are outside the scope of this report. These include the role of safeguards needed to promote sustainable REDD actions, such as respecting the knowledge and rights of indigenous people and local communities (Brown *et al.*, 2008; Parker *et al.*, 2008). Clarifying carbon rights and establishing mechanisms for benefit and costs sharing are also critical in designing domestic systems that can deliver national REDD credits for an international market. This report does not address REDD benefits and costs at the domestic level, but it can help to identify potential international financial transfers and mitigation efforts in the light of the current UNFCCC negotiations and the 2°C target policy goal.

Furthermore, any inclusion of REDD credits in the carbon market involves a number of decisions concerning the standards of credits (e.g., requirements concerning measuring, reporting and verification (MRV), and permanence and liability), procedures for certifications, etc. In this report we do not address these issues, but rather focus on two other important aspects as mentioned above: the supply (degree and form of inclusion) and demand (level of commitment) of REDD credits.

This report is organized as follows: Section 2 presents the basic economic theory of how the inclusion of REDD credits into a carbon market works. Section 3 summarizes key findings of previous studies. Section 4 outlines different options on how to include REDD credits in a carbon market, differentiating between the *degree of inclusion* and the *form of inclusion*, as well as other options for including REDD credits in the carbon market like banking, lower reference levels, the corridor approach and flexible caps. Section 5 presents the different scenarios, that result from stylized and realistic assumptions on the *degrees of inclusion* of REDD credits in the carbon market and the *commitment level* of countries, including the current low and high pledges, and the reduction targets consistent with meeting the 2°C target. The results of the scenario analysis using the FAIR model (den Elzen and Lucas, 2005; den Elzen *et al.*, 2011) are presented in section 6. Some concluding remarks are given in section 7.

2. The basic economics of REDD credits in a carbon market

Sketching a partial equilibrium model of the global carbon market helps us to understand the underlying assumptions and concerns of including forest carbon credits in the market.[9] The supply side is initially represented by the marginal costs of emissions reductions in all sectors except forestry. The supply curve for emission reductions gives the provision of carbon credits (emissions reductions) at different carbon prices. When forest carbon (REDD) is included as an option alongside other mitigation options, the supply curve shifts to the right, i.e., for any given carbon price more emissions reductions can be achieved. This is illustrated in Figure 1. The magnitude of the shift in the supply curve depends on the costs of REDD and the rules for REDD integration, e.g., the offsetting ratio or equivalence factor (see section 4). Higher REDD costs and stricter rules make the supply shift and the subsequent impacts on the carbon price and overall emissions and costs smaller (Dixon *et al*., 2008).

The demand side is more complex. We discuss three conceivable situations for how demand for carbon credits varies by the carbon price (i.e., the slope of the demand curve). The demand refers to either a politically set cap on global emissions (e.g., through a future climate agreement of UNFCCC), or the sum of pledges by countries. Our point of reference in Figure 1 is a situation with a fixed cap on global emissions reductions and no inclusions of REDD (Alternative I).

One of the main concerns of including REDD in the global carbon market is that it will "flood the market" and crowd out other mitigation activities, and thus have limited or no additionality (Leach, 2008; Fry, 2008; Bozomski and Hepburn, 2009; EU Commission, 2009; Obersteiner, 2009; Schneck *et al.,* 2011). This corresponds to Alternative II in Figure 1: the global cap is fixed, i.e., we have a vertical demand curve for emissions reduction. As seen in Figure 1, including REDD credits in a carbon market

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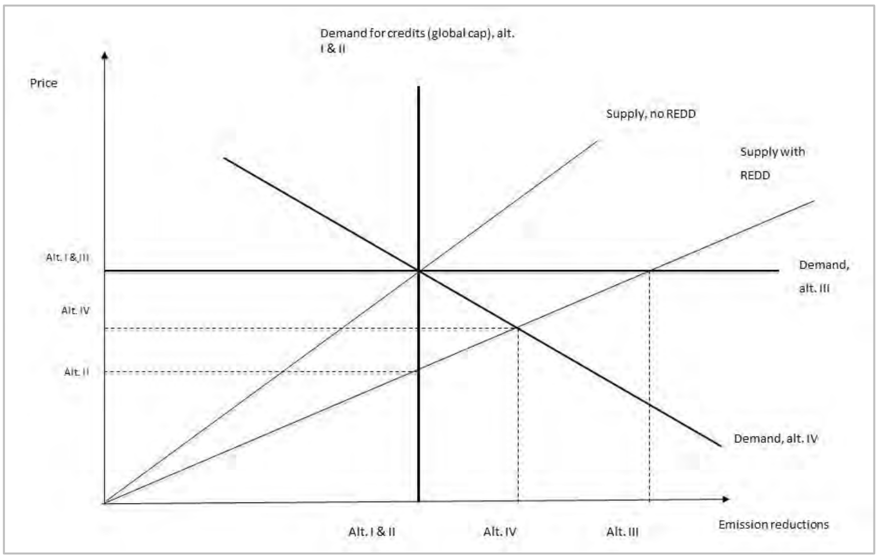
[9] A general equilibrium model would have shed light on likely general equilibrium effects, but is being assumed away for simplicity as the main task is to describe the carbon market in a straightforward manner.

without any change in the global emission cap (demand) will not change the overall emissions; it gives no additionality as the crowding out effect on other (non-REDD) mitigation efforts is 100%.[10] The price and the overall mitigation costs will drop.

Figure 1: The impact of including REDD credits under different assumptions about the demand



Notes:
Alternative I: Initial situation, no REDD inclusion.
Alternative II: No change in cap: 100% crowding out.
Alternative III: No change in price: higher cap, 100% additional.
Alternative IV: No change in costs: intermediate with some crowding out and some additional reductions: lower price, higher cap.

According to basic economic reasoning, moving the mitigation efforts from a high cost to a low cost (REDD) sector is considered positive as the costs of achieving the same goal are reduced. Thus crowding out effects are not necessarily negative, but just reflect a cost efficient reallocation of emissions reductions after REDD is included. Crowding out effects thus need to be distinguished from leakage, i.e., when a particular project or sector policies lead to higher emissions outside the project area or in other sectors, *and these emission increases are not accounted for*.

[10] If REDD credits are more uncertain or less effective than other credits, e.g., due to unaccounted leakage or reference levels set above BAU, the crowding out effect can be higher than 100%, i.e. the global emissions reductions are lower with REDD inclusion.

Hence the key difference between *leakage* and *crowding out* is that the latter is accounted for in a climate mitigation mechanism (in our case: being part of a global climate mitigation regime). There are, however, political concerns related to crowding out effects, and the issue therefore receives considerable attention in this report.

If the overall cap for GHG emissions in the rest of the economy remains unchanged, including REDD credits will yield lower price and cost. This may enhance the willingness to adopt higher commitment levels. To address the concerns about no additionality in Alternative II, an opposite and analytically extreme case is a policy objective that REDD should be 100% additional to the initial mitigation efforts (the case without REDD inclusion). Related to our framework, this implies that the global reduction target or cap is changed such that the carbon price is kept constant. This corresponds to a horizontal demand curve, and is illustrated as Alternative III in Figure 1. The fixed carbon price implies that REDD inclusion will not affect the mitigation level of the non-REDD sector. Overall mitigation costs will increase by an amount equal to the REDD costs.

Alternatives II and III represent analytically extreme cases, and an intermediate and more realistic assumption is that commitment depends on the carbon price, as expressed in alternative IV with a downward sloping demand curve in Figure 1. This corresponds to a situation where the demand is politically set by the sum of the mitigation commitment for each country, or by a mutually agreed global cap on emissions with commitments being based on to what the countries conceive as feasible, including their costs. In this more realistic case the additionality of REDD inclusion is between 0% and 100%. The carbon price is lower, but overall emissions reduction goes up. One special case within this alternative, analyzed as a separate scenario in the FAIR model, is when we assume that the total (REDD and non-REDD) abatement costs should be kept at the same level as before the inclusion of REDD in the carbon market.

3. Previous studies on REDD and carbon markets

A REDD inclusion in a global carbon market will have very different outcomes depending on the design for integration, and on the overall global climate policy (and carbon market) which REDD is to become part of.[11] An important rationale for including REDD credits in the global carbon market is to provide funding for forest conservation and sustainable forest management. Linking the carbon market to the land use sector is according to Stern (2006) the only way in which sufficient capital will flow into this sector. The Stern Review argues that to expect public sector funding to provide funding earmarked for forestry conservation at this level will be politically infeasible due to competing demand for these funds. Most REDD financing proposals argue for global funds and/or emission trading markets as their preferred source of funding (Angelsen, 2008; Parker *et al.,* 2008). Carbon market funding for REDD may also provide incentives to invest in new low carbon technologies, to transfer existing cleaner technologies and finance to developing countries (Eliasch, 2008).

The potential for greater cost reductions and the opportunity to achieve higher mitigation targets have been the main arguments for the inclusion of REDD credits to global carbon markets. The reductions in forest emissions vary, however, considerably across studies. A comparative study of global marginal cost curves for REDD activities by Kindermann *et al.* (2008), using three different models (GTM, DIMA and GCOMAP), finds that the average of these model estimates indicates that by 2030, a 10% reduction in emissions from deforestation would be abated for less than USD 2–5/tCO_2[12]. For USD 10–21/tCO_2 one could achieve a 50% reduction in emissions from deforestation. Other estimates of the marginal cost of REDD include a study by Busch *et al.* (2009), who finds

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[11] For a specific focus on economic tools, modeling challenges and priorities for future research on REDD, see a recent overview by Lubowski and Rose (2013).

[12] That is the average of the global estimates. The price estimate varies depending on the model used and for the different regions.

that for less than USD 5/tCO_2 up to 73–84% reductions in deforestation emissions can be achieved. Using the data presented in Böttcher *et al.* (2011), a carbon price of USD 15/tCO_2 would eliminate about 50% of the deforestation emissions in 2020 (as compared to BAU).

Murray *et al.* (2009) argue that these low cost studies tend to underestimate the full cost of reduced emissions from deforestation and forest degradation as they commonly only consider the opportunity cost of the reduction and not the rents the seller receives. Further, these studies may also ignore or underestimate the transaction costs, costs of MRV systems, costs related to setting up the required institutions, and the costs of implementing the required policies. Recent studies indicate that accounting for institutional and political barriers reduces the mitigation potential (Lubowski and Rose, 2013). Bush *et al.* (2009) include sellers' rent in addition to the opportunity cost, and this raises costs by a factor of three or more. Leakage is also included, resulting in an increased cost of REDD by about almost 20%.

Several studies have estimated the effect on carbon prices on the global carbon market and mitigation costs of including REDD, not only looking at the marginal cost curves of avoided deforestation. Anger and Sathaye (2008) simulated the inclusion of REDD at the global carbon market. They report a dramatic drop in the carbon price, from EUR 68/tCO_2 when neither CDM nor REDD credits are used as offsets, to EUR 11/tCO_2 when CDM credits are allowed without restrictions, and to EUR 6/tCO_2 when both CDM and REDD credits are allowed without restrictions. Overall mitigation cost is reduced by 40%.

The Environmental Defense Fund (EDF) has also investigated the market impact of introducing REDD credits (Piris-Cabezas and Keohane, 2008). Looking at CDM and REDD credits separately as in Anger and Sathaye (2008), EDF finds that the carbon price is EUR 23/tCO_2 when CDM credits are allowed for up to 10% of the commitments. The price reduces to EUR 20/tCO_2 when REDD credits are included without restriction, and declines further to EUR 16/tCO_2 when all forestry credits are allowed in the market without restrictions. Mitigation costs are reduced by 31% in 2020 by allowing forestry credits in all carbon markets. The absolute mitigation cost is about three times higher than in Anger and Sathaye (2008). This is largely because EDF assumes steeper reduction targets in developed countries by including the demand by the Lieberman-Warner bill in the U.S. (H.R. 2454), which implies a reduction of 19% by 2020 compared to 2005 emissions, and 71% by 2050. The Lieberman-Warner bill also allows for credit banking that could prevent drastic price changes over time (U.S. Congress, 2008).

Concerns that REDD will be cheaper compared to other mitigation mechanisms, such as CDM, can run both ways. Anger and Sathaye (2008) find that competition from CDM carbon offsets and feedback of credit imports on carbon prices cause only 300 million tons of REDD credits to enter the emission trading system. This is only a 1/10 of the potential supply of REDD offsets as predicted by the same model for current carbon prices. Table 1 (at the end of this chapter) presents an overview of other studies that have analyzed the effect of the carbon price for REDD and other mitigation activities, as well as the associated cost estimates.

To what degree the REDD potential is harnessed depends to a large extent on the carbon prices and the resulting compensation paid for avoided deforestation and forest degradation. The effect of carbon prices on REDD has not been widely analyzed, and the few studies available show a wide range of results, such as those presented above. Most models of the carbon market have for simplicity assumed that carbon prices remain constant. Sohngen and Sedjo (2006) analyzed how different paths for carbon prices would affect reductions in deforestation: if real carbon prices where starting at a low initial prices of USD 10–20 per tCO_2 in 2010, followed by sharp price increases they argue that there will be little mitigation during the next 20 years. But, with a price policy where real carbon prices would increase by 3–5% per year, starting at initial real prices ranging from USD 75 to USD 100 per tCO_2, it would slow deforestation by 60–85% over the next 20 years. This argument would also apply to afforestation: land owners will delay action to take advantage of higher future carbon prices. When prices are low in the introductory phases and higher prices are expected in later periods, potential sellers will wait to register their land in the carbon program.

Even though low prices and hence low costs generally are considered a virtue, concerns remain about the implications of lower carbon prices if REDD credits are included in the market. The main worry is the crowding out of mitigation efforts in other sectors through (over)supply of REDD credits due to the low marginal costs of reduced forest emissions. This crowding out effect depends critically on a number of assumptions on, for example, whether REDD credits become fully fungible and a ceiling on to what extent REDD can be used as offsets. Several studies (Fry, 2008; Leach, 2008; Bozomski and Hepburn, 2009; Schneck *et al.,* 2011) have analyzed the risk of "market flooding" in relation to the size of the existing Emission Trading Schemes (ETS) of the European Union. Murray *et al.* (2009) suggest that price reduction benefits do not necessary cause flooding or substantial diversion of effort from other sectors. The above studies argue that the inclusion of REDD can bring down the allowance price as it substitutes for higher-cost mitigation alternatives at the margin, but more than 70% of the abatement must still come from other sectors for the capped countries to meet their commitments.

The inclusion of REDD needs to ensure that mitigation activities in one region does not lead to displacement of emissions (leakage) (Obersteiner *et al.,* 2009), thereby lowering the overall emissions reduction. Many have assumed that REDD is particularly prone to leakage, but according to Schwarze *et al.* (2002) forests are not more vulnerable than other sectors. The degree of leakage will depend on the scale of accounting and the level of participation. Broad participation is critical to prevent leakage to countries that do not participate in a forest carbon program and emphasizes the need for proper incentives and accounting being in place also outside the non-contracted forested areas (Murray *et al.,* 2009). This form of leakage is in space, whereas permanence addresses leakage in time. Forest carbon release is vulnerable to disturbances, such as drought, forest fires or pests. A successful climate change framework must assure that emission reductions are locked in over time through long term commitments and rules for how to deal with such disturbances.

A final concern relates to additionality, i.e., whether the carbon market integration will yield global reductions that come on top of what would happen without inclusion. The World Bank (2008) argues that it must be demonstrated that the proposed REDD project is additional. It will be pertinent to evaluate the sustained policies of any sector, and the use of reference scenarios will be important to determine the additionality of REDD. This is essentially a question of setting a reference level for forest emissions that is not higher than the BAU scenario (Meridian Institute, 2011). The standard problem is that one cannot observe what would have happened without the intervention (the counterfactual), and predictions have a high degree of uncertainty. No additionality will make the international community paying for tropical “hot air”, i.e., reductions that are not real.

The substitutability (fungibility) of REDD credits vis-à-vis carbon credits from other mitigation sources can be restricted in several ways. The Center for Clean Air Policy’s report (2007) on the “dual market” approach specifies the creation of a new carbon market for forest carbon units that is only partly fungible with the post-2012 global carbon market. They propose that Annex I countries commit a percentage of their mitigation target to come from the REDD market set by the COP. This limits how much of the overall commitment can be met through REDD, and hence reduce the threats to the already established carbon market. To solve the problem of uncertainty of who will buy (and sell), they suggest that the Annex I countries specify which developing country credits they will buy such that these countries can make the potentially expensive changes to their domestic policies and practices.

If one decides to establish a separate market for REDD credit trading, linking it to the other carbon trading markets will provide an additional source of revenues and ease the pressure on public funds. This requires that the forest carbon credits can be used for offsets, i.e., for countries with caps to achieve, in part or fully, their commitments, by buying REDD credits. In that way the dual market is similar to a single cap on Annex I countries, with a separate ceiling on how much can be met by the purchase of REDD offsets.

While acknowledging that a number of technical and methodological issues remain to be resolved before REDD may be included in the carbon market, the majority of studies illustrate the significant potential for mitigation and REDD funding. The studies are summarized in Table 1, with the broad conclusions being:

- *Overall mitigation costs are reduced by 7%–40%*
  depending on the model assumptions, the degree of inclusion of REDD credits, and the time horizon.
- *The carbon price is reduced by 22%–60%*
  i.e., the reduction is larger than for overall mitigation costs. The magnitude of the price decrease hinges, *inter alia*, on the restrictions of REDD supply as well as whether the estimate assumes a change in the global cap.
- *Deforestation is reduced by up to 80%*
  but critical remarks remain regarding the realism of the underlying costs assumptions and implicit assumptions about smooth REDD implantation at the national and local levels.
- *Higher capital flows to REDD regions*
  Most studies support the finding that there will be an increase of capital flow to REDD regions. While theoretical analyses would suggest this capital flow will come at the expense of other flexibility mechanisms in the Kyoto Protocol such as CDM or domestic mitigation efforts by Annex I countries, it is still not clear from the models to what extent this will happen. The changes in capital flows are the combined result of a lower carbon price and changes in the amount of credits traded.

