Reference emission levels for REDD: Implications of four different approaches applied to past period's forest area development in 84 countries

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Abstract

The course is set for a REDD scheme to be integrated in a potential future climate agreement. For an accreditation of the corresponding emission reductions, a reference emission level needs to be set. In this paper, we compare four approaches for a REDD reference emission level, namely *Compensated Reduction* (CR), *Compensated Conservation* (CC), *Incentive Accounting* (IA) and *Corridor Approach* (CA). The economic advantageousness of the four baseline approaches is compared in terms of generated credits for 84 Non-Annex-I countries. Referring to 1990 to 2000 as the hypothetical "reference period" and to 2000 to 2005 as the "commitment period" based on FAO data, we show which groups of countries would have benefitted most in economic terms by each of the four baseline approaches, and how the groups are characterized by ecological, economic and social indicators.

The approach presented in this paper shows the amount of credits or debits which would have been generated if a REDD scheme had been already established. As a result, in the periods in focus, the group of countries which would have generated most credits under CR is that of those least developed countries (with regard to HDI) which have a high forest cover, whereas CC would have been most advantageous for countries which show a recent increase in their forest area.

The presented approach shows which windfall effects would have had to be considered if a REDD scheme had already been established. Furthermore, the results imply that countries' individual characteristics correspond to the question of which different approaches might be the most favourable in terms of generation of credits. Finally, further potential objectives of a REDD regime other than the mere generation of credits are discussed.

Keywords: REDD, reference emission level, method

Zusammenfassung

Emissions-Referenzen für REDD: Auswirkungen von vier unterschiedlichen Ansätzen angewendet auf die Waldflächen-Entwicklung vergangener Perioden in 84 Ländern

Die Anrechnung von REDD-Maßnahmen in ein zukünftiges Klima-Abkommen wird international diskutiert. Um entsprechende Emissions-Reduktionen quantifizieren zu können, müssen Referenz-Emissionen bestimmt werden. Im vorliegenden Artikel werden vier Methoden zur Erstellung einer solchen Referenz verglichen: *Compensated Reduction* (CR), *Compensated Conservation* (CC), *Incentive Accounting* (IA) und *Corridor Approach* (CA). Die ökonomische Vorteilhaftigkeit dieser Methoden hinsichtlich der Höhe der generierten Gutschriften für 84 Non-Annex-I Länder wird verglichen. Mit Bezug auf eine hypothetische Referenzperiode von 1990 bis 2000 und einer Verpflichtungsperiode von 2000 bis 2005 wird anhand von FAO-Daten aufgezeigt, welche Ländergruppen am meisten von jedem der vier Ansätze profitiert hätten. Diese Ländergruppen werden charakterisiert durch ökologische, ökonomische und soziale Indikatoren.

Der vorliegende Artikel zeigt die Höhe der Gut- bzw. Lastschriften auf, die entstanden wären, wäre ein REDD-System bereits eingeführt. Als Ergebnis lässt sich u.a. ableiten, dass Länder, die am meisten Gutschriften unter CR generiert hätten, gering entwickelte Länder (in Bezug auf HDI) sind, die einen großen Waldflächenanteil aufweisen. Länder, die am meisten Gutschriften durch CC generiert hätten, zeigen dagegen in jüngster Zeit einen Anstieg der Waldfläche.

Der vorgestellte Ansatz zeigt, welche Mitnahme-Effekte hätten berücksichtigt werden müssen, wäre ein REDD-System bereits eingeführt gewesen. Weiterhin zeigen die Ergebnisse, dass Ländergruppen, für die unterschiedliche Ansätze am vorteilhaftesten (in Bezug auf generierte Gutschriften) gewesen wären, Unterschiede in ihren Charakteristika aufweisen. Schließlich werden mögliche weitere Ziele eines REDD-Systems diskutiert, die nicht ausschließlich auf die Generierung von Gutschriften zielen.

Schlüsselwörter: REDD, Emissions-Referenz, Methoden

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1 Introduction

Approximately 60 % of carbon stocks in terrestrial ecosystems in vegetation and soil is stored in forest ecosystems (IPCC 2000; Streck et al, 2006). In past periods developing countries showed high losses of forest area (FAO 2005). Deforestation and degradation are responsible for 18 % of anthropogenic emissions worldwide (Stern et al, 2006).

Reducing Emissions from Deforestation and Degradation in developing countries (REDD) could thus have a large impact on emission reduction. REDD is not yet integrated in the present climate agreement, the Kyoto-Protocol. Several methodological aspects are still under discussion. However, the course is set for REDD to be integrated into a future climate framework. REDD was on the agenda at the 13th COP (2007, Bali). As COP 15 (2009, Copenhagen) failed to deliver a binding agreement, it will be discussed again in the proceeding 16th COP (2010, Cancún).

A REDD regime as it is discussed today will make those reductions of emissions accountable which are caused by deforestation and degradation. This needs a reference emission level (i.e., a 'baseline') to be set, against which actual emissions are contrasted.