Table 1: Previous studies on implication of REDD inclusion in carbon markets

Study	Model/ method	Assumptions	Key findings
Anger and Sathaye (2008)	A dynamic model of the forestry sector and a static model of the world carbon market	Demand for carbon credits based on assumed Annex I reduction targets for 2020. No cap is placed on the use of credits.	International carbon permit price is almost halved due to the low-cost credit supply from tropical forest regions when allowing forestry credits on all carbon markets. Total compliance costs for industrialized countries decreases by more than one third if forest carbon is included even when accounting for conventional low-cost abatement options in developing countries via the CDM. Tropical rainforest regions receive substantial net revenues from exporting carbon-offset credits from reducing deforestation to the industrialized world. As a consequence of including REDD in the carbon market CDM host countries face decreasing revenues due to the increased competition for carbon-offset credit supply Less domestic action as a result of the price signal on the ETS.
Eliasch review (2008)	Estimation for the review by the UK office of Climate Change's Global Carbon Finance (GLOCAF)	Using 2020 IIASA marginal abatement cost curves. Timeline: 2020, 2030 and 2050	The cost of reducing emissions to 50% below 1990 levels when including REDD will reduce costs by 25–50% in 2030 and 20–40% in 2050. If deforestation is unabated the global economic cost of climate change is estimated to raise around USD 1 trillion a year by 2100. Including REDD in the global cap and trade market could reduce deforestation by 75% by 2030. EU carbon market price would be similar during phase III whether a) member states committed to a 20% emissions cut with a 30% supplementarity limit or b) committed to a 30% emission cut with a 50% supplementarity limit.
den Elzen *et al*. (2009)	FAIR model (PBL-Netherland Environ-mental Assessment Agency)/Partial Equilibri-um as solution concept with a simulation solving method and a recursively dynamic solution horizon	Using 2020 marginal abatement cost curves from three sources, including IIASA, Timeline: 2020	Including REDD in the carbon market could decrease the global abatement costs significantly (25 to 40%). This could lead to low costs or even net gains for the non-Annex I countries. With the addition of AR, the global abatement costs could even be reduced by 40–65% in 2020. Inclusion of the forest sector in the global carbon market could lower the abatement costs of meeting stringent reduction targets. Emission credits from REDD can offset part of the Annex I reduction, and increase financial flows from Annex I to non-Annex I countries. REDD countries would also use REDD to meet own reduction targets. It also has the benefit of reducing deforestation by 30–70% in 2020.
Bosetti *et al*. (2010)	Dynamic integrated assessment	Includes endogenous technical change. Allows for baking of credits. Timeline: 2050	Integrating REDD in the global carbon market can provide incentives for lowering deforestation rates while lowering the cost of global mitigation efforts by 10–23% depending on different model estimates. Allowing for banking of carbon credits, the cost reduction is greater, about 7–20% prior to 2050, and global REDD contributes from 7%–9% of total global abatement for the first half of the century, with and without banking. Argue that the lower estimates of cost savings might be due to their modeled restrictions on REDD trading prior to 2020.
Murray *et al*. (2009) Nicholas institute			The success of REDD as a compliance strategy for Annex I countries depends on its costs relative to other sectors; the greater the difference the more of an impact the REDD credits will have on the carbon market. Inclusion of REDD could lower the carbon market price by 43% if all international forest carbon is included, and by 22% if deforestation only is included. When allowing for banking, the inclusion of REDD can accelerate abatement.
Dixon *et al*. (2008) pre-pared for the New Zea-land Ministry of Agricul-ture		REDD credits are environmentally equiva-lent carbon units from other sources Aggregated reductions, including the U.S.	60% reduction from core commitments for Annex I countries will take full advantage of the efficiency gains of REDD integration in the global credit market. GHG mitigation of 25–40% compared to 1990 levels. Total cost for expanded commitments are high. Annex I compliance cost increase by 85%. Transfers to REDD countries increase 2.5 times compared with core commitments.

Study	Model/ method	Assumptions	Key findings
KEA3 (New Zealand) for Greenpeace International	Numerical partial equilibrium model	Commitments at the 2 degrees target. Enforces a balance between supply and demand for a post 2012 market Timeline: 2020 Unrestricted REDD, 20% and 50% supplmentarity requirements	Carbon price decreases by 57% due to their anticipated REDD supply if there is no increase in commitments. Unrestricted REDD inclusion reduces overall deforestation by 82%. Compliance cost will be lowered by 49%. Crowding out occurs through displacement of Annex I domestic abatement efforts in all of their scenarios due to the lower cost of REDD activities compared to CDM activities. Risk that the reduced global carbon price will discourage investments in technology and infrastructure, and that the lower net abatement cost will lead to a higher level of overall consumption in both Annex I countries and in offset regions.
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4. Options for including REDD credits

Any inclusion of REDD credits in a carbon market (i.e., as offsets) involves a number of decisions concerning the standards of credits (e.g., requirements concerning measuring, reporting and verification (MRV) and permanence/liability), procedures for certifications, the form and degree of inclusion, etc. It is outside the scope of this report to include all aspects of possible future REDD inclusions (for further discussions, see for example Karousakis *et al*., 2007; Eliasch Review, 2008; Murray *et al.*, 2009). We focus on two important aspects of the options to include REDD credits in the carbon market: (i) the degree of inclusion, i.e., any restrictions on the overall amount of REDD credits to be included, and (ii) the specific form of inclusion, i.e., demand/supply side restrictions, or quantity/price restrictions.

4.1 Degree of inclusion

There are three broad options for inclusion of REDD credits in the market: (i) no inclusion, (ii) partial inclusion, and (iii) full (non-restricted) inclusion of REDD credits to the global carbon market, as summarized in Table 2 and discussed in further details below.

Table 2: Overview of options for REDD inclusion

Main options	Specifications
No REDD inclusion	1) No inclusion and no market for REDD credits
	2) Establish own REDD credit market outside the global carbon market, subject to own targets
Partial REDD inclusion	1) Overall quantity restriction a) Supply side restriction b) Demand side restriction
	2) Reduced value of REDD credits a) Quantity reduction (i.e., discounting of REDD credits) b) Price reduction on REDD credits
Full REDD inclusion	REDD credits fully fungible with credits from other sectors

4.1.1 No inclusion

The no inclusion option implies that international funding for REDD must be raised outside the carbon market. This could either be in the form of public funds (e.g., official development aid – ODA), voluntary contributions, or a separate market for REDD credits.

Proposals for creating a parallel, independent market, subject to own targets for global forest carbon reductions, have been analyzed in Hare and Macey (2008). Specifications of this are found in the dual market approach (Ognowski *et al.*, 2007), and in the Greenpeace proposal of separate credits for tropical forests (Livengood and Dixon, 2009).

A major question concerning the establishment of a separate REDD market is where the demand would come from. One possibility is that Annex I (and potentially also other) countries commit to buying a specific amount of REDD credits, and that this becomes part of the overall climate commitment of the country (dual market). Analytically, this is very similar to the partial inclusion options discussed below, i.e., an overall cap, where some proportion can be met by buying REDD credits.

4.1.2 Partial inclusion

The partial inclusion comes in two versions: (1) *quantity restriction* on the amount of REDD credits permitted in the market, or (2) *value reduction* of REDD credits. For quantity restrictions two options exist: (1a) *Supply side restrictions*, i.e., an upper limit on amount of credits that REDD countries (individually, and/or as a group) can sell in the market for a specified period of time, and (1b) *demand side restrictions*, i.e., an upper limit on the amount of that Annex I (and potentially other) countries can buy and use as offsets. An example of demand restriction is the current CDM rules, which specifies the maximum amount of CER an Annex I country can use to meet its Kyoto target.

The existence of restrictions means that we do not achieve an equilibrium price where demand equals supply, i.e., the price the buyers are willing to pay exceeds the price which suppliers are willing to sell for (i.e., their marginal costs of REDD). Anger *et al.* (2009) thus suggest, in line with common economic reasoning, that in a demand restricted system the REDD credit price will be lower than the international permit price, whereas in the case of supply restrictions the REDD price is the same as the international permit price. However, it is also conceivable that in a demand restricted system competition among suppliers of REDD credits will drive the price down.

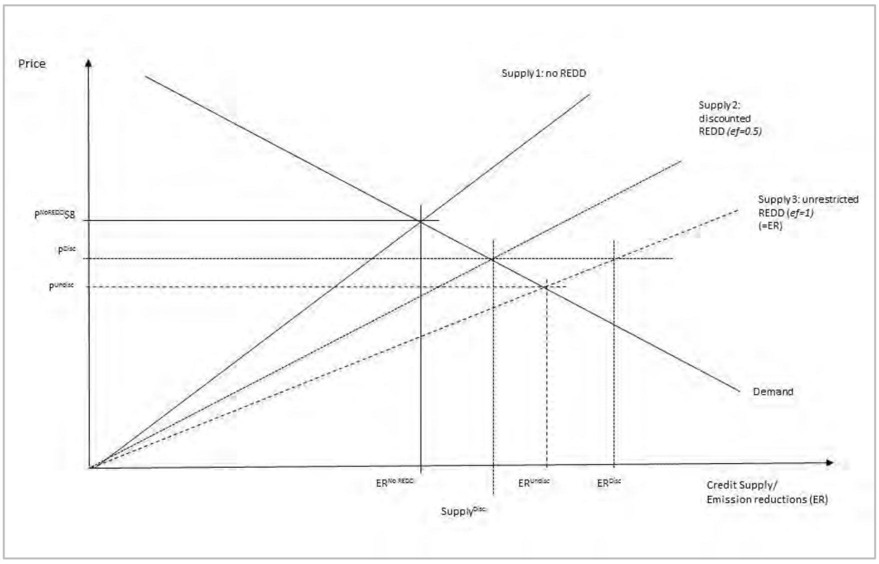
The option of a value reduction can either in the form of: (2a) a *quantity reduction (discounting),* or (2b) a *price reduction* of REDD credits. If *quantity reduction* is chosen, this could take the form of introducing an equivalence factor (discount factor or offsetting ratio), such that an estimated one ton of CO_2 reductions from REDD is exchanged for less in the market, i.e., $tCO_2^{REDD} = ef * tCO_2^{OTHER}$, where *ef* is an equivalence factor less than one. For example, if *ef* = 0.5, a country buying REDD credits must obtain two REDD credits for every credit that is being offset (i.e., avoided reductions in own country). A key feature of this system is that the overall emissions reductions may become larger than when setting *ef* = 1, i.e., no discounting. If *ef* < 1, every ton CO_2 being offset with REDD would increase the overall reductions by a factor of (1-ef). We label this the *additionality effect* of REDD discounting. Note, however, that this effect is modified by the fact that the price REDD countries receive will be lower, thus the overall supply is lower compared to the case of unlimited and non-discounted REDD credits.

Figure 2 gives a graphical representation of the effects of discounted REDD credits.[13] The basic idea of partial offsetting is that for any given price (P^{Undisc}), the emissions reductions is given by the Supply 3-curve, but only a fraction of the emissions reductions from REDD is supplied in the market (if *ef =0.5* then half is supplied).[14] Thus, in the case of discounted REDD credits (partial offsetting), the market equilibrium is found where the demand curve and the Supply 2 curve intersects, while the overall emission reductions (ER^{Disc}) is found by extending that line for the equilibrium price (P^{Disc}).

[13] We disregard the supply of carbon credits from other mitigation efforts (i.e., CDM). Also, for clarity of exposition, we assume that the RL = BAU, and that there are no domestic (non-Annex I) REDD actions. Compared to Figure 1, we only discuss the case with a demand curve in-between the two extreme cases. Note, however, that the main result of higher overall emissions also hold for the case of a vertical demand curve, i.e., a fixed global cap.

[14] Graphically, this means that the horizontal distance is the same between the Supply 1 and Supply 2, and between the Supply 2 and Supply 3 curves.

Figure 2: Discounting REDD credits supplied to the market



The figure illustrates the impact of a system of partial offsetting, compared to a situation with 1:1 offsetting. Partial offsetting will reduce the supply of REDD credits in the market (shift from Supply 3 to Supply 2), which increases the carbon price.

Although the carbon price has increased, the REDD credit suppliers only get half of this price per tCO_2 (when *ef = 0.5*), which reduce the incentives to reduce deforestation. At the same time, the actual emissions reductions are twice the amount being used as offsets. The net effect on global emissions depends on the elasticities of the demand and supply (marginal costs of emissions reductions), as expressed by the slope of the curves in Figure 2. For further theoretical discussion, see Murray *et al*. (2012). In section 5 we provide an empirical estimate of the impact of REDD credit discounting.

Discounting can be at the demand side or at the supply side. If it takes place on the demand side, a buyer needs to acquire more than one credit for every ton of emissions being offset, as proposed by the Waxman-Markey draft (2009). One supply side option is to discount emission credits issued by the particular sector, as suggested by Chung (2007): one ton of CO_2 in avoided deforestation is equivalent to less than one credit put on the market.

The effects of discounting in the case of CDM have been analyzed by Schneider (2008). The concern that discounting might punish project developers turns out to be proven wrong; he finds that in a carbon market where there are limitations on the use of CDM credits, the suppliers could benefit through the resulting higher price of Certified Emission Reductions (CERs). He therefore argues that discounting on the supply side would be preferable to discounting on the demand side. If applied to the demand side, there is a possibility that countries that use CERs for compliance will apply different discount rates, hence creating market distortions.

A final option is a *price reduction* (2b), i.e., REDD credits are being sold at a fixed price lower than the price of other credits, or as a fixed share of the (market) price of other credits. This effect would be similar to the above, with the important exception that there would be no additionality effect. From a climate perspective, a quantity reduction or discounting is therefore to be preferred over price reduction. A second issue special for the option of a price reduction is the following: assume the price of REDD credits is USD 5 per ton CO_2 while the market price for other credits is USD 10. This could create an excessive demand for REDD credits, and a system to allocate credits among buyers must be in place.

4.1.3 Full REDD inclusion

The option of full (unrestricted) inclusion of REDD credits into the carbon market is analytically simpler than the partial options. REDD credits are fully fungible and traded 1:1 with other credits. The market will allocate reductions across sectors and countries in a cost efficient way. Hence, the main concern relates to the issue of market flooding, in part related to the uncertainty of any future supply of REDD credits. The magnitude of this uncertainty depends on both how the system is designed (standards, regulations, etc. needed for any market to function), and how REDD countries are able to deal with a range of issues, including implementing policies that can supply REDD credits.

Systems that combine the above three options are possible. For example, the main system might be full inclusion, but with provisions of restrictions kicking in if the carbon price falls below a certain level (to avoid too large crowding out effects from REDD inclusion).

4.2 Forms of inclusion

Linking emissions trading schemes requires mutual recognition of allowances in the different sectors and a recognized definition of credits. The most straightforward theoretical option is to trade REDD credits directly in the market, but other more indirect options are also conceivable. One option, proposed by Norway, is to auction a proportion of the total cap of Assigned amount units (AAUs)[15], and put the proceeds into a fund which then buys REDD credits (UNFCCC, 2009b). The proposal is supported by the Philippines and Indonesia in their submissions to the AWG-LCA (Murphy *et al.*, 2009). This is, in theory, equivalent to a demand restricted inclusion of REDD credits in the carbon market (assuming the restriction is binding), although the different specifications of a fund system may make it differ from the partial inclusion (e.g., other standards for delivery of co-benefits).

A more indirect way of raising funds for REDD activities would be a tax on transactions in the carbon market. REDD will not be linked to the market, and REDD credits cannot be used as an offset. Hence, funding for REDD activities are funded by other mitigation sources. This option is similar to other proposed ways to raise funds for climate mitigation, such as a tax on international aviation or bunker fuel. These other alternatives are not discussed further in the report. For a broader discussion of different financing proposals for mitigation and adaptation, see Muller *et al.* (2008) and Hof *et al.* (2011).

4.3 Further options

There are several additional options and issues that are to be decided on if REDD are to be included in a carbon market. We discuss four of these here: banking, reference level and uncertainty, corridor approaches, and a flexible, political adjustment of caps.

4.3.1 Banking

The risk of the carbon market being flooded with cheap REDD credits can be minimized through banking of credits. This option could not only be an opportunity to minimize risk of flooding from a REDD inclusion, but a central element of the global policy being modeled, with or without REDD. Banking simply means that a country or another entity can re-

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[15] Under the Kyoto Protocol, the "caps" or quotas for Annex I countries are known as Assigned Amounts. The quantity of the initial assigned amount is denominated in individual units, called Assigned amount units (AAUs), each of which represents an allowance to emit one metric ton of CO_2 equivalent, and these are entered into the country's national registry.

duce own emissions or buy carbon credits beyond the cap in the current period, and use the surplus credits to comply with the cap in later periods (they put the credits in "the bank"). When allowing for banking of early stage actions to reduce emissions against future obligations, i.e., as a project credit buffer, one could also raise current demand for REDD (Lubowski, 2008). Banking can help achieve earlier reductions, hence increase the climate benefit and also be cost efficient in the long run (Murray *et al.*, 2009).

In the first Kyoto commitment period demand for emission allowances and credits from Annex I countries has been fairly low compared to the potential supply (Eliasch, 2008). This has implications for the banking option to work: "borrowing" against future offset is only going to be efficient if future offsets themselves are predictable. Bosetti *et al.* (2011) find that if future reduction requirements are uncertain, actors prefer to give up some technology innovation and shift to more REDD which facilitates more banking (banking combined with REDD generates a higher option value).

The long-term credibility of targets anticipated by market participants will provide incentives for saving credits for use under tighter future targets. Piris-Cabezas and Keohane (2008) analyze a global REDD system that allows for banking of credits. To model banking they assume agents in the market are rational and have full information, and therefore correct expectations about the future. As a result, the carbon prices must increase at a constant rate (in their study, an exogenous interest rate of 5%). For a fixed emission reduction target they find that the carbon price in year 2020 without banking is USD 11/tCO_2, compared to USD 30/tCO_2 when allowance banking is permitted. Without banking the demand will be driven only by current demand, while the banking option will increase current demand because it will take into account future emissions restrictions. It should be noted that for agents to be indifferent between actions today and in a future time period, prices need to follow a Hotelling (1931) price path, i.e., the price increase equals the interest rate (all arbitrage possibilities are exploited).

If REDD can help build a store of relatively low-cost emission reductions, this "bank" may also reduce price volatility in the future by providing a buffer against unexpected changes on either the supply or demand side. Banking can thus reduce the potential problem of sudden "market flooding" by cheap REDD credits.

4.3.2 *Reference levels*

The REDD reference levels (baselines) determine the amount of credits that REDD countries can put on the markets. An emission reduction can be defined as the difference between the actual emissions in a period and the business as usual (BAU) baseline. In the literature on REDD a distinction is now commonly made between two distinct meaning of the term baseline or reference level: (i) the BAU baseline, and (ii) the crediting or compensation baseline (Angelsen, 2008; Meridian 2011). While the BAU baseline is the benchmark to measure emissions reductions and impacts of REDD interventions, the crediting baseline is the benchmark for financial compensation, and defines from which level of emissions a country can start to supply REDD credits to a carbon market. The crediting baseline is therefore comparable to an emission quota, with one important exception; liability is limited in the way that countries are not required to buy carbon permits if forestry emissions are above the crediting level.

REDD crediting baselines could be set below BAU baselines, cf. Meridian Institute (2011). Major rationales for this is to reduce REDD transfers (REDD costs for Annex I countries and REDD rent in non Annex I countries), and also principles of "burden sharing". Setting crediting baselines below BAU is a way for non-Annex I countries to assume higher levels of responsibility, and the difference between the crediting baseline and the BAU can be seen as an uncompensated REDD contribution from developing countries. REDD crediting baselines could also be set above REDD BAU baselines in some cases, e.g., for the purposes of providing incentives to High Forest cover/Low deforestation (HFLD) countries to participate in the REDD system, improving overall global performance by reducing leakage.

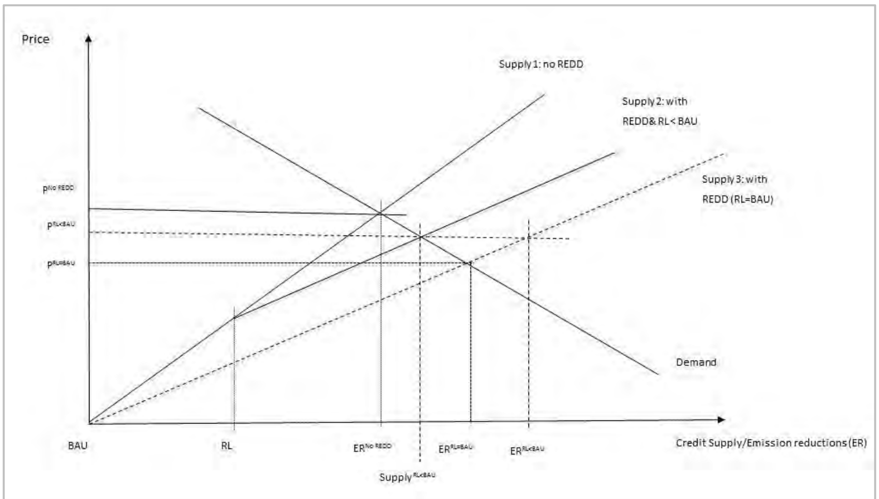
The impact of setting the reference level (RL) below the BAU is illustrated in

Figure 3. REDD countries must first reduce their emissions from the BAU level up to RL before credits can be supplied to the market.[16] The revised market supply curve is then given by the REDD line (Supply 2 curve). Since the supply for any given carbon price is lower than in the case of RL = BAU, the result is a higher carbon price and lower volume of traded credits. However, to get the overall emissions reductions, we have to add the REDD reductions not being put on the market (the dif-

[16] If we assume voluntary participation in REDD, we have to also assume that the REDD rent earned from participation in the carbon market is sufficient to cover the costs of the initial, uncompensated REDD reductions.

ference between BAU and RL). Graphically, this is found by extending the equilibrium price line (when RL<BAU) to the Supply 3 line; this shows that marginal costs of REDD and the emissions reductions will be higher than in the case when RL = BAU. The net effect, compared to the RL =BAU scenario, is a deeper overall emission cuts.[17]

Figure 3: The impact of setting the reference level (RL) below the BAU baseline



In summary, the impacts of setting the reference level below the BAU scenario (as compared to RL = BAU) are:

- Higher carbon prices and higher emissions reductions from REDD.[18]
- Higher emissions reductions from non-REDD, i.e., smaller crowding out effects.
- Lower transfers from Annex I to non-Annex I countries.

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[17] If we consider the two other alternatives of our initial Figure 1, in the case of a vertical demand curve (fixed global cap), the additionality effect will be 100%, whereas it will be 0% in the case of horizontal demand curve.

[18]This is true only conditional on all REDD countries participating to the same degree which depends on the incentives created in this theoretical model.

4.3.3 Uncertainty and the corridor approach

There are several uncertain aspects related to the impact of a REDD inclusion:

- What will be the demand for REDD credits?
- To what extent are countries able to supply REDD credits that comply with the standards set?
- What is the BAU scenario, and therefore the starting point for setting reference levels that determine the supply of REDD credits?

Developing mechanisms to deal with uncertainty is important for at least two reasons. First, one should seek to avoid situations that produce undesirable outcomes such as flooding of the market with cheap REDD credits and high crowding out, or – the opposite case – of strict rules such that hardly any REDD credits are transacted and therefore limited funding is being provided for REDD.

Second, risk needs to be predicable and shared among the parties. The risk from a REDD country's perspective relates to the BAU scenario being higher due to unpredictable drivers (e.g., high demand for agricultural products), costs being underestimated, or policies enacted being less effective than foreseen. The country risks being undercompensated. The risk from buyer of REDD credits, concerns the possibility of overcompensation and paying for non-additional "reductions" or "tropical hot air".

One possible approach to deal with this uncertainty is the corridor approach, proposed by Schlamadinger *et al.* (2005). This approach recognizes that any point estimate of the reference level is uncertain. A discount factor is therefore introduced, where deeper emissions reductions get an increasingly lower discount factor (i.e., higher compensation). The approach can therefore be seen as a variant of the discounting or equivalence factor discussed earlier and which formed the basis for scenario 3a.

The corridor approach defines an interval (corridor) around the point estimate of the RL, with the discount factor increasing from 0 to 1 (no to full compensation) within this interval. Thus a REDD+ country will get some compensation even if they are "unlucky" and face strong deforestation drivers, making the policies less successful in reducing deforestation. A donor country will, on the other hand, not pay full compensation in the opposite case, i.e., deforestation is reduced for other reasons than successful REDD policies.

4.3.4 Flexible caps

The Kyoto Protocol is based on the archetypical tradable permit system, where there is an absolute cap on emissions from Annex I countries. However, flexible caps for the cap-and-trade (CAT) policy may have benefits both in terms of reduced costs and increased rents from trading, as well as being more acceptable from a policy perspective due to the uncertainty of abatement costs and future economic growth. The inclusion of carbon credits from REDD activities have raised concerns for decreasing carbon price and more uncertainty, making the idea of flexible caps an interesting option. To adjust for the potential problems related to too high/low price on traded carbon units, a price floor and a price ceiling could be correcting for some of the uncertainty. How to set these prices and how to enforce it may not be a simple task, and there are several ways of obtaining the same result through other mechanisms.

McKibbin and Wilcoxen (2002) propose a hybrid policy instrument including the best features of a tradable permit system and an emission tax. They claim that this hybrid policy would be flexible and decentralized. The annual permit price could be adjusted as needed when better information becomes available and countries that would be interested in joining could do so domestically without international negotiations. Murray *et al*. (2008) study how allowance supply can be made more flexible by including a quantity limit, that they label the "allowance reserve." They then add a quantity limit where a price ceiling would allow an unlimited volume of allowances. Through their analysis they find that a sufficiently flexible cap-and-trade system can in theory do at least as well as and potentially better than a tax. This allowance reserve would provide both a ceiling price at which cost relief is provided and a maximum number of allowances to be issued in exercising that relief.

Several design features for the cap-and-trade system have been proposed to reduce uncertainty, among them making targets more flexible by indexing target allocations to GDP, thus making them targets for the emissions/GDP ratio or emission intensity (Jotzo and Pezzey, 2005). This implies that more permits are issued under this flexible target system, if GDP turns out higher than expected. Gielen *et al*. (2002) discuss what they refer to as a relative cap and trade policy that restrict emissions per unit of output per unit of input. They compare this relative cap to the absolute cap together with a subsidy on output or input, and find that there are higher rents incurred by the cap, but that there are higher cost related to the monitoring and uncertainty of the emission constraint.

The New Zealand Emission Trading Scheme (NZ ETS) has included a reasonable flexible cap that aims to encourage New Zealand businesses to lower emissions in line with their particular circumstances (Moyes, 2008). As opposed to other countries, the NZ ETS involves no independent cap on emissions set by the Kyoto Protocol, but it imposes a price on all emissions without fixing a limit on total emissions permitted within New Zealand. In addition to using New Zealand issued carbon units, emitters may import an unrestricted number of carbon units issued under the Kyoto Protocol for compliance.

In the U.S., there is a debate on comprehensive versus sector-specific emission reduction programs. There is a general reluctance to join the Kyoto Protocol due to stringent (costly) targets, although the U.S. the Regional Greenhouse Gas Initiative (RGGI) is developing a multi-state cap-and-trade system where the RGGI sets the arena for power plants in various states to join or form their own regional cap-and-trade systems where the cap is not set for the country as a whole. These should be sufficiently flexible to encourage expansion to other greenhouse gases and other sectors (Wilson, 2008).

4.4 Summary of options for a balanced introduction of REDD credit

Table 3 summarizes the preceding discussion on how to ensure a balanced introduction of REDD credits in to the carbon market, ensuring additionality and minimizing the risk of politically undesirable crowding out of other mitigation efforts.

Among the six options outline in the table, options 2, 3 and partly 6 establish mechanisms that automatically ensure that higher supply of REDD credits lead to larger overall emissions reductions, i.e., REDD credits are not being offset 1:1 at either the country or global level. Options 4 and 5 do not ensure additionality, but seek to keep the carbon price higher (in the early periods for option 5) and thereby avoid or limit flooding.

Each of the proposals has its merits, and they can also be combined. In the modeling exercise of the next chapters we assess options 3 and 4. The scenarios focus on aspects related to the degree of inclusion as well as to the level of commitment for emissions reductions.

Table 3: Options for how to achieve a balance between REDD integration and overall emissions reductions

Options	Details	Comments
1.Simultaneous political decisions	Decisions on REDD inclusion is accom-panied with tighter global emission cap.	Assumes close simultaneity in the decisions. Caps and rules for REDD supply could also be updated regularly to ensure a balance.
2.Flexible caps	Overall cap depends on carbon price and REDD inclusion	Rules are established that makes the overall cap and country commitments a function of carbon price, REDD credits available, and possibly other factors.
3.Discounting of REDD credits	More than one REDD credit used for offsetting is equivalent to one non-REDD credit used for offsetting.	Ensures that each REDD credit purchased results in higher overall emissions reduc-tions, as credits not equivalent in the market.
4.Restriction on demand or supply of REDD credits	A cap on how much REDD that can be used as offsets (demand restriction), or how much a REDD country can supply	Avoids too low carbon prices and crowding out, but no automatic mechanism to ensure additionality.
5.Banking of credits	Surplus carbon credits in current period can be used for compliance in later periods	Ensures a more stable carbon price path, and avoids the risk of initial high crowing out effects. Effectiveness hinges on the long term credibility and predictability of the climate regime, including carbon market.
6.Tighter referen-ce levels	RL set below BAU for REDD, i.e., some reduction done by country before REDD credits can be supplied in the market.	Ensures some initial and additional forestry reductions, and therefore that total reduc-tion higher than the offset.

5. Scenarios and modeling assumptions

5.1 Overview of scenarios

The key for a successful integration of REDD credits in the global carbon market is getting the balance right between the supply (rules of REDD inclusion), and the demand (the overall cap on emissions or aggregate of countries' commitment). Ten scenarios are generated by varying the key demand and supply side variables, and are shown in Table 4.

Table 4: Overview of scenarios

Commitment level	**REDD integration**		
	None	**Partial**	**Full**
Low pledge	No REDD/ Low pledge (1)		
High pledge	No REDD/ High pledge (2-DEFAULT)	Discounted REDD/ High pledge (3a) Price REDD/ High pledge (3b)	Full REDD/ High pledge (4)
Two degree target	No REDD/ 2 degrees (5)	Discounted REDD/2 degree (6)	Full REDD/ 2 degrees (7)
Constant carbon price			Full REDD at equal price (8)
Equal costs			Full REDD at equal costs (9)

5.1.1 REDD integration

In line with the discussion of section 4, three different alternatives are suggested for the degree of REDD credit inclusion in the carbon market: No integration (default scenario), full and unrestricted integration, and partial or restricted access, e.g., discounted credits. In the no integration scenarios, we expect some REDD realization to take place in the form of Nationally Appropriate Mitigation Actions (NAMAs) or through other forest conservation actions outside of the carbon market. We assume these actions to be within the range of 20–25% below 2020 BAU deforestation emission levels only for Brazil and Indonesia, based on our own judgment and discussion with experts, and 30% below 2020 BAU deforestation emission for Mexico according to their NAMAs. Sections 5.2 and 5.3 describe the REDD integration assumptions of the scenarios.

5.1.2 Commitment level

The overall commitment or reduction target for both Annex I (developed) and non-Annex I (developing) countries determines the demand for REDD credits, and is critical for the results. In the UNFCCC negotiations in Cancún (2010), and a year earlier in Copenhagen (2009), urgent action was called for to limit global warming to 2°C. In order to reach this climate goal, Annex I and non-Annex I countries were encouraged to submit emission reduction proposals and mitigation actions for the year 2020. As of February 2012, 42 Annex I Parties submitted emission reduction proposals (pledges), of which 15 contained quantified economy-wide targets, and 45 non-Annex I Parties submitted NAMAs, first for inclusion in the Appendices to the 2009 Copenhagen Accord (UNFCCC, 2009a) and later for “anchoring” these pledges in the Cancún Agreements (UNFCCC, 2010a).

Some developed countries have submitted both a *high pledge* that is conditional on a high level of ambition from other countries or domestic legislation, and a *low pledge* that is unconditional. Therefore, we include both a low pledge scenario (all countries implement their low pledge) and a high pledge scenario (all countries implement their high pledge) in our analysis. For countries that have made a conditional pledge only, such as Canada, Japan and the U.S., we have assumed that this pledge is valid for both the low and high pledge situation, similar to the assumption made in UNFCCC documents. For developing countries the methodology for calculating the reductions resulting from the NAMAs is based on den Elzen *et al.* (2011b), but the evaluation has been revised to reflect the PBL BAU emission scenario developed for the recent OECD Environmental Outlook (OECD, 2012). These PBL emission projections contain all Kyoto greenhouse gases (except CO_2 emissions from land-use changes) and are calculated by the PBL TIMER energy model (van Vuuren *et al.*, 2006; 2011) and the PBL IMAGE land use model (Bouwman *et al.,* 2006), using the GDP projections of the OECD ENV-Linkages model (Burniaux and Chateau, 2008). The CO_2 emissions from land-use changes (deforestation in non-Annex I regions) are based on the IIASA forestry model, G4M and correspond to 3.3 $GtCO_2$ in 2020. (See Appendix 1 for more details on the BAU scenario).

The *low pledges* assumptions on mitigation efforts that are used in the model for Annex I countries corresponds to 12% below 1990 levels by 2020. For the EU the reduction target is assumed to be 20% below 1990 levels by 2020, and for the U.S. the low pledge is 17% below 2005 levels. For non-Annex I countries the calculations of their pledges lead to a 4% reduction below 2020 BAU emission levels. India and China pledged to reduce its emission intensity (emission per GDP unit) with 40% and 20% below 2005 levels by 2020. In addition, China pledged to increase the share of non-fossil fuels in primary energy consumption to 15%. For China the calculated reduction below BAU emissions is 6%, whereas for India it does not lead to a reduction (den Elzen *et al.*, 2011b).