Various methods for setting the reference emission level are discussed and negotiated internationally. These methods differ in various respects, e.g. manner of accounting, allocation of generated credits and the question of whether additional goals should be integrated (see Parker et al, 2009). At country level, different methods would produce different amounts of credits (and thus, benefits) for each respective country, and hence receive different acceptance (Friends of the Earth International 2008). Potential winners and losers of a REDD regime are discussed in the literature (da Fonseca et al, 2007; Friends of the Earth International 2008; Griscom et al, 2009), based on classifications of the countries. Griscom et al (2009) for example distinguish five classes of countries according to their forest cover and deforestation rate. Their results show that countries with high forest cover and low deforestation rate in the past would be disadvantaged by a reference emission level which refers only to the historical development of their forest cover.

Obviously, the question of whether a country will accept a proposed REDD scheme is dependent on the amount of credits generated by this scheme: under the assumption of economic rationality, a country will accept a potential REDD regime if this regime offers enough gains by generating credits, so that potential net benefits are achievable when protecting forest resources. Other requirements for a method of setting the reference emission level emerge from the parties' submissions to the UNFCCC (United Nations Framework Convention on Climate Change; see webpage, submissions by the parties). Summarizing these requirements, the method generally needs to be applicable in any participating country; its implementation should be possible with passable effort, and it should provide a reliable calculation. Furthermore the method would have to reflect different national circumstances in an equitable manner considering all relevant aspects, so that any participating country would face a potential for benefits, and thus commitment. Evidently, a further necessary condition is that the reference emission level is set in a manner which is effective, i.e. which actually reduces deforestation on global level. Otherwise it will fail this basic goal.

In this paper, four approaches for setting the reference emission level are analyzed with regard to their implications for individual countries. Historic data of FAO about forest area change was used. The objective is to outline which benefits would have resulted for the countries in case a REDD regime had been already established. Deducing country preferences in this manner is hypothetical in so far as the "reference period" as well as the "commitment period" have been in the past: the countries actually did not have any opportunity to react to incentives which might have been associated with a REDD rewarding scheme. Thus, any change in forest area or carbon stock observed in the past has obviously been motivated not by REDD credits, but by other reasons. As the approach reflects forest area gains or losses which indeed have occurred without any REDD regime, the results can be interpreted as identifying windfall effects (i.e. effects not generated additionally) which would have to be considered if a REDD scheme had already been established.[1]

2 Methods

Several baseline methods are discussed (see Parker et al, 2009). In this paper the focus is given on four approaches for establishing reference emission levels (Table 1).

The database used for all calculations is the Forest Resource Assessment (FRA) by FAO (FAO 2005), which offers country data about forest area and forest area change in the periods 1990 to 2000 and 2000 to 2005 as well as data about the countries' average aboveground carbon stocks in forests in the year 2005. It thus does not account for degradation. FRA data were used because of widespread availability for most of the countries in focus. However, since these data are not collected independently,

[1] This can help to avoid windfall gains. However, "non-additionality" needs not necessarily be interpreted as being unjustified. It can be a result of earlier efforts to improve the sustainability of forest management, or of other actions which support the goal of reducing deforestation.

but rely on information provided by the respective countries, their quality varies between countries. This should be kept in mind when interpreting results. The calculation of the reference emission level in this paper uses the first period (1990 to 2000) as "reference period", on the basis of which the reference emission level is calculated. Actual deforestation in the second period (2000 to 2005), set as the "commitment period", is contrasted against this reference. The resulting amount of credits or debits is interpreted as the country's resulting performance which would have occurred under REDD. It was calculated by converting FRA forest area data into carbon units, i.e. by multiplying forest area by the average aboveground carbon content in a country's forests in the year 2005.[2]

Table 1:
Characteristics of the investigated approaches for setting a reference emission level

Approach	Author	Key aspect
Compensated Reduction (CR)	Santilli et al. (2005)	Emission reduction relative to past development
Compensated Conservation (CC)	Submission of India (UNFCCC 2007a; UNFCCC 2007b)	Increase in absolute carbon stocks
Corridor Approach (CA)	Submission of Joanneum Research and others (UNFCCC 2006)	Reducing emissions below a corridor. The corridor depends on variation in emissions from deforestation and degradation in the reference period
Incentive Accounting (IA)	Mollicone et al. (2007)	Emission reduction in relation to a global reference

Creditable carbon was calculated for the last year of the "commitment period". This might not reflect actual emission avoidances during the whole "commitment period" but is in coherence with the Kyoto Protocol's accounting requirements. The aim of emission reduction in the Kyoto Protocol is to reach a 5 % reduction in 2012 as compared to the year 1990 (UNFCCC 1998). Likewise, in case there was first an increase in emissions during the "commitment period" which was reduced by the end of the relevant period, only the resulting stock in the end of the commitment period is relevant.

The description of the analyzed approaches uses the following variables:

[2] The reference emission level contrasted against actual deforestation in this paper bases on historical trends only, i.e. national circumstances are not considered in a special manner.

FA_{1990}, FA_{2000}, FA_{2005}	Forest area in 1990, 2000 and 2005, respectively [in ha]
C_{2005}	Carbon content in aboveground biomass in forests in the year 2005 [in tC/ha] (calculated by dividing aboveground carbon in forests in 2005 by forest area in 2005)
$cr_{90\text{-}00}$, $cr_{00\text{-}05}$	Forest area change rate in the periods 1990 to 2000 and 2000 to 2005, respectively [in % p.a.]
$ac_{90\text{-}00}$, $ac_{00\text{-}05}$	Annual change in forest area in the periods 1990 to 2000 and 2000 to 2005, respectively [in ha p.a.]
$gcr_{90\text{-}00}$	Global forest area change rate in the period 1990 to 2000 [in % p.a.] (average of the investigated countries, weighted by the countries' initial forest area in 1990)

Compensated Reduction (CR)

This approach was firstly brought to the international scene by Santili et al. (2005). It accounts for reducing the deforestation rate below a reference which refers to historical average national deforestation (see Parker et al, 2009). The resulting emission reduction would be creditable at the end of the commitment period.

In the present paper, the resulting credits (or debits) generated by CR are calculated by the difference between actual forest area in 2005 and the forest area which would result in a simple trend continuation of the first period's deforestation. The change in forest area in the period 2000 to 2005 is compared to this linear extrapolation according to the formula:

$$\Delta_{CR} = (FA_{2005} - \frac{FA_{2000} - FA_{1990}}{2} - FA_{2000}) * C_{2005} \quad 1$$

Compensated Conservation (CC)

The approach bases on a submission of India to UNFCCC in 2007 (UNFCCC 2007a; UNFCCC 2007b). An increase of the carbon stock is the key criterion. This increase is accountable subsequent to or at the end of a commitment period. Given a reference level set in an adequate period, this approach could easily integrate early actions which are undertaken prior to a commitment period.

For the scope of this paper, the reference level is set as the average forest area in the period 1990 to 2000. Forest area in the year 2005 is then compared to this reference, calculated by:

$$\Delta_{CC} = (FA_{2005} - \frac{FA_{1990} + FA_{2000}}{2}) * C_{2005} \quad 2$$

Corridor Approach (CA)

The Corridor Approach, developed by Joanneum Research and others (UNFCCC 2006), focuses on long-term emission reductions and generates a corridor using historic deforestation rates in a certain reference period as upper and lower corridor limit. The corridor serves as a buffer in order to sort out non-lasting reductions of deforestation. Creditable emission reductions within the corridor are either bankable until the country reaches the lower corridor limit (variant 1), or the creditable emissions will be reduced with a factor approximating 0 near the upper corridor limit and 1 near the lower limit (variant 2).

Originally, the upper and lower bound of the corridor is set according to past emissions during a reference period. This is not possible here, because FRA data deliver only one single average deforestation rate for the "reference period" 1990 to 2000. Therefore the corridor is set in this calculation at +/- 20 % of the average emissions during the "reference period" (like in Griscom et al, 2009).

$$\Delta_{CA} = (ac_{00-05} - ac_{90-00}) * C_{2005} \qquad 3$$

This approach is the only approach which considers average values of a country's forest area change across the reference period, which leads to a reduced amount of creditable carbon in the fixed year at the end of the commitment period in relation to the other approaches.

Incentive Accounting (IA)

The Incentive Accounting approach by the Joint Research Center (JRC) and others compares a country's national deforestation rate to a global reference (Mollicone et al, 2007). These authors propose half of the global deforestation rate as global reference. For countries whose deforestation rate is above this reference a different formula for baseline calculation is applied than for countries below this reference. Countries with high deforestation rates are rewarded for reducing their emissions, while countries with low deforestation rates are rewarded for maintaining their carbon stock (Parker et al, 2009; Skutsch et al, 2007). [3]

In this study, an average change rate of -0,455 % p.a. of forest areas in the assigned "reference period" was calculated for the countries (deforestation rate weighted by initial forest area in 1990). For calculation of the implication of IA an "allowed forest area" (for the year 2005, $FA_{2005,a}$) is deduced using the formulae below which are different for countries with high and low deforestation. $FA_{2005,a}$ is then compared to the actual forest area in 2005. $FA_{2005,a}$ and the resulting credits or debit for the countries are calculated with the following formulae:

$$\Delta_{IA} = (FA_{2005} - FA_{2005,a}) * C_{2005} \qquad 4$$

For countries with **low deforestation** (change rates above half of -0,455 % p.a.):

$$FA_{2005,a} = FA_{2000} * [1 + \frac{gcr_{90-00}}{2}]^5 \qquad 5$$

For countries with **high deforestation** (change rates below half of -0,455 % p.a.):

$$FA_{2005,a} = FA_{2000} * [1 + cr_{90-00}]^5 \qquad 6$$

Choice of most preferred alternative

The amount of credits (or debits) resulting from each of the approaches described above influences the approach's acceptability for a country. We distinguished two cases in order to predict which of the approaches would be chosen by an economically rational decision maker: In a first calculation variant, we asked, which of the alternatives CR, CC, CA, or IA would be preferable under the condition that REDD was mandatory. Under this condition the decision maker prefers the approach generating the highest amount of credits, if there is at least one approach resulting in credits; otherwise, he prefers the approach generating the lowest amount of debits. In a second calculation variant the possibility of not participating in a REDD regime was allowed for. Here a decision maker refuses participation in REDD if all accounting approaches lead to debits, and otherwise again chooses the approach generating most credits.[4] In order to avoid redundancies, we

[3] In the original approach the global reference represents a conversion rate, which refers e.g. to conversion of intact forest to non-intact forest or other land use. This would also support an integration of degradation (Mollicone et al, 2007). In this study, data about conversion rates was not available. The change rates were calculated as deforestation rates only.

[4] For simplicity, we assume that the REDD regime will also be chosen in the case of indifference (i.e. if the most preferable alternative produces neither credits nor debits).

omit CA and IA in the second variant, thus restricting the choice set to the alternatives CR, CC, and no participation.