Brazil and Indonesia submitted NAMAs that lead to a total emissions reduction of 36% and 26% for the low pledge compared to their national estimates of BAU emissions levels including land-use CO_2 emissions by 2020. The 2020 emission target resulting from the pledged reduction was calculated from the national BAU emission projections (Presidency of the Republic of Brazil, 2010; Indonesian Ministry of Finance Green Paper, 2009), based on den Elzen *et al.* (2012). This level was then used for calculating the reduction below the PBL BAU emission projections. The nationally provided projections were often higher than the PBL BAU projections. Therefore, the calculated reductions for which the PBL BAU projections were used would generally also be lower than those for which the national estimates were used, as we also see here. For Brazil this corresponds to a reduction of 18%, and for Indonesia to an increase of 34%, compared to the PBL BAU including land-use CO_2 emissions. For Indonesia, we do not take into account the national BAU for peat land emissions or the expected reduction due to the NAMAs in this sector, as they are highly uncertain.

For the *high pledges*, Annex I countries are included in the model with an aggregate reduction of 19% below 1990 levels. The EU increases its pledge to 30% reduction below 1990 levels and the U.S., Canada and Japan remain the same as under the low pledge. The calculations of the non-Annex I countries emissions show an increase in their aggregate reduction to 5% below BAU levels by 2020. This is mainly due to China and India that improve their emission intensity targets to 45% and 25% below 2005 levels. Again for China the non-fossil target is included. For Brazil and Indonesia there are high pledges of 39% and 41% below national BAU, which leads to a reduction of 22% and 9% below the PBL BAU scenarios, using the same methodology as described for the low pledge (den Elzen *et al*., 2012).

In addition, we introduce scenarios with a commitment level by 2020 that is considered in line with the *2 degrees* limit on global warming. These scenarios assume ambitious aggregate Annex I reduction target of 30% below 1990 level by 2020, and also a comparable effort by non-Annex I countries of about 15% below 2020 BAU emission levels, based on den Elzen *et al.* (2009). For the allocation across the individual Annex I countries the same reduction below BAU is used. For non-Annex I countries the reduction for individual countries is differentiated dependent on income levels as described in den Elzen *et al.* (2009). This allocation of emission reductions among countries may seem arbitrary; however results are not too sensitive to it as they are only presented at the aggregate regional level. For the case of Brazil, Indonesia, Mexico and South-Korea we use the submitted high NAMAs as targets for the two degrees scenarios, as they result in more ambitious targets than the ones calculated using an equal reduction below baseline allocation. As we are assuming a global market through 2020, the 2 degrees target is of particular interest as it holds expectations for longer term reductions.

Table 5 shows commitment levels of different Annex I and non-Annex I regions/countries for the scenarios as described above.

Based on the conditional pledges the UNEP "bridging the gap report" (UNEP, 2011) projects emissions to be within a range of 51 to 53 $GtCO_2$ depending on whether strict or lenient accounting rules are following their mitigation target. The projected emissions under the unconditional pledges commitment will be within a range of 53 to 55 $GtCO_2$, depending on the strength of the accounting rules. Finally, the emissions level by 2020 consistent with a likely chance to meet a two degrees climate target lie in the range of 41 to 46 $GtCO_2$. These ranges serve as a reference for the results of the scenarios.

Table 5: The reduction targets of individual Annex I countries (as %-below 1990 levels) and non-Annex I countries (as %-below PBL BAU levels)

Region	Scenario (as explained in Table 4)			
	1	2	3–4, 8–9	5–7
Annex I	**Pct. reductions below 1990 levels**			
Canada	-3	-3	-3	10
USA	5	5	5	19
EU*	20	30	30	31
Ukraine**	20	20	20	47
Russia	15	25	25	53
Japan	25	25	25	24
Oceania***	-35	4	4	3
Non Annex I	**Pct. reductions below PBL BAU levels**			
Mexico	30 (*30* [i])	30 (*30* [i])	30	30
South America (excl Brazil)	0 (*0* [i])	0 (*0* [i])	0	17
Brazil	5 (*20* [i])	11 (*25* [i])	22	*13* [ii] *(25* [i]*)/22* [iii]
Western Africa	0 (*0* [i])	0 (*0* [i])	0	0
South Africa	12 (*0* [i])	12 (*0* [i])	12	17
India	1 (*0* [i])	3 (*0* [i])	3	7
China	6 (*0* [i])	6 (*0* [i])	6	17
Rest of Asia Region (excl Indonesia)	0 (*0* [i])	0 (*0* [i])	0	7
Indonesia	-8 (*20* [i])	-7 (*25* [i])	9	*8* [ii] *(25* [i]*)/ 9* [iii]
Korea	25 (*0* [i])	25 (*0* [i])	25	25

Notes:

* Europe includes EU-27, plus Croatia, Iceland, Norway and Switzerland.

** Ukraine region includes Ukraine and Belarus.

*** Oceania includes Australia and New Zealand.

[i] Indicate the REDD reduction.

[ii] For No REDD / 2 degrees (see Table 6 for details).

[iii] For other 2 degrees scenarios (see Table 6 for details).

5.2 Pure cases: full integration or no integration

To illustrate the broad discussion of REDD inclusion in the carbon markets we analyze some pure cases of full integration and no integration of REDD carbon credits to the global carbon market. The full inclusion and the no inclusion cases are both varied with the high pledges to explore the potential of REDD inclusion on the market. To strengthen climate policy foundations it is important to examine the effect of different ambitions for mitigation policies in various parts of the world. Broadening participation is a key priority for the climate regime, and to analyze the effects of changes in abatement efforts and the variations in accessibility of cost-effective mitigation options may shed light on important policy choices. Setting an ambitious mitigation target is an important part of the discussion on both Annex I and non-Annex I countries' responsibility for and contribution to the GHG reduction activities. The definition of ambitious targets may pinpoint what the NAMAs are in the different sectors, i.e., policy measures that can help move the baseline but not necessarily require a carbon cost for implementation. Without ambitious commitments from developing countries, expanding credit to whole sectors may imply increased subsidies for mitigation in developing countries without contributing to GHG reductions (Baron *et al.*, 2009).

5.2.1 No REDD inclusion

We explore scenarios with *no REDD inclusion for the low, high and two degrees* commitment levels (i.e., scenarios 1, 2 and 5). Scenario 2 is considered as the default case.

Scenarios with no REDD inclusion in the global carbon market assume that Brazil and Indonesia (financed by non-compliance market sources) undertake a 20% reduction compared to BAU deforestation CO_2 emissions for the low pledges, and 25% for the high pledge and two degrees scenarios. In addition to the calculated reductions for the GHG emissions excluding land-use CO_2, the total reductions can be calculated, as given in Table 6. For example, Brazil's high pledge in the no REDD inclusion scenarios leads to a reduction below PBL's BAU by 2020 of 0% for all GHG emissions excluding land-use CO_2, and 11% including land-use CO_2. REDD reductions due to REDD realization account for Brazil and Indonesia and its abatement costs are reported as a separate item in these scenarios and not assigned to any party as it is uncertain who will bear the costs.

For the two degrees scenarios without REDD inclusion Brazil and Indonesia are assumed to fulfill the total NAMAs (i.e., 22% and 9% below PBL BAU including land-use CO_2 emissions), which in combination of the assumed REDD realization of 25%, leads to higher reductions for the greenhouse gas emissions including land use CO_2 emissions (i.e., 13% and 8% below PBL BAU).

5.2.2 Full REDD inclusion

We explore *full integration of REDD with a high pledge and two degrees* commitment level (scenarios 4 and 7). For the full REDD integration we assume that the aggregated global target can be met by including REDD as a mitigation option in the carbon market, one to one credit of other mitigation options. For Brazil and Indonesia, this would imply a reduction of 22% and 9% below PBL BAU including land-use CO_2 emissions, and all REDD reductions are financed by the carbon market. These scenarios assume the cost optimal implementation of the full NAMAs for all countries including Brazil and Indonesia. This leads to a higher REDD reduction for Brazil and a lower REDD reduction for Indonesia than the 25% REDD realization assumed in the no REDD inclusion scenarios, as will be shown and further discussed in the results.

Table 6: The main assumptions for the scenarios in terms of inclusion of REDD in the carbon market and reduction targets

#	Scenario name	REDD in carbon market	Emission target of Annex I countries	Emission target of non-Annex I countries	Brazil	Indonesia
			Pct. below 1990	Pct. below BAU		
1	No REDD/Low pledge	No	12	4	5 (-6*/ 20**)	-8 (-13*/ 20**)
2	No REDD/High pledge	No	19	5	11 (0*/ 25**)	-7 (-13*/ 25**)
3a	Discounted REDD/High pledge	Partial-Discounted	19	7	22[ii] (19[i])	9[ii] (9[i])
3b	Price REDD/High pledge	Partial-Price Reduction	19	6	22 (0*/ 52[iii])	5 (- 3*/ 95[iii])
4	Full REDD/ High pledge	Full	19	6	22	9
5	No REDD/ 2 degrees	No	30	14	13 (22*/ 25**)	8 (9*/ 25**)
6	Discounted REDD/2 degrees	Partial-Discounted	30	14	22[ii] (6[i])	9[ii] (3[i])
7	FullREDD/ 2 degrees	Full	30	14	22	9
8	Full REDD at equal price	Full	N/A	N/A	N/A	N/A
9	Full REDD at equal costs	Full	N/A	N/A	N/A	N/A

Notes:
*Indicate the reduction excluding LULUCF CO_2.
** Indicate the REDD reduction.

[i] Indicate the reduction before discounting.
[ii] Indicate the reduction after discounting REDD reductions.
[iii] REDD is increased to meet the overall reduction target of all greenhouse gas emissions, including land-use CO_2.
N/A: Not Applicable (no assumptions made).

For the two degrees scenarios with a full REDD inclusion the reductions targets for all countries are more stringent than under the high pledge scenario (see Table 6), except for reduction targets of Brazil and Indonesia, which are assumed to be the same as under the high pledge scenario with full REDD inclusion.

5.3 Variations in the integration of REDD credits

A major argument for including REDD into carbon markets is that one can achieve deeper emission reductions with REDD. Keeping the overall commitments constant (as in the above scenarios) will not address these arguments, hence the additionality of REDD inclusion is zero. On the other hand, funding for REDD activities through market based mechanisms can be achieved without REDD credits being fully fungible or fully integrated in the market. Thus, we investigate four additional options that are considered as partial degree of inclusion of REDD credits in the carbon market as was described in section 4.

5.3.1 Discounting REDD credits

One of the partial inclusion options suggested in section 4 is the discounting of REDD credits compared to other credits. We explore *discounting for a high pledge and a two degrees* commitment levels (Scenario 3a and 6), and we assume that REDD credits are discounted by a factor of ½, i.e., one CDM credit is equivalent to two REDD credits after discounting. We also assume that only internationally traded credits are being discounted. This implies that for REDD countries, for example Brazil, one REDD carbon ton used for meeting their domestic target (NAMAs) is equal to one REDD carbon credit to meet this mitigation target. Discounting REDD credits could be argued to be an approach where one is stepping up the global emission reductions, or as Schneider (2009) labels it in his analysis of discounting CDM credits: a CDM with global atmospheric benefits.

5.3.2 Price reduction

Reducing the price of REDD credits as described in section 4 is another partial inclusion option. In our *price reduction* scenario (scenario 3b) we do not set a random price at which REDD credits are sold, assuming that this price would be lower than the CDM price as explained in section 4. Instead, we determine the necessary REDD actions for Brazil and Indonesia to achieve their full NAMAs keeping the non-REDD actions assumed in the no REDD inclusion scenarios (i.e., 0% reduction for Brazil and an increase of 13% for Indonesia). This assumption results in an increase of the REDD actions (REDD realization of 25%) compared to the default scenario; for Brazil REDD emissions reductions are up to 52% and for Indonesia the up to 95% below the PBL BAU scenario (Table 6). These REDD reductions are assumed to be part of the NAMAs of Brazil and Indonesia and therefore cannot be sold as offsets in the carbon market. If Brazil and Indonesia have additional REDD potential after fulfilling their NAMAs then they can undertake REDD actions to sell as offsets at a certain REDD price. We estimate an average REDD price using the reductions and abatement costs for Brazil and Indonesia and explore whether this is lower than the CDM price. Hence, there is no additionality effect, the supply is restricted and avoided deforestation actions are increased according to the national expectations of Brazil and Indonesia. There are increased REDD reductions as compared to the no inclusion case, but no additionality effect as REDD credits do not become part of the carbon market. Furthermore, the abatement costs for Brazil and Indonesia are reported as a separate item as it is not clear yet who will bear them.

5.3.3 Constant price

In this scenario (scenario 8) we keep the *carbon price constant after REDD credit inclusion* to analyze the additionality potential of REDD inclusion on global emissions. This corresponds to Alternative III in Figure 1. We use the price of the default scenario (2) as a carbon price by 2020. We then include REDD credits in the market, and increase the emissions reductions for countries to maintain a constant price. This scenario therefore does not assume a commitment level of regions, but these are estimated by the model (Table 6).

5.3.4 Constant global abatement costs

An intermediate case is to keep the *overall abatement costs constant*, that is, similar to those in the default scenario 2, which will lower the price but increase the overall reductions. We explore this in scenario 9. This is highly relevant to analyze the overall emission reduction gain one can achieve by including REDD, for a given level of effort (global costs). This corresponds to Alternative IV in Figure 1. For the outcome of scenario 9, we do not report costs or reductions for Annex I, non-Annex I, Brazil and Indonesia due to the methodology used for allocating the additional emissions reduction in this scenario. In order to achieve the same global abatement costs as the default case but in a carbon market including REDD credits, the emission reduction targets of Annex I are increased by 1% and between 8 and 13% for non-Annex I REDD regions compared to those in the default case. These assumptions are rather arbitrary, but lead to equal global abatement costs (Table 7). We therefore report the carbon price and global emissions in 2020 as an illustration of the magnitudes (Table 8), and focus on these global figures rather than the regional allocation of costs.

5.4 Modeling Assumptions

We use the FAIR model to assess the ten scenarios outlined in the previous sections. FAIR is a decision making tool developed and used by PBL Netherlands Environmental Assessment Agency. It includes a set of marginal abatement costs (MAC) curves for mitigation in different sectors and countries/regions of the world, a carbon market model, and a climate model. The objective of the model is to calculate abatement costs and permit price (multi-gas) using MAC curves, and to calculate the buyers and sellers and financial flows on the international carbon market. The scenarios are not affected by macroeconomic impacts, gains of ancillary benefits or cost/gains of changes in fuel trade, so we are only observing the direct abatement costs. More information of the model is given in Appendix 1, and www.pbl.nl/fair

The following key assumptions for the FAIR model calculations are made for all scenarios unless specified otherwise:

- *Full participation:* We have assumed full participation of Annex I countries in emissions allowances trading and JI, and non-Annex I countries in CDM (used for offsetting) with higher accessibility factors (see below) by 2020. For the equal carbon tax scenario the abatement costs correspond to those under a no trade situation.

- *MAC curves:* The marginal abatement cost (MAC) curves of the energy and industry-related CO_2 emissions are calculated in the PBL's energy model by imposing a carbon tax and recording the induced reduction of CO_2 emissions. The MAC curves of the non-CO_2 GHG emissions are exogenous to FAIR and based on Lucas *et al*. (2007). The deforestation MAC curves are based on the IIASA forestry model, G4M (Kindermann *et al*., 2006; 2008) and are described in Böttcher *et al.* (2011). Some details on the MAC curves are provided in Appendix 1.
- *Carbon price:* In the FAIR model, there is only one equilibrium international carbon price for CDM, JI, REDD (when included in the carbon market) and emission trading is assumed. When REDD carbon units are not traded in the global carbon market, REDD activities are not affected by the global carbon price. In the absence of REDD, Non-Annex I countries only participate in the CDM.
- *Minimum domestic reductions in Annex I countries:* We assume that all individual Annex I countries must achieve at least two-thirds of their target through domestic emission reductions (den Elzen *et al*., 2011). This assumption is based on: (1) the domestic target of the European Emissions Trading System and EU's announcement that up to a maximum of 4% of the 20% target and 9% of the 30% target may be achieved by using international offsets, and (2) the announcement of the Japanese government that Japan does at least 60% domestically. In our calculations we assume the US achieves 100% of its target with their domestic action, based on the announcements made by the US at the UNFCCC workshops in April 2011 and June 2012 that the reduction target for 2020 will be implemented through various national policy instruments, and as there is no current federal law in the US that provides for emissions trading or international offsets (UNFCCC, 2012). To the extent that the 2/3 domestic reduction restriction is binding, the international price of REDD and CDM credits and price of domestic reductions will be different in the model, with the latter assumed to be higher. This assumption only applies for the scenarios using the pledges as levels of commitment. For the two degrees scenarios and the equal carbon tax we assume no domestic restrictions given the higher reduction targets for regions.
- *Minimum domestic reductions in Non-Annex I countries:* We assume that Mexico, Brazil and Korea achieve their target fully with domestic action, as described in their NAMAs, although their actions depend on international financing. After achieving their domestic target they can

undertake more reductions, and sell these emission credits on the carbon market. This assumption applies for the pledges scenarios only. For the two degrees targets no domestic restriction is assumed for non-Annex I countries/regions.

- *Land Use-Land Use Change and Forestry (LULUCF) credits in non-Annex I countries:* Developed countries use credits from LULUCF to fulfill their targets. Based on the work of the Joint Research Centre (JRC) the model calculation assumes a central estimate of credits arising from afforestation/reforestation and deforestation and from four accounting options of forest management of 379 $MtCO_2$ credits in 2020 for all developed countries (den Elzen *et al.,* 2011).
- *Other flexible mechanisms:* Besides REDD, and within the restriction of 2/3 domestic reductions, Annex I countries can meet the target by either using Joint Implementation (JI) in Russia and Ukraine or implementing Clean Development Mechanism (CDM) projects in Non-Annex I countries (offsetting). Here we assume the CDM only covers the emission reductions of all Kyoto greenhouse gases from all sources, except from CO_2 emissions from land use and land-use change (deforestation). So, basically CDM includes all emission reductions of non-Annex I countries, except for REDD. The supply of CDM and JI has limitation (see below).
- *Joint Implementation in Russia and Ukraine:* We assume that Russia and Ukraine can only supply 60% of their total potential for JI projects with other Annex I regions, which is equal to the highest CDM accessibility factor (see next paragraph, and Appendix, Table A2) of, for example, Brazil. For other Annex I countries we assume full emission trading and no restrictions on JI supply, if any.
- *Limitations of CDM supply:* Non-Annex I countries only participate in CDM. Only a limited amount of the CDM abatement potential is assumed to be operationally available on the market due to the project basis of the CDM and implementation barriers, such as properly functioning institutions and project size, only between 10 and 20% (Michaelowa and Jotzo, 2005). We assume that these shares of CDM supplied in the market increase for 2020, and depend on the income level of the country, see Appendix Table A2.
- *Limitations in REDD supply:* For the REDD sector the MAC curves for deforestation emissions developed by IIASA and used for the calculations here, include limitations on the supply due to three elements: discount rate, corruption and hurdle factors. The first element is used to calculate the net present value of agriculture

activities and affects the supply by changing the baseline emissions. A low discount rate represents better governance in a country. The second factor represents the capacity of a country to make the carbon payments effective. When the corruption factor is set to zero, the same carbon price can yield in higher abatement as the money can be spent more efficiently (Böttcher *et al.*, 2011). The later factor corresponds to a calibration factor use to reproduce historic rates of land use and smooth the effect of inconsistent input data. We use the limited REDD curves that already include realistic assumptions on the capacity of countries to implement REDD given their national circumstances as well as historic developments.

6. Results using the FAIR model

Any model simulation is based on a large set of assumptions. In addition to those listed above, there is uncertainty related to the MAC curves, the underlying assumptions about economic and technological development, and the baseline scenarios. The scenarios presented do therefore indicate the direction and order of magnitude of the effects, and the uncertainty and the many assumptions underlying the results should be kept in mind. The PBL BAU including and excluding land-use CO_2 emissions, also referred to as our baselines (i.e., including all Kyoto gases), MAC curves and input data used in the scenarios have briefly been presented in previous sections and are described further in Appendix 1.

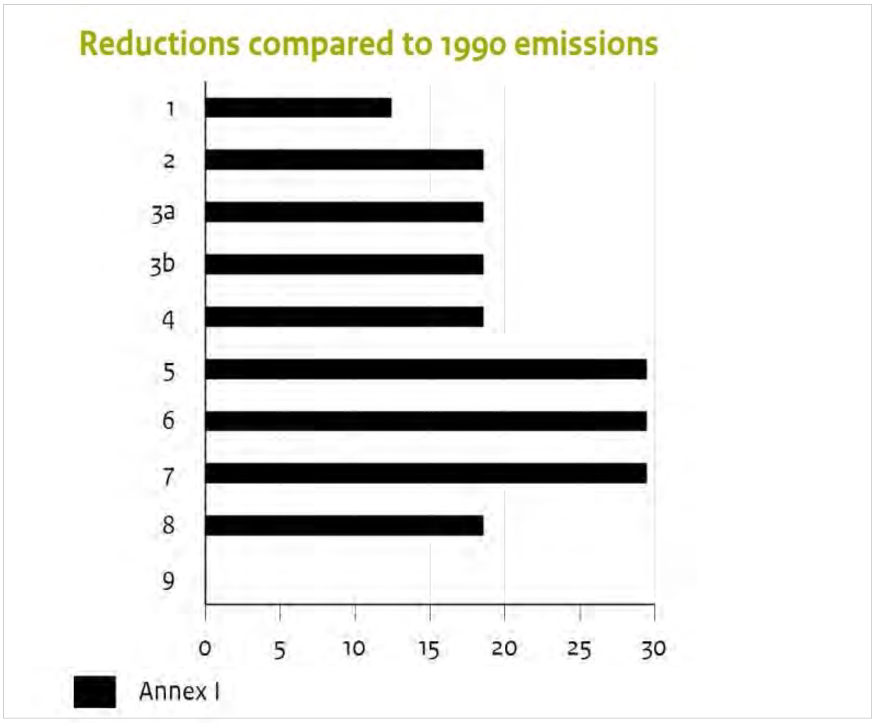
6.1 Overall emissions reductions

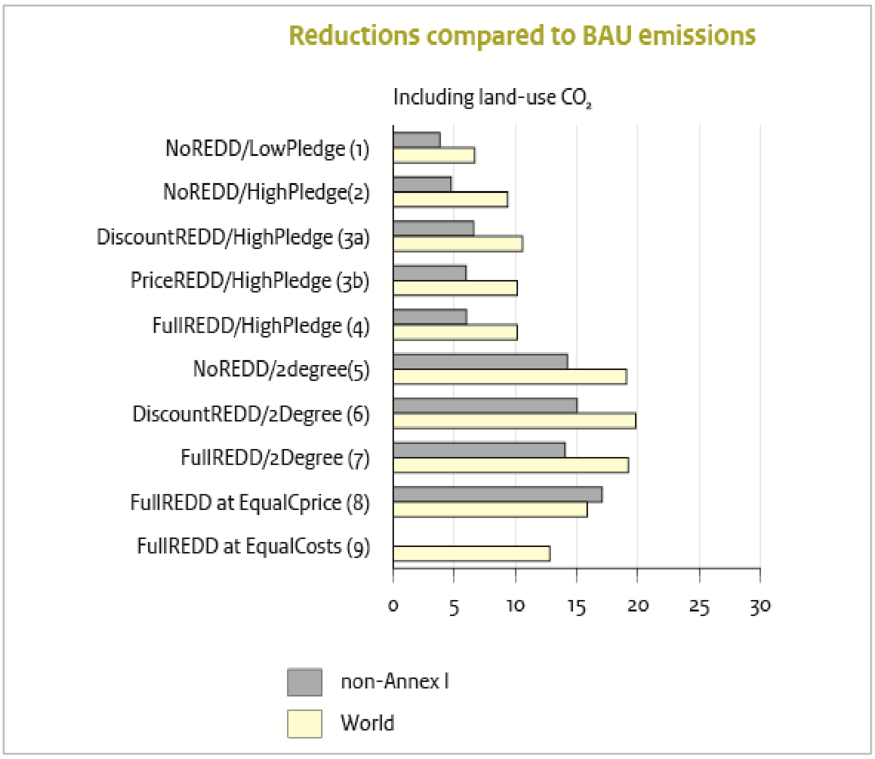
Figure 4 shows the commitment levels resulting from the different assumptions made for the low and high pledges and the two degrees targets as described in chapter 5. The difference among scenarios for the non-Annex I reduction targets is mainly due to the implementation of the Brazilian and Indonesian NAMAs and its composition of REDD relative to other reductions. The full implementation of the low NAMAs lead to a 4% reductions, the high NAMAs lead to a 6% reduction and the two degrees targets to a 14% compared to PBL BAU levels including land-use CO_2 emissions for non-Annex I regions by 2020.

The default case (scenario high pledge/no REDD) leads to a global reduction of 9% compared to PBL BAU levels including land-use CO_2 emissions. Assuming that the world would shoulder the same abatement costs as for the default scenario but including REDD fully as part of the carbon market, this scenario (9) slightly increases the global reduction target by 4 percentage points (i.e., 13% reduction compared to BAU levels including land-use CO_2 emissions), mainly as a result of larger reductions in non-Annex I regions. Moreover, assuming the same regional carbon price than that of the default scenario and including REDD fully in the carbon market, this scenario (8) leads to more ambitious global reductions (i.e., 16% below BAU incl. land-use CO_2 emissions). This scenario shows the outcomes for 100% additionally of REDD in the carbon market as discussed in section 2 (see Figure 1). Annex I countries do not change their targets compared to those in scenario 2, given that they do not have deforestation emissions and therefore no REDD potential. Non-Annex I countries increases the target up to 17% when assuming the same carbon price as in scenario 2 (i.e., USD 19/tCO_2) and deforestation emissions are included in the carbon market. In summary, the global reduction is increased by 67% compared to the default scenario assuming the same carbon price and including REDD in the carbon market (scenario 8) and by 35% when assuming the same global abatement costs and including REDD in the carbon market (scenario 9).

The impact of discounting is rather low when comparing the full REDD inclusion scenarios and the discounting scenarios in terms of the increase of the global emissions reduction for both the high pledge and the two degrees commitment levels. For the high pledge scenario the traded REDD tons (REDD credits to be discounted by a factor of 2) are 0.3 GtCO_2 and for the two degrees scenario 0.8 GtCO_2. Total REDD reduction correspond to 1.1 and 2.1 GtCO_2, respectively. The total REDD reductions after discounting are almost the same as the ones obtained under a full REDD inclusion (0.9 and 2 GtCO_2) and therefore the effect of discounting on the total global reduction is rather small. The benefit of discounting is more in terms of reducing the risk of "flooding" the carbon market with REDD credits. In Table 7 the difference between the non-Annex I reductions in scenarios 3a and 4 are mainly attributed to discounted REDD actions, while the difference between scenarios 6 and 7 comes from both REDD as well as other sectors (given the more ambitious targets).

Figure 4: Reduction targets for non-Annex I and the world (pct. compared to PBL BAU including land-use CO_2 emissions) and for Annex I (pct. compared to 1990 levels)





Comparing the discounting and the no REDD inclusion scenarios is not straightforward as the reductions for Brazil and Indonesia are not comparable between these scenarios. Thus one should be careful to conclude whether the effect in the increase emission reductions is due to higher targets or due to discounting of REDD actions. Some intermediate scenarios that only increase the targets for Brazil and Indonesia without any discounting were explored and they suggest the second explanation. For costs, no comparison should be made between discounting and no REDD scenarios as the commitment levels and carbon market are different. The benefits of discounting are only evident when comparing this scenario with the one of full REDD inclusion.

For the price reduction scenario (3b) the assumption made for the NAMAs on energy and industry sectors has an implication on the amount of REDD that Brazil and Indonesia will use for their domestic actions in order to achieve their full NAMAs part of their high pledge. This also has implications on the amount of REDD they can supply in the carbon market. In particular for Indonesia, an increase of 13% over the PBL BAU excluding land-use CO_2 emissions leads to a 100% use of Indonesia's REDD potential (i.e., around 95% reduction of deforestation emissions below PBL BAU for CO_2 deforestation emissions by 2020, see Table 7). Together these two reductions on REDD and non-REDD sectors result in a maximum total reduction of 5% compared to PBL BAU levels (including land-use CO_2 emissions). The REDD potential is therefore not enough for Indonesia to meet its full NAMA if the target on non-REDD sectors is fixed. This demonstrates the importance of and links between the key ingredients in scenarios: careful estimates of mitigation potentials in different sectors, realistic reference levels, and the ambitions (targets) set for emission reductions.

The two degrees reductions are indeed more ambitious that the current high pledges for both Annex I and non-Annex I regions. For the low pledge scenario (scenario 1) global reductions are 7%, for the high pledge scenarios (scenarios 2 to 4) global reduction vary between 9 and 11% and for the two degrees scenarios (scenarios 5 to 7) reductions are between 19 and 20% all compared to PBL BAU levels including land-use CO_2 emissions. For the high pledge scenarios and for the two degrees scenarios the highest global reduction is achieved in the discounting scenarios (3a and 6).

6.2 Emission reductions, carbon price and abatement costs by groups of countries

Comparable to other studies, the carbon price is reduced from USD 19 to 7/tCO_2 (a reduction of around 60%) when there is a full inclusion of REDD in the market and the same commitment levels are kept (see Table 7, scenarios 2 and 4). The benefits of the full inclusion of REDD in the carbon market are higher for Annex I countries that have approx. 12% lower abatement costs than Non-Annex I regions that more than double their net abatement costs after full inclusion of REDD in the market. The lower carbon price reduce the gains of traded credits from REDD and CDM of non-Annex I countries, whereas their domestic costs remain the same, which increases the net abatement costs (domestic costs minus gains of trading credits), as we will elaborate further in the regional scale outcomes. The impacts of lower carbon prices more than outweigh the REDD transfers they receive. This also results from the domestic reduction restrictions for Annex I regions that are not entirely free to trade and therefore do not reduce emission where costs are lowest. Under unrestricted conditions it is expected that the non-Annex I countries would gain from the financial revenues of REDD and CDM projects, and global costs are reduced with full inclusion of REDD in the market, as the international carbon price increases substantially compared to that under restrictions for Annex I regions.

Discounting REDD credits results in a more ambitious scenario at almost the same global abatement costs as the undiscounted full REDD inclusion scenario (see Table 7, scenario 4 and 3a). The crowding-out effect is less dramatic than when allowing full inclusion of REDD. The carbon price drops from USD 19 (default case) to USD 9/tCO_2 (quantity discounted REDD) instead of USD 7/tCO_2 (when allowing a full REDD inclusion, see Table 7, scenario 2, 3a and 4).

For scenario 3b the carbon price is kept at the level of the default case since the REDD actions are kept on a separate market. The marginal price for delivering REDD reduction coming from Brazil achieving its full NAMA and Indonesia using its full REDD potential is between 9 and 11 USD/tCO_2. Setting any price higher than this for REDD credits would deliver additional REDD credits from Brazil and other REDD regions. For Indonesia the calculations shows that the whole potential is already used in order to achieve its NAMAs, therefore Indonesia do not deliver any additional credits. Moreover, since this price is lower than the CDM price (USD 19 /tCO_2) an excessive demand for REDD credits can take place, as noted in section 4. A system to allocate credits among buyers must be in place but we do not make any assumptions on this matter. The total REDD costs for Brazil and Indonesia are equal to USD 6 billion in 2020 (Table 7). These costs have to be financed as well but it is not clear yet under which mechanism or which party will bear the costs.

A full inclusion of REDD in the market (scenario 4) reduces the global costs in 2020 by around USD 9 billion compared to the price reduction scenario (scenario 3b). There is a trade-off between keeping the carbon price at a higher level by keeping REDD in a separate market and restricting the demand of REDD credits from Brazil and Indonesia, i.e., scenario 3b and reducing global costs by fully including REDD in the carbon market, i.e., scenario 4 (see Table 7). In the discounted scenario global deforestation emissions are reduced by 32% while in full inclusion scenario they are reduced by 27% (Table 8). Further we will see the implications in terms of reduction of deforestation emissions in Brazil and Indonesia, where the situation is similar.

The global deforestation emissions are reduced as follows for the different scenarios compared to PBL BAU for CO_2 deforestation emissions level by 2020 (in parenthesis compared to 2005 levels): 8% (32%) (Scenario 1), 10% (33%) (Scenario 2), 32% (50%) (Scenario 3a after discounting), 22% (42%) (Brazil and Indonesia only in Scenario 3b), 27% (46%) (Scenario 4c), 10% (33%) (Scenario 5), 62% (71%) (Scenario 6 after discounting) and 61% (71%) (Scenario7). Interactions with CDM are particularly relevant in determining how far the REDD actions go for different regions, as will be seen below.

In the two degrees scenarios, with partial and full REDD inclusion the global emissions reduction, carbon price and abatement costs are significantly increased compared to the high pledges scenarios. Non-Annex I regions profit from the trade when the demand from Annex I regions increases with the targets.

Scenarios with a (relatively) high carbon price result in non-Annex I net gains and in scenarios with a low carbon price non-Annex I have net costs for the aggregate region. As we will see further in a more regional detail, CDM is influenced by the dynamics of including REDD in the carbon market, as well as the financial flows to developing countries and not necessarily REDD host countries.

Other two degrees scenarios excluding LULUCF CO_2 emissions, as the ones showed by den Elzen *et al.* (2008), lead to similar prices (USD 60–88/tCO_2) to those presented here (USD 108/tCO_2), although this depends critically on the emissions cap by 2020. Integrating REDD fully in the carbon market helps in achieving the two degrees target (see Figure 5) at lower costs, and therefore makes the target politically more acceptable. However, achieving this climate target assuming that REDD is additional to efforts in other sectors, and scenarios 5 and 6 are at the high end of the UNEP (2011) range of scenarios with a likely change to meet a two degrees target, i.e., 45 and 46 GtCO_2, respectively. Thus to increase the likelihood of meeting the two degree target, other technologies are still required as part of countries mitigation portfolios, as included in the FAIR model: reductions in non-CO_2 greenhouse gases, carbon plantations, carbon capture and storage, bioenergy and energy efficiency improvements.