In both calculations the countries were grouped by the approach which they preferred. The groups resulting from variant 2 were in a further step analyzed by ecological, economic and social indicators, using the data available from FRA and additionally, the World Bank (World Bank 2008) and UNDP (UNDP 2009). This step of the analysis is merely exploratory (i.e. it tries to detect relations between variables, rather than to explain them causally).

It is not yet decided at which countries the prospective REDD regime will finally be targeting. According to Parker et al. (2009) the focus is given to developing countries; in other cases, analyzes target at Non-Annex-I countries (Parker et al, 2009), whereas Griscom et al. (2009) calculate implications of different baseline approaches for tropical countries only. As there is no clear definition of the term 'developing countries', the present paper includes all those 84 Non-Annex-I countries for which data are available.

3 Results

Amount of credits and debits generated by the four approaches

Figure 1 shows the sums of creditable carbon resulting from each of the four baseline approaches. The respective sums of creditable carbon differ considerably between individual countries as well as between regions.[5] The highest effect concerning creditable carbon would have resulted under CC which shows either the highest amount of credits or the highest amount of debits in every region:[6] In seven out of nine regions negative values (i.e., net debits) would have been generated by CC; positive values (net credits) would only have been generated in East Asia and the Caribbean. Summarising across all regions, CC would have resulted in an overall 'loss', i.e. net debits of -6,072.74 Mt C.[7]

All three other baseline approaches sum up to positive values in the overall balance. The highest overall amount of credits would have been achieved by applying IA (638.75 Mt C), followed by CR (276.57 Mt C). CA has the weakest effect of all methods; it would have generated credits of only 54.84 Mt C.[8], [9]

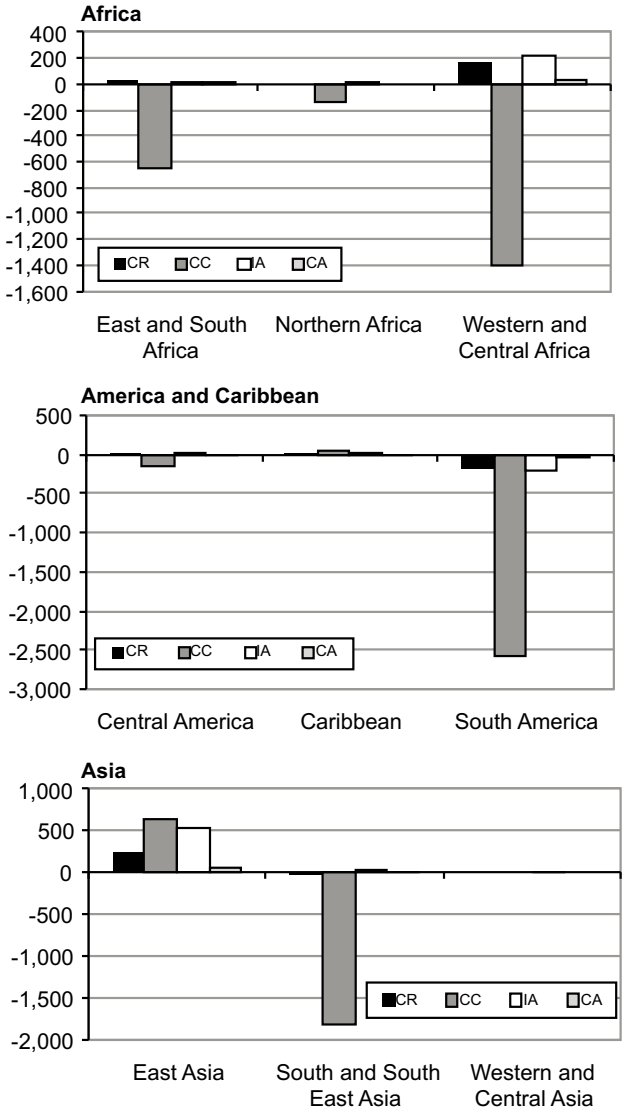

Figure 1:

Regional sums of creditable carbon (Mt C) generated by four baseline approaches (credits (+) and debits (-) generated by individual countries balanced on regional level; different scales on ordinates)[10]

[5] In Western and Central Asia, the amount of debits/credits generated under each of the approaches is so small that it is barely visible in Figure 1.

[6] These overall values represent regional aggregates, of the amount of creditable carbon which would have resulted for the individual countries.

[7] Note that these sums of creditable carbon refer to developments before 2005. Any changes in deforestation trends past 2005 are not considered.

[8] The lower amount of credits generated under CA might be caused by the use of average values for forest area change over the "commitment period". Due to the extrapolation of a historic trend in the other approaches, the highest / lowest value is resulting at the end of the "commitment period". Considering an average value for the whole period, this calculation causes an overestimation.

[9] In our calculation 27 countries could have accounted their emissions immediately (either credits or debits) while 57 countries did not cross a limit of the corridor set in the second period.

[10] European countries (Albania, Serbia & Montenegro, Republic of Moldova) are not displayed in the figure due to low amount of creditable carbon)

Comparing regional results, it turns out that there are regions in which every baseline approach would lead to a positive overall result (country group East Asia), and other regions in which all results are negative irrespective of the approach used (country group South America); but for most of the regions it depends on the baseline approach whether credits or debits are produced (e.g., in the group Western and Central Africa the differences are very substantial).

Figure 1 reveals regionally aggregated results. The results for single countries within these regions may differ, that is, even if the overall balance for a region results in credits, some countries within this region might have produced debits (for example, China would have been the only country in East Asia generating credits under CC, compensating for the debits of all other neighbouring countries). Since any country's participation in a future climate agreement will be decided by the country itself, it will be helpful to put focus on the country level if deducing which of the approaches might be most likely accepted by the countries.

Choice between the four alternative approaches only (Variant 1)

Under mandatory participation in REDD (variant 1), 20 countries would have chosen CR, 19 countries CC, and 17 countries each CA and IA, respectively (Table 2). For 11 countries CA and CR would have delivered the same results, implying that the respective countries would have been indifferent between these two approaches (in any case, the amount of credits in this group would have been very small; it sums up to only -0.205 Mt C).

Regarding involved forest area, countries which would have generated most credits by CA account for about 38 % of the total forest area of the investigated countries. The highest amount of carbon credits would have been achieved by choosing CC. 19 countries would have generated most credits by CC. These countries cover in total about 17 % of the forest area.

Table 2:

Number of countries and their generated credit (+) or debit (-) by their individually preferable baseline approach (the column CR / CA refers to indifference between the approaches CR and CA due to similar amounts of credits / debits)[1]

County group		preferable approach					
		CR	**CC**	**IA**	**CA**	**CR / CA indifference**	**Total**
Africa	Number of countries	10	7	8	7	9	41
	Forest area in 2005 (T ha, sum)	94,915	4,976	293,746	53,850	162,991	610,478
	Creditable carbon (Mt C)	42.23	31.13	260.76	-0.02	-0.20	-
America	Number of countries	4	2	3	3	1	13
	Forest area in 2005 (T ha, sum)	66,546	18,834	65,361	510,824	3,938	665,503
	Creditable carbon (Mt C)	21.92	103.51	49.00	-34.05	0.00	-
Asia	Number of countries	6	9	4	7	1	27
	Forest area in 2005 (T ha, sum)	73,979	285,903	26,154	124,821	867	511,724
	Creditable carbon (Mt C)	89.19	948.92	2.85	-15.86	-0.00	-
Europe	Number of countries	0	1	2	0	0	3
	Forest area in 2005 (T ha, sum)	0	2,694	1,123	0	0	3,817
	Creditable carbon (Mt C)	0	4.04	2.04	0	0	-
Total	Number of countries	20	19	17	17	11	84
	forest area in 2005 (T ha, sum)	235,440	312,407	386,384	689,495	167,796	1,791,522
	creditable carbon (Mt C)	153.34	1,087.61	314.65	-49.93	-0.20	-

[1] The three European countries are Albania, Serbia & Montenegro and Republic of Moldova

The preferences over the approaches are spread amongst the countries or regions. In Europe, CC and IA offer best results for all three European Non-Annex-I countries, but in the other continents every approach would have been preferred by at least one country. In the investigated African countries CR would have received broadest support, while CC would have been favoured in Asian countries. Across all continents, IA would have received the broadest support in Africa.

Including the option of not participating in REDD (Variant 2)

Table 2 has demonstrated that there is no clear favourite approach for all countries or across all continents if the participation in REDD is mandatory. In a next step, it has to be examined whether this result changes if countries were allowed not to apply the REDD scheme in case all of the alternative baseline approaches produce debits (variant 2). To simplify matters, the recalculation has been restricted to the three choices CR, CC, and no participation in REDD. The analysis focuses on the approaches CR and CC because these are the approaches with the most opposite method for calculation. Results show that again no unequivocal favourite emerges: only half of the 84 countries would prefer CR under these conditions, the other half is spread almost evenly between a preference for CC and the 'no participation'-option (Table 3, top).

Relations between preferred baseline option and country characteristics

In a next step, criteria which might indicate support or refusal of an approach by a given country need to be identified. For this purpose, different indicators concerning economic, ecological and social characteristics were analyzed in order to group the countries with same preference in classes. [11]

Indicators related to forest area

A relevant difference between the three options becomes visible in the forest area change rate. This is not surprising, as the continuation of past trends indicates the preferable approach. But the differences in forest area change were clearly distinct only in the "commitment period", which is responsible for the generation of credits. The average forest area change rate was negative for both of the country groups CR and "no participation" but the first is much smaller (i.e. less negative). It can be concluded, that countries with historically high deforestation would not have considered a participation as beneficial, while for countries with less (but still existing) deforestation a participation in REDD could have been beneficial (Table 3).