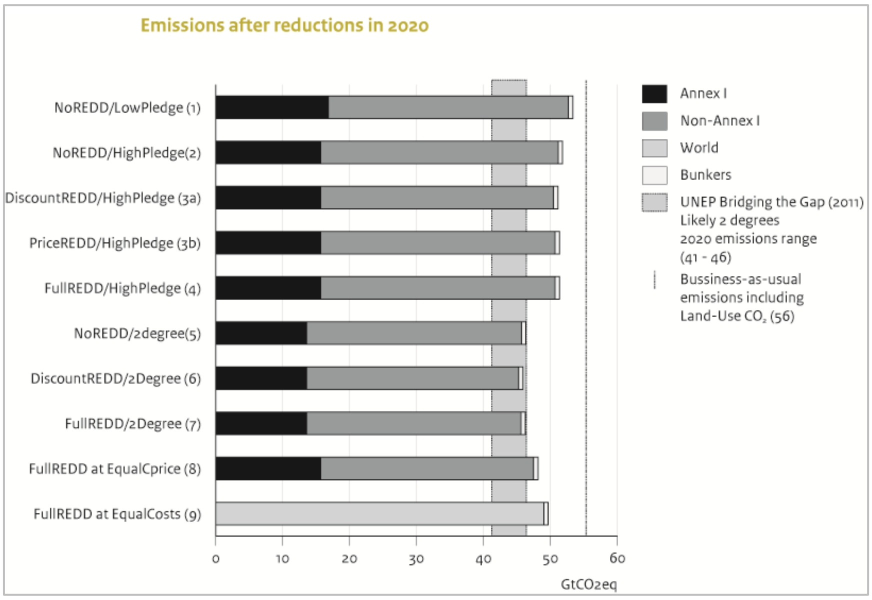
Interestingly, the two degrees scenarios also show how non-Annex I countries increase their benefits due to the higher Annex I targets (higher demand), no domestic restriction for Annex I reductions (full trade) and the effect that at this higher prices (due to the higher demand) there is more “room” for REDD and CDM to take place at the same time and therefore they compete less with each other.

Table 7: Main outcomes in the different scenarios in 2020

#	Scenario name	Reductions ($GtCO_2$)			USD/tCO_2 in 2020		Abatement costs in USD billions (% of GDP)			
		World	Annex I	Non-Annex I	Carbon price**	Domestic prices***	World	Annex I	Non-Annex I	REDD Costs*
1	No REDD / Low pledge	3.8	2.3	1.4	6	5–85	53 (0.07)	32 (0.07)	19 (0.07)	1.5
2	No REDD / High pledge	5.3	3.5	1.8	19	25–84	71 (0.1)	59 (0.13)	9 (0.03)	2.0
3a	Discounted REDD/High pledge	6.0	3.5	2.5	9	23–83	73 (0.1)	53 (0.12)	20 (0.07)	
3b	Price REDD/ High pledge	5.7	3.5	2.2	19	25–84	77 (0.11)	59 (0.13)	9 (0.03)	6.3
4	Full REDD / High pledge	5.7	3.5	2.2	7	23–83	74 (0.1)	52 (0.12)	22 (0.08)	
5	No REDD /2 degrees	10.8	5.6	5.2	108	108	247 (0.34)	224 (0.5)	21 (0.08)	2.0
6	Discounted REDD/2 degrees	11.2	5.6	5.6	72	72	163 (0.23)	187 (0.42)	-24 (-0.09)	
7	Full REDD /2 degrees	10.8	5.6	5.2	63	63	157 (0.22)	173 (0.38)	-16 (-0.06)	
8	Full REDD at equal price	8.9	3.5	5.4	19	19	91 (0.13)	59 (0.13)	31 (0.11)	
9	Full REDD at equal costs	7.2			16		71 (0.1)			

Notes:
* Correspond to the REDD abatement costs of Mexico, Brazil and Indonesia that need financing.
**Price for CDM, JI, emission trading and REDD (when included in the carbon market) on the international carbon market. For case 1, 2a and 3c the REDD price is not presented here but is lower than the international carbon price and corresponds to the price at which the last ton of carbon is abated in the regional REDD MAC curves.
***Correspond to the domestic prices for Annex I countries. Range given the different Annex I regions.

Figure 5: Emission targets in 2020 (before emissions trading and CDM) for different scenarios compared to PBL BAU levels including land-use CO_2 emissions



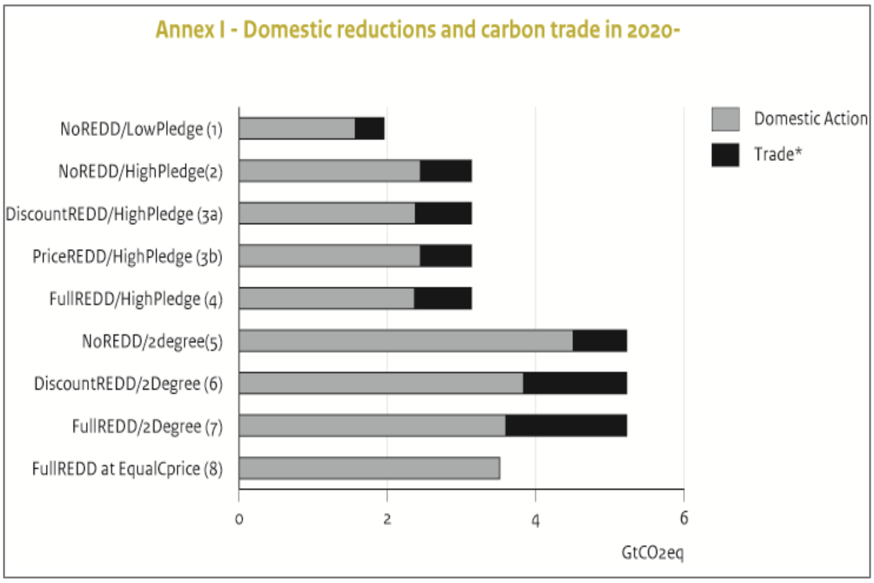
The reduction targets and absolute emission reductions, previously described, lead to different emission levels in 2020. In Figure 5 we compare this emission target levels to the PBL BAU levels including land-use CO_2 emissions as well as to the emission levels range necessary for a likely change for meeting a two degrees target from the UNEP Bridging the gap report (UNEP, 2011). All scenarios presented here for the pledges, do not reach the range of global emissions necessary in 2020 for meeting a two degrees climate target with a likely change (higher probability than 66%, i.e., between 41 and 46 $GtCO_2$ by 2020) according to the UNEP Bridging the gap report (UNEP, 2011).

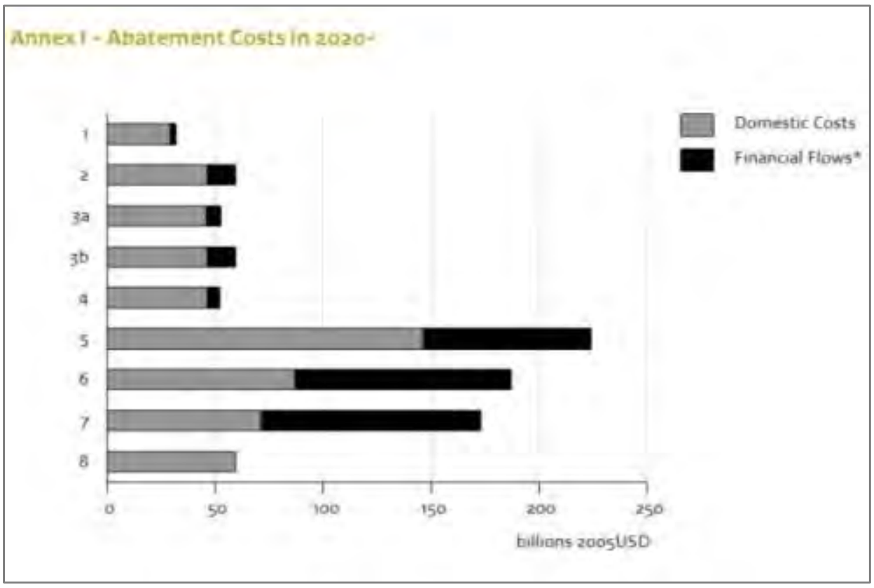
In terms of environmental effectiveness, i.e., total reductions achieved, the partial inclusion of REDD in the market, particularly the discounted scenarios, leads to similar impacts as a full inclusion scenario at similar abatement costs for the pledges and slightly lower for the two degrees scenario, as mentioned before.

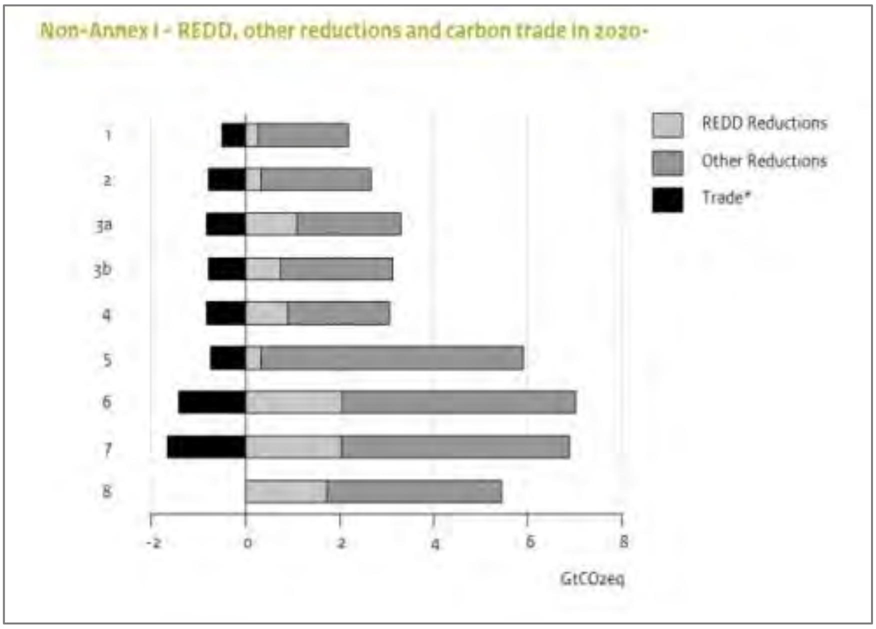
6.3 Abatement costs and trade

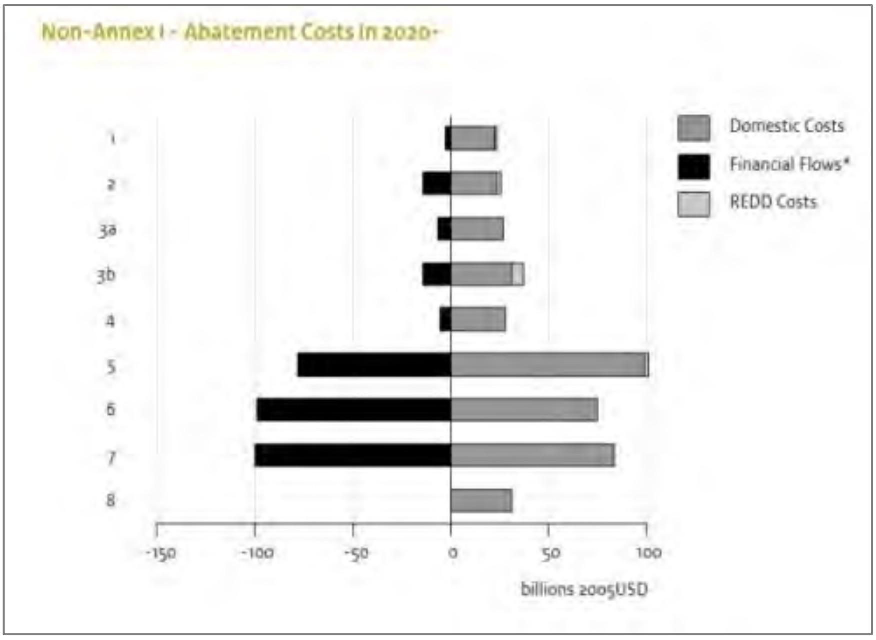
Figure 6 shows more detailed information about how Annex I and non-Annex I are meeting the reductions (after accounting of emissions trading and CDM) presented in Table 7. It also presents the related costs to these reductions and financial flows due to emissions trading.

Figure 6: Annex I and non-Annex I reductions and abatement costs in 2020









*Sellers in the carbon market have negative trade and financial flows (gains).
Note: The reductions are split in domestic reductions and trade for Annex I (top left) and in REDD and other reductions and trade for non-Annex I (bottom left). Abatement costs in 2020 for Annex I (top right) and non-Annex I (bottom right) corresponding to the reductions and financial flows due to emissions trading. The REDD costs are presented as part of non-Annex I costs for those scenarios where REDD is kept out of the carbon market. However this does not imply they are bearing them.

Full inclusion of REDD for the default case (see Figure 6: scenario 2 to 4) results in very similar trade between Annex I and non-Annex Ibut around double REDD actions in non-Annex I. Most of the REDD countries increased their supply of credits to the market significantly (including Western Africa, Rest of Southern Africa, Rest of South and Central America) and some CDM countries are reducing much less domesticly (including China, India and South Africa). China, which is a supplier of CDM credits in the default scenario, reduces its supply of CDM credits by around half due to the full inclusion of REDD in the carbon market. This is a result of various assumptions such as the domestic restriction of Annex I reductions (i.e., 2/3 of their target must be done domestically) as well as the fact that the ambition level is kept at the same level for all regions. CDM countries receive less revenue when including REDD fully in the market due to lower carbon price. A partial inclusion (discounting) modified this effect and increases the environmental effectiveness.

Quantity discounting results in benefits for both Annex I and non-Annex I regions when compared to the full REDD scenarios. Annex I countries costs remain almost the same and non-Annex I costs are slightly reduced while achieving more reductions take place in non-Annex I.

The current pledges for Annex I regions are not sufficiently ambitious to generate enough demand in a market fully including REDD. These can be seen in most scenarios from 2 to 4 that use the pledges as commitment level for Annex I regions. The emissions trading for Annex I is almost the same in all scenarios and the maximum costs generated from emissions trading take place when REDD is not integrated in the carbon market due to the higher carbon price. When moving to more ambitious targets (see figure 6: scenario 2–4 compared to 7, top left panel), the emissions trade between Annex I and non-Annex I is doubled, and the financial benefits for non-Annex I are increased again as a result of higher carbon price in this scenario.

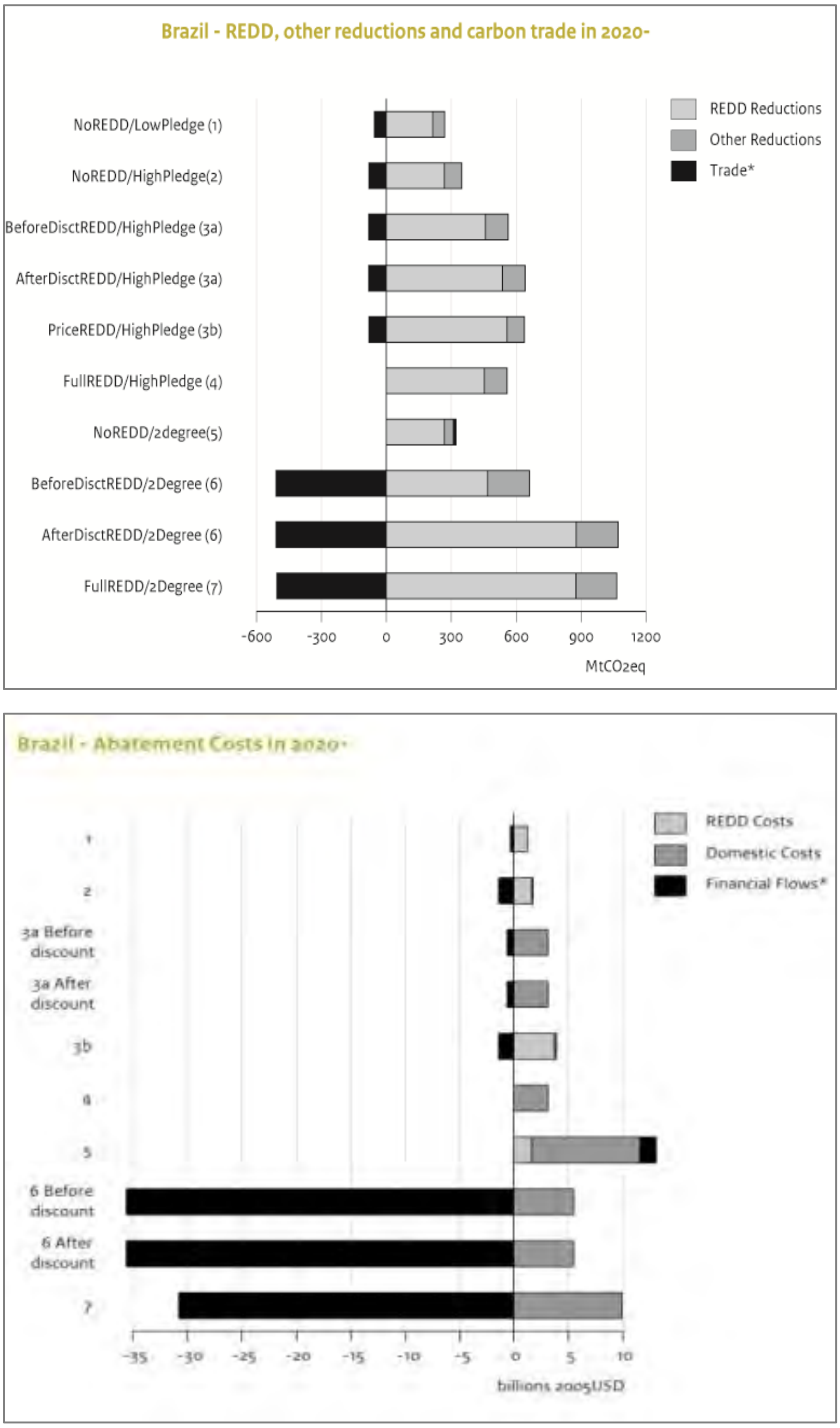
For the equal carbon price scenario (scenario 8), we present the global costs and emission reductions for the same global carbon price as in scenario 2 (i.e., USD 19/tCO_2). Compared to the default case the reductions and costs are the same for Annex I while for non-Annex I REDD reductions increase from 1.8 to 5.4 GtCO_2 and the costs are also increased from USD 9 to 31 billion.