Table 3:

Indicators for country groupings by preference of approach for calculating the reference emission level in variant 2 (i.e. choice between CR, CC and no participation); grouped by preferences; displayed are unweighted means

	Preference CR	Preference CC	both negative, no participation	Total
number of countries	42	23	19	84
Forest area (T ha; sum)	839,960	327,915	623,647	1,791,522
Forest area change rate 1990 to 2000 (% p.a.) "**reference period**"	-0.91	1.15	-1.16	-0.40
Forest area change rate 2000 to 2005 (% p.a.) "**commitment period**"	-0.80	1.05	-1.57	-0.47
Forest cover 2005 (% of total surface)	35.4 %	18.9 %	24.2 %	28.4 %
Forest area per capita 2005 (ha / person)	1.4	0.4	1.9	1.2
HDI 2005	0.577	0.696	0.649	0.627
Agriculture value added 2005 (% of GDP)	24.0	17.4	20.2	21.3
CR creditable carbon (sum; Mt C)	307.09	219.09	-249.62	276.57
CC creditable carbon (sum; Mt C)	-4,249.97	1,111.17	-2,933.94	-6,072.74

[11] The differences between the groups' average values of the indicators were tested in an analysis of variance. As the 84 Non-Annex-I countries in this calculation do not represent a probability sample, no significances are displayed. Instead, differences with a relevant effect size are mentioned and discussed.

Likewise there were clear differences in average forest cover (as a percentage of a county's total surface) between the countries preferring CC and CR. According to Table 3, the CR group's average forest cover is almost twice as large as that of the CC group. Regarding forest area per capita, the average values of the country groups show relevant differences, mainly due to clear differences between the CR and CC group. The group preferring CC is characterized by the lowest average forest area per capita.

Relative size of agricultural sector

The contribution of agriculture sector to Gross Domestic Product (GDP) to a country gives information about the country's dependence on its agriculture sector[12]. Countries which would have generated most credits by CR are characterised by a high contribution of their agricultural sector to GDP. As the average forest area change rate of the CR group is negative in both periods, the countries have a net deforestation. Thus they would have generated credits mainly because of the reduction of their deforestation rate (note that in this case still negative change rates can result). These countries with strong dependency on the agriculture sector could profit from participation in REDD. Also with negative forest area change rates credits could have been generated if choosing the adequate approach.

Human Development Index

Deforestation is considered as being correlated to human development constraints, so the Human Development Index (HDI) could be used to account for deforestation, albeit in an ambiguous way (Jha et al, 2006). In the present study it was also found that a relevant difference between the country groups exists with regard to their average Human Development Index (HDI)[13]. The lowest HDI results for the countries which would have generated most credits by CR (average of 0.577). The highest average HDI resulted for the group which would have preferred CC. The clearest differences between average HDIs resulted from the difference between the CC and the CR group. Comparing average HDIs it could be deduced, that the less developed countries are not necessarily the losers of a REDD regime (Table 3). Thus other indicators seem to have more importance for concluding whether it is advantageous to participate or not, but HDI could be interpreted as indicating which approach would have generated most credits.

Implications of the changes in deforestation rates between "reference period" and "commitment period" on the grouping

If the reference level is constructed simply by extrapolating historic development, the countries could behave strategically during the reference period to get a better starting position, thus benefiting from a facilitated generation of credits during the commitment period. This would lead to perverse incentives if focussing exclusively on the performance during the reference period. High deforestation rates in the reference period would then enhance the generation of credits more easily during the commitment period.

To identify magnitudes of perverse incentives which would have resulted in past periods, the simple historic forest area development of the countries was analyzed in order to compare CC and CR (as the major opposite approaches for accounting). In CR, the more a country's forest area declines in the reference period, the easier for the country to achieve credits during the commitment period. Countries with reduced, but still existing net deforestation would have profited (e.g. Madagascar, Figure 2), while countries with a reduced, but still existing increase in forest area during the second period would generate a debit and thus would not benefit of such a way of accounting (e.g. Algeria, Figure 2). In CC the inverse effect would be given: increases reached during the commitment period could buffer reductions in the reference period, still resulting in an overall gain (or vice versa). In this context, CC accounts for long term reductions or increases in emissions (remember that in our calculation the reference emission level is fixed already in the middle of the reference period). Higher absolute losses during the reference period require higher efforts during the commitment period just to result to zero.

As analyzed above, the incentives a REDD scheme may offer to a country by its reference emission level approach differ according to a country's forest area change. But credits are not generated only because of change rates during the commitment period. As an example, in CR less negative changes during the commitment period than during the reference period could generate gains. Regarding forest area change, a relevant difference was found in the second period between the three country groups preferring CR, CC, and no participation, but there were no relevant differences regarding the performance of the for-

[12] The indicator agriculture, value added includes cultivation of crops and livestock production as well as forestry, hunting and fishing.

[13] The Human Development Index (HDI) is a combined indicator composed by a country's GDP per capita measured in purchasing power parity (PPP), life expectancy at birth, and literacy rates (adult literacy and combined primary, secondary and tertiary gross enrolment ratio). It assumes values between 0 and 1 and has no unit (UNDP 2009).

est area change rate.[14] As the average forest area change rate of the countries preferring CR is negative, most of the countries would profit in this approach by a reduction of deforestation rates compared to the reference period. Once forest area change rates are positive, this incentive could change, as still an increasing forest area is necessary for constant benefit in CR. The change rates in the "commitment period" are lower than in the "reference period" in both country groups which would prefer either CC or "no participation", but for the latter group the change rates are negative in both periods, while for the CC group they are positive in both periods (Table 3). The countries which would prefer CR show on average negative change rates in both periods, but a reduced rate in the "commitment period".