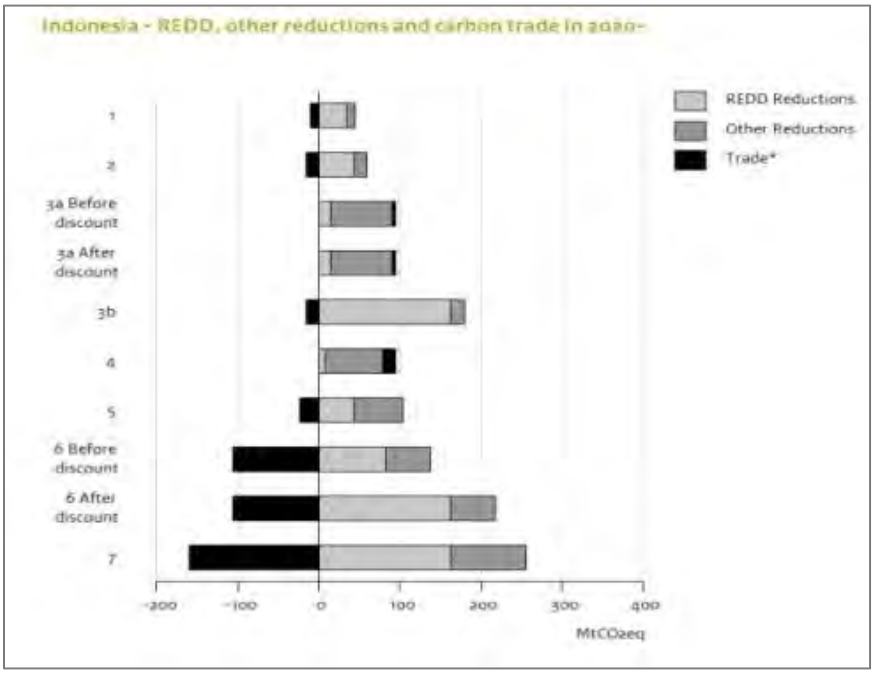
6.4 Outcomes for Brazil and Indonesia

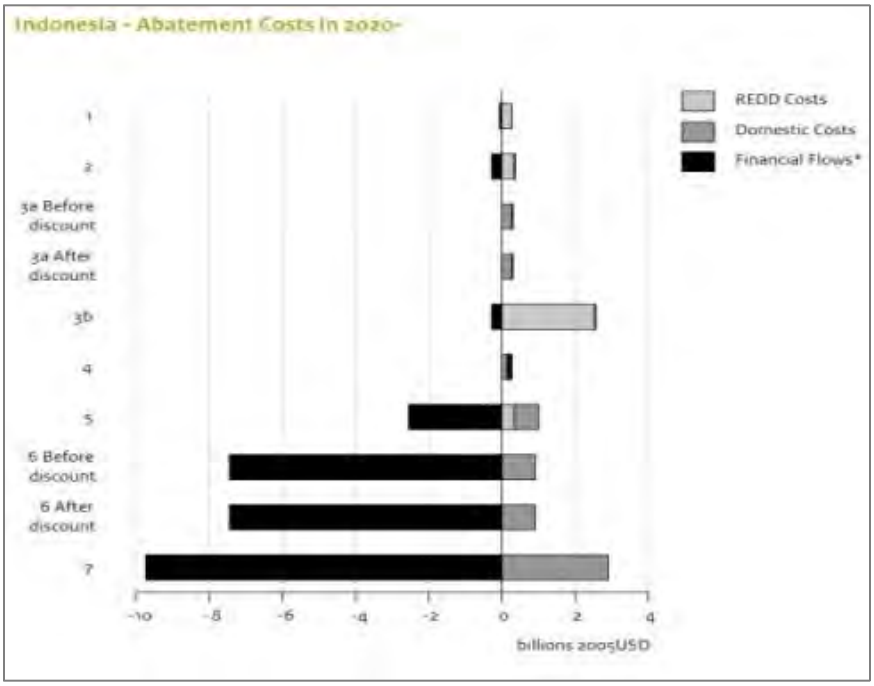
As discussed earlier, full inclusion of REDD leads to more global REDD actions, but Figure 7 shows that Brazil and Indonesia are not the ones supplying these extra reductions (see Figure 7 scenario 2 and 4). The additional reductions mainly come from regions like Rest of Central and South America, Western Africa, Mekong and Rest of Southern Africa. These countries are supplying REDD credits to the market as they do not have a domestic target to achieve first, i.e., all reductions can be supplied to the market. Brazil and Indonesia use their REDD reductions to achieve their own targets, and when these targets are increased Brazil increases its REDD action, and Indonesia uses potential from other non-REDD sector for meeting the target. This is highly dependent on the MAC curves for the different regions. This suggests that REDD in Indonesia is not as cheap as often assumed, and clearly more expensive than for other mitigation sectors. In the full REDD high pledge scenario Indonesia becomes a buyer in the carbon market as it is more effective to reduce emissions by offsetting them in other non-Annex I countries. For the two degrees scenarios Indonesia becomes a seller due to the higher carbon price resulting from the higher demand. At this price Indonesia undertakes more REDD and non-REDD actions than what is required to meet the target and profits from selling carbon credits in the market. This shows some of the dynamics between CDM and REDD when integrating REDD fully in the market and balancing this with more ambitious targets.

For Brazil the situation under the high pledge scenario and full REDD integration is not as extreme as for Indonesia (Brazil does not become a buyer), but still the increase in the demand from other regions results in an almost doubling of actions in REDD and non-REDD sectors (scenarios 4 and 7). Scenario 3b shows that achieving the full REDD reduction in order to achieve the full NAMA lead to quite high costs for Indonesia (i.e., USD 2.3 billions) compared to the costs of fulfilling the NAMA allowing the use of other mitigation options like in scenario 4. Again this is particularly related to regional MAC curves and the commitment levels.

Figure 7: Effect of the REDD inclusion options on Brazil and Indonesia







Notes:

Left panel: Brazil (top) and Indonesia (bottom) reductions in 2020 from REDD and other reductions and emissions trading.

Right panel: Associated costs for the reductions and financial flows resulting from emissions trading.

When full integration of REDD in the carbon market takes place, Brazil reduces its deforestation emission by around 42% compared to BAU levels while for an assumed restricted REDD action in order to meet its own target by using REDD the deforestation emissions are reduced by 52% (see Figure 7, scenario 3b to 4). This is more environmentally effective for Brazil than the assumption on the REDD realization of 25% compared to PBL BAU for CO_2 deforestation emissions level for the default scenario. Our discounting option of REDD in the carbon market leads to a reduction of 50%, while the maximum reduction is achieved with a two degrees full integration of REDD (i.e., 82%) all under PBL BAU by 2020. The absolute REDD reductions can be seen in Figure 7 for both Brazil and Indonesia.

The joint Brazilian and Indonesian REDD reductions correspond to the following shares of the global REDD reductions: 93% (Scenario 1), 94% (Scenario 2), 46% (Scenario 3a after discounting), 100% (Scenario 3b), 58% (Scenario 4), 41% (Scenario 6 after discounting) and 53% (Scenario 7). However, as mentioned above, these regions mainly use REDD actions to fulfill their own target and the regions supplying REDD credits are those without a target.

6.5 Summary of scenarios

The main findings from the model analysis are summarized in Table 8.

6.5.1 Scenarios 1 and 2: No REDD inclusion & high/ low pledges

Abatement costs

When REDD is not included in the market global costs of abatement vary between USD 53 and 71 billion (i.e., 0.07% and 0.1% of the global GDP) for the low and high pledges, respectively. The costs for Annex I countries vary between USD 32 (low pledge) and 59 billion (high pledge) and for non-Annex I between USD 9 (low pledge) and 20 billion (high pledge).

Carbon price

The carbon market price for CDM credits is USD 6/tCO_2 for the low pledges and USD 19/tCO_2 for the high pledges. We observe higher domestic prices for individual Annex I countries due to the domestic reduction restrictions (2/3 of mitigation undertaken domestically, except for the US for whom the domestic restriction is 100% as the US has announced not to use international offsets to achieve its pledge).

REDD

REDD activities rely on non-market funding. Based on our assumptions, global deforestation emissions are reduced by 8% to 10% below PBL BAU for CO_2 deforestation emissions. Our calculations show that between USD 1.5 and 2 billion in 2020 are required to finance the assumed REDD realization for the low and high pledges scenarios in 2020.

Table 8: Summary of scenarios

#	Scenario name	Carbon price in 2020 (USD/ tCO_2)	Global greenhouse gas emissions in 2020 ($GtCO_2$)	CO_2defor. Emission: % below BAU levels in 2020 (% below 2005 levels)			Global abatement costs in 2020, USD billion (% of GDP)
				World	Brazil	Indonesia	
1	No REDD inclusion/ Low pledge	6	52.7	8 (32)	20 (32)	20 (50)	53 (0.07)
2	No REDD inclusion/ High pledge	19	51.2	10 (33)	25 (37)	25 (54)	71 (0.10)
3a	Discounting REDD/ High pledge	9	50.5	32 (50)	50 (58)	8 (43)	73 (0.10)
3b	Price REDD/High pledge	19	50.7	22 (42)	52 (59)	95 (97)	77 (0.11)
4	Full REDD inclusion/ High pledge	7	50.7	27 (46)	42 (51)	4 (41)	74 (0.10)
5	No REDD inclusion/ 2 degrees	108	45.7	10 (33)	25 (37)	25 (54)	247 (0.34)
6	Discounting REDD/ 2 Degrees	72	45.2	62 (71)	82 (85)	95 (97)	163 (0.23)
7	Full REDD inclusion/ 2 degrees	63	45.6	61 (71)	82 (85)	95 (97)	157 (0.22)
8	Full REDD inclusion at equal price	19	47.5	52 (39)	79 (67)	72 (44)	91 (0.13)
9	Full REDD inclusion at equal costs	16	49.2				71 (0.10)

6.5.2 Scenario 3a and 3b: Partial REDD inclusion & high pledges

In the discounting scenario (scenario 3a), a country buying REDD credits must obtain two REDD credits for every credit that is being offset (i.e., avoided reductions in own country). In the price reduction scenario (scenario 3b), REDD credits are being sold at a fixed price lower than the price of other credits and are not integrated in the carbon market.

Abatement cost

The global abatement cost lies between USD 73 and 77 billion (i.e., 0.1 and 0.11% of the global GDP) for policies of discounting and price reduction, respectively. When discounting REDD credits, the abatement costs are USD1 billion higher for Annex I and USD2 billion lower for non-Annex I compared to a full REDD inclusion. This is an effect of the slightly higher carbon price (USD9 compared to USD7/tCO_2) due to the restricted REDD supply. The effect is still rather limited as domestic restrictions still apply. For the two degree scenarios the benefit of the increase price due to discounting is more explicit as there are no domestic restrictions. In the price reduction case there is no change in abatement costs for Annex I regions with respect to a no inclusion case as REDD is kept is a separate market. Higher costs compared to the no inclusion case for the non-Annex I regions occur due to higher targets of Brazil and Indonesia, that are assumed to achieve their full NAMA by increasing REDD actions. Who will carry the REDD costs that Brazil and Indonesia encounter is not specified in the model.

Carbon price

The carbon price is USD 9/tCO_2 with discounting and USD 19/tCO_2 for the price reduction scenario. We find that around USD 6 billion in 2020 is needed to finance Brazilian and Indonesian REDD activities when fulfilling its full NAMA using REDD in a price reduction scenario. These reductions and respective costs yield an average price for REDD credits between USD 9 and 11/tCO_2 in the price reduction scenario.

REDD

The discounting case is attractive from an environmental point of view. Restricting the supply of REDD credits to the carbon market by discounting the quantity of these credits can help increase the global deforestation emissions reduction to 38% below BAU at the same global costs as with no REDD inclusion. Global costs are higher compared to a full inclusion due to the higher carbon price, which demonstrates how discounting helps to contain the flooding effect of including REDD in the carbon market. Further, there is an additionality effect in terms of higher overall reductions from including REDD however this is low at the global level mainly due to the volume of the discounted REDD carbon tons (only those traded in the market). In the price reduction case there is no additionality effect as REDD credits are not fungible with other credits. The price reduction case assumes REDD actions to be undertaken in a separate market with resulting deforestation emission reductions of 22%

below BAU. Price discounting reduces deforestation emissions 50% in Brazil and 95% in Indonesia in 2020.

6.5.3 *Scenario 4: Full REDD inclusion & high pledges*

Abatement costs

Under full REDD inclusion global abatement costs are about USD 74 billion for the high pledge scenarios in 2020. The slightly higher costs, compared to scenario 2 (USD 71 billion), is explained by the more ambitious reduction targets for Brazil and Indonesia from 5 to 6% below BAU (i.e., about 0.4 $GtCO_2$) results in for non-Annex I. Further, restriction on domestic actions for both Annex I and non-Annex I countries (in line with their pledges and NAMAs) has an effect on the abatement costs of regions due to non-economic optimal reductions. Overall, abatement costs for Annex I countries decrease by about 15% to USD 52 billion while the costs for non-Annex I double to about USD 22 billion.

Carbon price

Compared to the no inclusion case, the carbon price drops by 60% to USD 7/tCO_2, which is within the range of other studies. Therefore, it would be expected that global abatement costs would decline. However, our finding on the increased abatement costs for non-Annex I regions and no global costs reductions can be explained by the domestic restriction that 2/3 of emission reductions must be done domestically for Annex I countries (100% for the US and for some non-Annex I regions). Hence a smaller effect of REDD supply on the carbon trading market is observed in the results.

REDD

Full REDD inclusion reduces global deforestation emissions by 17 to 25% below BAU (compared to 8–10% for no REDD inclusion).

6.5.4 *Scenarios 5–7: Two degrees target & no, partial or full REDD inclusion*

Abatement costs

Reductions of Annex I and non-Annex I regions are increased to the two degrees target pledge resulting in a global abatement costs between USD 157 and USD 163 billion (i.e., 0.22% and 0.23% of the global GDP) for full and partial REDD inclusion, respectively. When there is no REDD inclusion under the same target the abatement costs are USD 247 billion.

The costs for Annex I countries vary between USD 173 billion under full REDD inclusion and USD 187 billion under partial inclusion. Non-Annex I countries gain around USD 16 and USD 24 billion for the full and partial inclusion. In the case of no REDD credits in the market, global costs are significantly higher (USD 247 billion), and also the non-Annex I countries have positive costs (USD 21 billion).

Carbon price

The carbon price is USD 63/tCO_2 for full REDD inclusion, USD 72/tCO_2 for partial inclusion, and USD 108/tCO_2 with no inclusion.

REDD

Under the highly ambitious two degrees target, we achieve a reduction of global deforestation emissions of 60% below BAU in the partial and full REDD inclusion scenarios. Under the two degrees scenario combined with higher demand, full REDD trade and no domestic restrictions for achieving country targets there is less direct competition between CDM and REDD, and there is a higher carbon price. Hence most non-Annex I regions profit under these scenarios.

6.5.5 Scenario 8: Equal price

Fixing the equilibrium price at the level where one is meeting the current high pledges without any REDD activities (i.e., USD 19 /tCO_2) and then including REDD in the carbon market results in an increase of global reductions by 7% (almost 4 GtCO_2), from 9% to 16% below BAU including land-use CO_2 emissions in 2020. Global deforestation emissions would be reduced by 52% below BAU in 2020 compared to the REDD realization assumed that leads to 10% below BAU in 2020.

6.5.6 Scenario 9: Equal Costs

If the same amount of money is spent to achieve both current pledges and NAMAs in a global emission trading scheme where REDD is be fully integrated, the global reductions could be increased by about 4 percentage points (from 9 to 13%) below BAU levels, including land-use CO_2 emissions in 2020.

7. Concluding remarks

This report has reviewed and analyzed the implications of introducing REDD credits in a future global carbon market. A major challenge is to introduce REDD in such way that, on the one hand, sufficient funding is mobilized and the REDD potential realized, and on the other hand, the inclusion avoids politically controversial crowding out effects on other mitigation efforts, and ensures that REDD becomes additional. We have discussed several ways to achieve this balance, as summarized in Table 3. The options include simultaneous political decisions on the global emission caps, restrictions on the volume of REDD credits (on either the demand or supply side), setting reference levels for REDD below BAU baselines, partial offsetting or discounted REDD credits to generate additional, non-traded reductions, and a corridor approach with gradually increasing payments for REDD. Each of these has its merits, and together they demonstrate that practical and relatively simple options are available to deal with the dilemma and minimize the risk related to introducing REDD in carbon markets.

We note, however, that an inclusion of REDD credits in a global carbon market is unlikely to materialize in the short term for two major reasons: First, a global carbon market is not yet established, and its creation hinges on the progress in the UNFCCC climate negotiation and/or key countries taking on stronger commitments and including REDD as an option to meet these commitments. Yet, many of our conclusions are still relevant for a situation with more fragmented carbon markets. Second, there is a number of issues related to the supply of REDD credits that need to be resolved and that are outside the scope of this report: MRV standards, safeguards for rights and social impacts, setting of reference levels to ensure additionality, ensure permanence, design and implement national level institutions and policies which can deliver emissions reductions and provide an effective and equitable sharing of REDD revenues, etc.

We have modeled ten different scenarios for REDD inclusion, varying the rules for integration, and the global pledges (emission caps or commitment levels). The scenarios are based on the reduction pledges put forward by developed and developing countries in the Cancún Agreements, and on own assumed reduction targets for the countries compatible with meeting the long-term climate goal of 2°C, as referred in the Cancún Agreements. These mitigation scenarios are placed in the context of including fully, partially or not including REDD as an off-setting option for developed countries. The most relevant suppliers of REDD credits in our modeling results are Brazil, Indonesia, Rest of South America and Rest of South East Asia. However, the actual supply is highly dependent on the MAC curves for REDD and baseline emissions.

We believe the analysis undertaken is useful for several reasons. Using basic economic reasoning and analysis is helpful to sort out and specify more precisely different arguments and options in the debate. Further, simulation models help to indicate orders of magnitude on different effects. The modeling exercise is also useful to pinpoint factors which are critical to reach a desired outcome, and therefore should be the focus of political negotiations.

Three important conclusions emerge from this report. First, full inclusion of REDD credits *under current High Pledges* is likely to suppress carbon prices to levels that may be politically unacceptable and not in line with policies aimed at providing strong incentives for moving towards a low-carbon economy.

Second, if REDD credits are to be fully included in the markets, the global ambition for emission reductions must move towards the two degrees target if one is to avoid major crowding out effects..

Third, getting global emissions on the track towards a two degrees target will be much more expensive without REDD (about 57% higher compared to full inclusion). Achieving the two degree target seems very challenging without a realistic plan on how to finance and harness the lion's share of the REDD potential.

Glossary

Additionality
Additionality is the requirement that a REDD project or policy should generate emissions reductions beyond what would have happened without the project or policy (i.e., the business as usual scenario).

Assigned Amount Units (AAUs)
Under the Kyoto Protocol, the "caps" or quotas for Annex I countries are known as Assigned Amounts. The quantity of the initial assigned amount is denominated in individual units, called Assigned Amount Units (AAUs), each of which represents an allowance to emit one metric ton of CO_2 equivalent, and these are entered into the country's national registry.

Business-as-usual (BAU)
Refers to a future without new climate projects or policies. BAU future emission projections are therefore projected emissions assuming no new climate projects or policies are implemented.

Cap and Trade (CAT)
A system under which a country or region is faced with a limit (cap) on the total amount of greenhouse gases that can be emitted. The difference between realized emissions and the cap can be traded in the international carbon market. If the country has excess allowed emissions the country can sell on the market, while countries that have a shortage of allowances can buy permits on the market.

Carbon price
The price at which emission credits of greenhouse gases (in CO_2) are traded on the market.

Clean Development Mechanism (CDM)
One of the three flexible mechanisms under the Kyoto Protocol. CDM allows developed countries to invest in emission reduction projects in developing countries. Developed countries investing in CDM projects receive certified emission reductions (CER) that can be used to offset domestic emissions. In this way, CDM may help developed countries reach their emission reduction target.

Conference of the Parties (COP)
Annual meeting of the UNFCCC parties to assess progress in dealing with climate change performed since 1995.

Emission trading
One of the three flexible mechanisms in the Kyoto Protocol to allow for trade in emission allowances between countries. It can also concern trade in emission credits among private entities (e.g., companies), such as the EU ETS. A precondition for emission trading is a capping of the allowable emissions for each country or company joining the cap-and-trade system. If actual emissions are below the allowance level, the excess allowances can be sold to countries/companies that have not met their target.

High pledges
Refers to a scenario in which all countries implement their most ambitious High emission reduction pledge for 2020.

Low pledges
Refers to a scenario in which all countries with only a High emission reduction pledge for 2020 implement their pledge and all countries with both an unHigh and High pledge implement their (least ambitious) unHigh pledge.

Nationally Appropriate Mitigation Actions (NAMAs)
Set of policies and actions that countries undertake as part of a commitment to reduce greenhouse gas emissions

Pledge
For the purpose of this report, pledges include Annex I (developed countries) targets and non-Annex I (developing countries) actions as included in Cancun Agreements.

UNFCCC
The United Nations Framework Convention on Climate Change. (UNFCCC) is an international environmental treaty with the objective to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

USD
United States dollars (US$). We use 2005 US$ throughout this report.

Norsk sammendrag

En rekke spørsmål må avklares dersom REDD (reduserte utslipp fra avskoging og skogforringelse i utviklingsland) kvoter skal inkluderes i et fremtidig globalt karbonmarked. Denne rapporten fokuserer på en undergruppe av disse, nemlig implikasjonene av (i) ulike regler for inkludering av REDD kvoter (sertifiserte utslippsreduksjoner) og (ii) ulike globale forpliktelser (utslippstak). Rapporten ser på hvilke effekter alternative modeller og antagelser har på karbonpris, totale kostnader, internasjonale pengestrømmer til REDD tiltak, og reduksjoner i skogrelaterte utslipp samt utslipp i andre sektorer.

En viktig konklusjon er at vi kan gjøre mer i form av globale utslippsreduksjoner hvis REDD kvoter er inkludert i et karbonmarked. Risikoen for å overstrømme markedet med billige REDD kvoter som fortrenger klimatiltak i andre sektorer (*crowding out*) kan minimeres gjennom flere mekanismer, for eksempel, et lavere globalt utslippstak og diskonterte REDD kvoter.

Modellsimuleringene viser at en inkludering uten noen justeringer i det globale utslippstaket vil føre til betydelig lavere karbonpriser. Selv i scenarioet med høye forpliktelser, vil en full inkludering av REDD kvoter redusere karbonprisen med nesten to tredjedeler. Det globale utslippstaket må bevege seg ned mot hva som er forenelig med 2-gradersmålet dersom en skal inkludere REDD og samtidig opprettholde en høy karbonpris slik at det skapes sterke insentiver for utslippsreduksjoner i andre sektorer og i de industrialiserte landene (Annex I).

Samtidig vil det være svært utfordrende å nå 2-gradersmålet uten å utnytte mesteparten av REDD potensialet. Selv med full inkludering av REDD kvoter og ingen begrensning på andelen av utslippsreduksjon som skal gjøres innenlands vil karbonprisen ligge på USD 63–72/tCO_2.

Oppsummert argumenterer rapporten for at det er miljømessig- og økonomisk forsvarlige måter å inkludere REDD kvoter i et karbonmarked. Fremtidige diskusjoner ville bli mer meningsfylte om premissene og alternativene er gjort eksplisitte, og debatten fokuserer på design av mekanismer, snarere enn en polarisert debatt for og mot inkludering.

De viktigste funnene i rapporten er:

- Større utslippsreduksjoner og lavere totale kostnader kan oppnås ved å inkludere REDD kvoter i et globalt karbonmarked.
- Flere faktorer påvirker effekten av en inkludering av REDD kvoter i karbonmarkedet, herunder reglene for handel med utslippskvoter, krav om innenlandske utslippsreduksjoner, totale (globale) klima-forpliktelser (utslippstak), og potensialet for tiltak og nivået på kostnader i andre sektorer.
- Karbonprisene uten inkludering av REDD kvoter blir betydelig høyere, og vil gjør det enda mer politisk utfordrende å nå et utslippsnivå i 2020 som er forenelig med 2-gradersmålet.
- En hovedutfordring er å få en balansert innføring av REDD kvoter, dvs. å sørge for at inkludering av REDD kommer i tillegg til eksisterende tiltak og dermed bidrar til dypere kutt i de globale utslippene (unngår fortrengning av andre tiltak). Dette kan oppnås gjennom mer ambisiøse globale forpliktelser som bringer oss nærmere en utslippsbane som er forenelig med 2-gradersmålet. Den økte etterspørselen etter klimakvoter vil dermed balansere det økte tilbudet som følge av REDD inkludering, og bidra til en høy karbonpris med sterke incentiver til utslippskutt i alle sektorer. Inkludering av REDD kvoter uten en skjerping av det globale utslippsmålet vil føre til en betydelig fortrenging av andre utslippsreduserende tiltak i andre sektorer.
- En annen mulighet til å oppnå en balansert innføring er gjennom diskonterte REDD kvoter (*partial offsetting*), dvs. et system hvor ett tonn reduserte CO_2 utslipp fra redusert avskoging i utviklingsland i et marked ikke fullt ut kan kompensere for ett tonn økte utslipp i industrialiserte land. Fortrengingseffekter kan også reduseres ved at referansebanen for skogrelaterte utslipp settes lavere enn *business-as-usual* scenariet.
- En inkludering av REDD kvoter har internasjonale fordelingsmessige effekter, og ulike konsekvenser for industrialiserte land (*Annex I*) og utviklingsland (*non-Annex I*). Blant utviklingsland vil en innfasing av REDD kvoter fortrenge CDM kvoter og dermed skape både vinnere og tapere (land med lavt REDD potensial).

Rapporten diskuterer seks ulike alternativer for en inkludering av REDD kvoter i et karbonmarked: (i) et lavere globalt utslippstak som er politisk bestemt, (ii) en justering av det globale utslippstaket avhengig av karbonprisen, (iii) diskonterte REDD kvoter (*partial offsetting*), (iv) kvantumrestriksjoner på etterspørsel og/eller tilbud av REDD kvoter, (v) *banking* av REDD kvoter (oppmuntre tidlig utslippsreduksjon og sikre en mer stabil pris over tid), og (vi) lavere referansebaner (som reduserer tilbudet av REDD kvoter). Alternativene (i), (iii), og (iv) er analysert nærmere i modellen. På etterspørselssiden er det lagt til grunn tre alternative utslippsforpliktelser for 2020, basert på løftene (*pledges*) som ble lagt fram på klimamøtet i Cancún (2010) og senere oppdatert: (i) lav reduksjon i utslippene, ii) høy reduksjon i utslippene, og (iii) utslippstak som er forenelige med en utslippsbane som gir 66 % sannsynlighet for å nå 2-gradersmålet. I tillegg analyseres to scenarioer hvor målet er å holde karbonprisen eller de globale kostnadene konstante etter en inkludering av REDD kvoter i markedet. Scenarioene er analysert ved hjelp av FAIR modellen, som er utviklet av *PBL Nederland Environmental Assessment Agency*. Modellen integrerer referanseutslipp og informasjon om de marginale kostnadene for utslippsreduksjoner i ulike sektorer og regioner, og allokerer den globale utslippsreduksjonen kostnadseffektivt mellom sektorer og regioner. I noen av scenarioene legges det også til grunn at industrialiserte land oppfyller 2/3 av sine utslippsforpliktelser gjennom innenlandske reduksjoner.

Hovedresultatene i modellsimuleringene er:

- I tråd med tidligere studier, finner vi et stort potensial for ytterligere reduksjon i utslipp ved å inkludere REDD kvoter i det globale karbonmarkedet. Utslipp fra avskoging reduseres i 2020 med 22–62 % i forhold til business-as-usual, og 42–71 % i forhold til 2005-nivå.
- I scenarioet som forutsetter et gitt globalt utslippstak (high pledges) vil en inkludering av REDD kvoter redusere den globale karbonprisen fra USD 19/tCO2 til USD 7/tCO2 i 2020. Prisreduksjonen er noe mindre (USD 9/tCO2) i scenarioet med diskonterte REDD kvoter.

- I scenarioet som forutsetter at det globale utslippstaket endres slik at karbonprisen holdes konstant og en tar utgangspunkt i high pledges fra Cancún, vil en inkludering av REDD kvoter redusere de globale utslippene fra 51,2 til 47,5 GtCO2 i 2020. I tilsvarende scenario som holder de globale kostnadene ved utslippsreduksjoner konstant vil de globale utslippene reduseres til 49,2 GtCO2. Til sammenligning har scenarioet med 2-gradersmålet globale utslipp på 45,7 GtCO2, dvs. at inkludering av REDD kvoter bringer oss om lag 2/5 av veien mot 2-gradersmålet uten en økning i de globale kostnadene. Under antakelsen om konstant pris er vi om lag 4/5 av veien mot dette målet.
- Det blir vesentlig dyrere å nå 2-gradersmålet uten inkludering av REDD kvoter i forhold til scenarioet med REDD inkludering; de globale kostnadene er 57 % høyere mens karbonprisen er 71 % høyere (> USD 100/tCO2).

Appendix 1: The FAIR model

Method

We use the FAIR[19] model to assess a set of options and scenarios. FAIR is a decision making tool developed and used by PBL Netherlands Environmental Assessment Agency (den Elzen *et al*., 2010; 2011). FAIR integrates baseline emissions (including all Kyoto greenhouse gases) and information on marginal abatement costs by sectors (MAC curves) and regions.[20] Based on this, it calculates regional and global abatement costs given regional GHG emission targets (as described in chapter 5). FAIR uses a cost-optimal implementation of these targets among regions, gases and sources through global trading of carbon credits. This means that the lowest cost mitigation options and technologies are used first. Using demand and supply curves, FAIR determines the carbon price in the international trading market, its buyers and sellers, and the resulting domestic and external abatement levels for each region.

The abatement costs represent the direct additional costs due to climate policy. These present a first-order estimate of climate costs, but do not capture indirect macroeconomic implications. There are several reasons why macroeconomic costs may differ from abatement costs. Mitigation policies could, for instance, induce a reduced demand for fossil fuels, which could lead to additional income losses via fuel trade for fossil fuel exporters (OPEC countries, but also Russia and Canada) (e.g., Dellink *et al*., 2010). However, macro-economic impacts are more uncertain. A comparison of costs estimates based on abatement costs and macro-economic calculations showed nevertheless a high degree of correlation, so that abatement costs can be seen as a good proxy, in particular at the level of aggregated regions (van Vuuren *et al*., 2009).

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[19] Framework to assess international regimes for the differentiation of commitments.

[20] *Annex I:* Canada, USA, EU (Central and Western Europe), Russian Federation, Japan, Oceania (Australia and New Zealand) and Ukraine region (Ukraine and Belarus).
Non-Annex I: Mexico, rest of Central America, Brazil, rest of South America, South Africa, Kazakhstan region, Turkey, Middle East, Korea region, China, Northern Africa region, India, rest of Southern Asia, Indonesia region, rest of South-East Asia, Western Africa, Eastern Africa and rest of South-Africa region.

Input Data

The IMAGE land use model (Bouwman *et al*., 2006) and TIMER energy model (van Vuuren *et al*., 2007) provide the greenhouse gas (GHG) emissions baseline (i.e., scenario in the absence of climate policy) for the Kyoto gases and the energy, industry and agriculture sectors. The scenario used here is based on the baseline developed for the OECD Environmental Outlook (OECD, 2012).

For the CO_2 baseline emissions from land use and forestry (i.e., deforestation CO_2 emissions) the scenario design by IIASA for the secretary of State of Energy and Climate Change (Böttcher *et al*., 2011), using the Global Forestry Model from IIASA (Kindermann *et al*., 2008) is used and refered to as the PBL BAU for CO_2 deforestation emissions. The global deforestation baseline emissions are around 3.3 $GtCO_2$ in 2020 as well as the global net land use since no afforestation or forest management measures are assumed. We assume that Annex I countries do not have emissions or sinks from deforestation and afforestation according to the baseline CO_2 emission scenario used here, but instead they have a certain amount of credits calculated based on other methodologies for accounting for net emissions on this sector as explain in section 5.4.Table A1 shows that Annex I has no emissions from LULUCF CO_2. The deforestation emissions decline in time starting in 2005 until 2050 in this BAU scenario.

Table A1: GHG emissions ($GtCO_2$, including Kyoto gases) for the reference scenario in 2020

	Incl. LULUCF CO_2 Emission		Excl. LULUCF CO_2 Emissions		Deforestation CO_2 Emissions	Net LULUCF CO_2 emissions
Region	1990	PBL BAU 2020	1990	PBL BAU 2020	PBL BAU 2020	PBL BAU 2020
World	38	56	32	53	3.3	3.3
Annex I	19	19	19	19	0.0	0.0
non-Annex I	18	37	13	34	3.3	3.3

The MAC curves of the energy and industry-related CO_2 emissions are calculated in TIMER by imposing a carbon tax and recording the induced reduction of CO_2 emissions. The MAC curves of the non-CO_2 GHG emissions are exogenous to FAIR and based on Lucas *et al*. (2007). The deforestation MAC curves correspond with the CO_2 baseline emission scenario (Böttcher *et al*., 2011) and use a linear path for the carbon tax imposed on the baseline to record emissions reduction. The maximum global abatement possible in 2020 is around 2.4 $GtCO_2$ which correspond to 84% of the deforestation emissions in the same year.

Appendix 2: CDM accessibility factor per region

Table A2: CDM/JI Accessibility factors in 2020

FAIR Regions	CDM/JI Accessibility
Canada	N/A
USA	N/A
Mexico	30
Rest Central America	30
Brazil	60
Rest South America	30
Northern Africa	30
Western Africa	20
Eastern Africa	20
South Africa	60
OECD Europe	N/A
Eastern Europe	N/A
Turkey	30
Ukraine +	60
Asia-Stan	30
Russia +	60
Middle East	60
India	20
Korea	90
China region	30
South East Asia	30
Indonesia region	20
Japan	N/A
Oceania	N/A
Rest of India	20
Rest South-Africa	20

N/A: Non Applicable

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How can REDD credits be included in a future global carbon market, and what are the impacts of inclusion? We analyze ten different scenarios through 2020, varying the global emission caps and the REDD rules. An inclusion of REDD credits without any adjustments in the global cap will lower carbon prices significantly and cause crowding out. The cap must move towards the 2 degrees climate target if REDD inclusion is to maintain high carbon prices and strong incentives for emissions reductions in other sectors. At the same time, reaching the 2 degree target without full REDD inclusion will increase global mitigation costs by more than 50%.

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