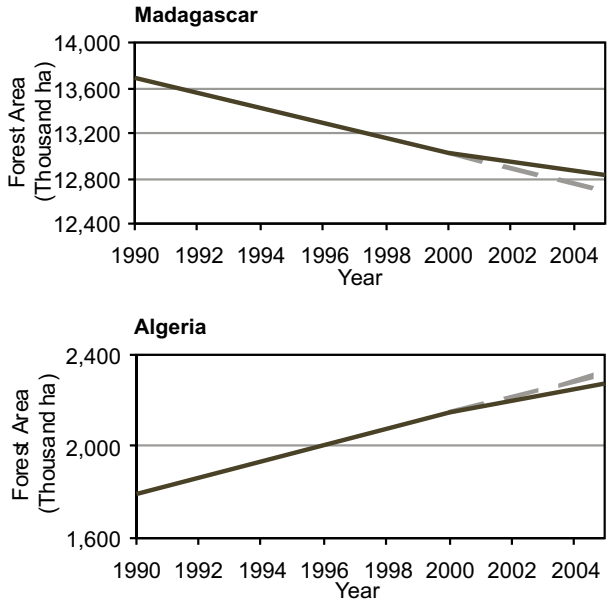

Figure 2:

Development of forest area in past periods in Madagascar (above) and Algeria (below). The continuous line represents actual forest area, the dashed line represents strict continuation of past development (the situation displayed represents the approach CR). In Madagascar credits would result in spite of continuous deforestation; in Algeria debits would result in spite of continuous increase of forest area (data source: FAO (FAO 2005))

Summing up, Table 3 shows that countries which would prefer CR are, on average, less developed countries and show higher forest cover. Countries which would prefer CC are comparatively higher developed (as measured by HDI) and have a lower forest cover. This country group has on average shown an increase in forest area during the "commitment period" (about 1 % p.a. on average). The countries which would not have benefited in a participation in a CC or CR REDD scheme still have a high forest area per capita, and had an average forest area change rate of -1.57 % p.a. during the "commitment period".

A country's forest cover would not have been relevant for the decision whether to participate in REDD or not, but it would have been relevant for the choice between CR and CC. As a general tendency, countries with lower forest cover would have favoured CC. Countries with a negative change rate in forest area would not necessarily decide against participating in REDD, but countries which would have favoured CC have higher change rates (which were zero or positive in every investigated country preferring CC). Countries which would not have generated credits in a CC or CR REDD scheme have a high forest area per capita and high deforestation rates. Regarding the group's average HDI, they are not necessarily amongst the least developed countries.

Preferences for any of the analyzed alternatives may change over time, according to the development of a country's deforestation rate. For example, a reduced but still negative change rate in the commitment period could lead to a preference for CR. Constant reduction of deforestation could lead to a shift and an increase in forest area. It could be likely, that once a constant increase of forest area is achieved, the preference would shift in favour of CC. This assumption is in coherence with the positive change rates in forest area of the countries which would prefer CC (see Table 3).

4 Discussion

In this paper, implications of different approaches for setting a reference emission level were calculated by using data of historic periods. The period 1990 to 2000 was set as the hypothetical "reference period". This "reference period" was used for the calculation of the reference emission level, which thus bases on historical development only. The following "commitment period", set from 2000–2005, gives information about actual country performance, which is contrasted against the reference. Thus the amount of credits or debits could be calculated which would have resulted if a REDD regime had already been established. Under the continuation of the given conditions, the differences in creditable carbon for the countries would result in different preferences towards each of the four baseline approaches which are analyzed here (Compensated Reduction (CR), Compensated Conservation (CC), Incentive Accounting (IA) and the Corridor Approach (CA)). Applied to 84 Non-Annex-I countries, credits would have been generated which would amount to 276.57 Mt C

[14] The differences were tested in an analysis with repeated measures. The groups were defined by their respective preference for setting the reference emission level, with forest area change rates in the "reference period" and "commitment period" as repeated measures. This analysis of repeated measures showed no relevant differences in forest area change rates.

under CR, 638.75 Mt C under IA, and 54.84 Mt C under CA. CC is the only approach resulting in an overall debit; this debit amounts to -6,072.74 Mt C.

These values are "hypothetical" in so far as the "reference period" as well as the "commitment period" have been in the past; no REDD regime has been established yet, and hence the countries have not had any incentive to adapt their deforestation behaviour in the "commitment period". In case a REDD regime will be established in the future, the countries might perform differently, as compared to what was observable in past. Some implications have to be discussed.

Windfall effects

The present analysis implies that the development of a county's forest area might have generated credits without any additional efforts directly motivated by REDD. Likewise, it is probable that during a REDD regime forest area change rates will be changing due to various reasons. If a positive forest area change rate continues in future periods during an established REDD regime, the additionality of such reductions might be challenged, and the resulting credits might be interpreted as some kind of "windfall gain". On the one hand, there is a severe menace of rewarding reductions which result from business as usual without any additional reduction efforts. Even if the deforestation rate is slowing down, this could be caused simply by diminishing forest resources (e.g. due to high deforestation rates in the past); also in this case a rewarding would generate windfall gains. A possible countermeasure could be the integration of an "anticipated deforestation rate" in the reference emission level (Karsenty 2008). National circumstances could then be considered in a more prominent manner. However, it is likely that windfall effects will to some extend continue in an established REDD regime.

On the other hand, some caution is advisable when identifying ostensible windfall effects, since a country might just have anticipated a future REDD regime ("early action"), or it may have introduced general measures against deforestation even without any reference to a possible future REDD regime. After all, it is even questionable whether "windfall gains" are really so much of a problem. They could cause at least incentives to maintain the status quo of forest conservation.

Preference of baseline approaches

As mentioned above, a reference emission level needs to meet certain requirements like applicability in any participating country, or the consideration of national circumstances in an equitable manner. It may be very difficult to determine a reference emission level that is able to cope with as many of those aspects as possible, and which is accepted by as many parties as possible. Using a consistent method for determining the reference emission level would treat any participating country equally. But for countries with a stronger bargaining position the arguments and commitments may be set and treated with more emphasis (see Noordwijk et al, 2008, for the case of Indonesia). The approaches discussed offer prospects and incentives for the countries to reduce emissions from deforestation and degradation. For countries generating mainly debits, further incentives could be necessary in case their participation is desired during the first commitment period in REDD (e.g. a banking system could enhance a broader participation for REDD). For future commitment periods, the aspects accountable for REDD need to be defined more clearly. As outlined above, preferences may change over time as some facets get more importance.

Incentives to participate in a future REDD scheme could be increased by an option to change the accounting approach in later commitment periods (this would refer to an idea of a moving baseline, which is set periodically for every commitment period). As an example, according to Table 3 many countries with a negative forest area change rate might want to choose CR during the first commitment periods, but change the accounting method once their forest area change rate has reached a certain level. If a change option was permitted, a REDD scheme could be attractive for more countries already from the beginning. On the other hand, the option of changing the calculation approach introduces a further possibility for behaving strategically. Thus it could enhance the generation of "hot air".

Specific objective of REDD

As REDD is a highly discussed political matter, the specific objective of REDD has more than one facet. In this paper, the advantageousness of any approach was implicitly defined just by the number of credits it generates. However, in the political sphere there are additional goals connected to REDD: Beyond focussing on carbon emissions or carbon stocks, issues like the protection of biodiversity in forests or the support of development goals play a significant role.

Even if the reduction of emissions was the only objective, it might be necessary to take the development of the carbon content in the forests more specifically into account. This would include an assessment of degradation as well as a provision for the problem of carbon stocked in plantations, since a possible change of natural forests into plantations could show adverse effects if plantations have lower carbon stock and / or lower carbon sequestration than natural forests they displace. In this case, the coexis-

tence of measures of accounting carbon sinks would need a closer look, in order to avoid a double accounting of afforestation / reforestation in CDM and in REDD. Moreover, if saving natural forests from deforestation and biodiversity aspects are important ancillary intentions of REDD, an accounting only on the basis of carbon stocks and stock changes might be problematic, since this would not differentiate between carbon stored in (existing) plantations and carbon stored in natural forests. Thus extra incentives might be necessary for protecting natural forests.

A focus on development assistance goals by implementing a REDD regime requires fostering the aspect of technology transfer and capacity building. On the one hand, transfers of knowledge and money associated with a REDD regime might directly support the establishment of sustainable forest management systems. On the other hand, money transfers for forest preservation may put forest resources into value, and thus strengthen the incentives for afforestation and forest preservation.

Data sources

Carbon accounting in the scope of UNFCCC is based on data reported in the National Communications. Only a few countries of those with high deforestation rates have communications for repeated periods, so data availability is low (see UNFCCC website[15]; cf. Karousakis et al (2007)). The quality of reported data could represent a weak point for a REDD regime anyway if countries can later renegotiate their commitments for the next period, in case they are in menace to fail their commitments (like mentioned by Hansjürgens (2009) as a general weakness of the existing climate agreement). So debits could be banked tacitly. [16]

Moreover, a major challenge for REDD will be the integration of degradation as the second "D" within "REDD". Including degradation may pose a different situation for the countries (see Noordwijk et al, 2008) and thus may cause a shift in the amount of credits which would have been generated by any approach. This is not the main topic of this paper, but as the data about forest area and forest area change used in this paper refer to deforestation only, an inclusion of degradation might lead to different results concerning the preferable method for the reference emission level.

[15] UNFCCC web page; National communications : http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

[16] Furthermore, the reliability of FAO data, which are used in the present paper is questioned (e.g. see Matthews 2001). In addition to that, FAO data about forest area includes plantations (according to country specific definitions). Newly established plantations or an increase of forest area are not discussed as being in the focus of REDD. Applying the approaches for reference emission levels to more reliable data (if available) could change the amount of generated credits and thus the grouping.

5 Conclusion

The approach presented in this paper shows the magnitude of credits or debits which would have been generated if a REDD scheme was already established. It can also be interpreted as showing potential windfall effects (which may be the result of early actions in a different interpretation) which could have resulted without additionality to what would have happened anyway, as every past change in forest area cannot have been motivated by REDD because the scheme has not yet been existing. If additionality is considered as a crucial element in REDD, reference emission levels would have to be set in a manner that such windfall gains are avoided. On the other hand, the necessity of avoiding windfall gains may be questioned. In case windfall gains do not need to be subtracted, the less direct connection to the recent country trends in forest area change rates could provide an option to valuate forest resources in Non-Annex-I countries. In this manner of accounting, a possibility would be given to reward early actions. Furthermore this accounting approach could offer an option to combine the REDD objectives of reducing emissions from deforestation and degradation with development goals by supporting Non-Annex-I countries. Incentives could be given in this way by benefit transfer as well as by capacity building for a valuation of the forest resources and keeping this value.

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