Climatic Change (2013) 119:269–275
DOI 10.1007/s10584-013-0780-x

SPRINGBOARD COMMENTARY

Implementing conservativeness in REDD+ is realistic and useful to address the most uncertain estimates

Giacomo Grassi · Sandro Federici · Frédéric Achard

Received: 10 October 2012 / Accepted: 24 April 2013 / Published online: 25 May 2013

One of the main challenges in reducing emissions from deforestation and forest degradation (REDD+), either within a future UNFCCC approach or as part of other voluntary initiatives, is to design a system which is credible and broadly implementable by developing countries. To ensure credibility of REDD+ high quality monitoring systems are needed, i.e. capable of producing accurate estimates of greenhouse gas (GHG) emissions and removals. However, a possible trade-off exists between the high quality system requirement and broad participation: if a significant number of countries will not fully access REDD+ because of not being able to produce accurate estimates, the consequent risk of leakage (i.e. emissions displacement to these countries) could undermine the ultimate scope of REDD+.

Plugge et al. (2012) analyzed the implications of applying the principle of conservativeness in the context of uncertainties of carbon stock change estimates in REDD+. While this principle is included in several UNFCCC documents (e.g., UNFCCC 2006), its application to REDD+ was proposed by Grassi et al. (2008) "to address the potential incompleteness and high uncertainties of REDD+ estimates"; i.e. "when completeness or accuracy of estimates cannot be achieved the reduction of emissions should not be overestimated, or at least the risk of overestimation should be reduced". Wide interest has been shown in this proposal (e.g., GOFC-GOLD 2012; Herold & Skutsch 2011; Meridian Institute 2011).

A key message from Plugge et al. (2012) is that, despite its attractiveness, the conservativeness principle does not appear to be implementable in many cases, because it drastically reduces the amount of emission reductions that can be claimed (e.g. "for countries with low deforestation rates REDD is obviously not an option for generating benefits, as they would need to implement monitoring systems that are able to estimate carbon stock changes with a total error well below 1 %"). Similar conclusions, using a similar approach, were also presented in Köhl et al. (2009).

We believe that this conclusion: on the impossibility for countries with low deforestation rates to generate REDD+ benefits under a conservative approach, is the consequence of the assumptions taken by these authors. In particular, some elements appear to have been overlooked by Plugge et al. (2012).

G. Grassi (✉) · S. Federici · F. Achard
European Commission, Joint Research Centre, Institute for Environment and Sustainability,
Via E. Fermi 2749, 21027 Ispra, VA, Italy
e-mail: giacomo.grassi@jrc.ec.europa.eu

Firstly, one of the underlying basic ideas beyond REDD+ is to incentivize actions (i.e. emission reductions) beyond "business-as-usual". According to this approach, future net emissions from REDD+ should be compared against an agreed "baseline",[1] which typically describes the expected business-as-usual net emissions. While in many cases it can be expected that this baseline will be equal to or lower than historical emission levels, in some cases (i.e. countries with low historical deforestation rates) the baseline could potentially include the expectation of increased emissions as compared to the past. Baseline-like concepts have been discussed both within UNFCCC (i.e. "reference levels", RL, and "reference emissions levels", REL) (UNFCCC 2012) and within several REDD+ initiatives. Thus, the possibility of countries with low deforestation rates to generate REDD+ benefits will largely depend on the criteria used to set their baselines.

Secondly, Plugge et al. did not consider other and potentially more effective approaches to implement the conservativeness principle in REDD+ (e.g. Grassi et al. 2008). Even more importantly, some very simple conservative approaches have already been implemented by REDD+ initiatives, such as the Amazon fund,[2] demonstrating the feasibility and the utility of this principle.

This comment aims to:

- Highlight the technical and scientific differences between the approaches of Plugge et al. (2012) and Grassi et al. (2008) for the implementation of the conservativeness principle.
- Summarize and further discuss a scientifically defensible yet realistic approach to implement conservativeness in REDD+ context.

1 Different approaches to implementing convervativeness lead to different conclusions

The different possible approaches for implementing the principle of conservativeness in REDD+ include the following:

1) The "Reliable Minimum Estimate" (RME), i.e. approach A2 in Grassi et al. (2008) and the approach used by Plugge et al. (2012). This approach has been suggested by the IPCC (2003) in the context of assessing changes in soil carbon. In practice, the changes in the carbon content between two temporally-separated sample pools are quantified by comparing the difference between the lower limit of the confidence interval of the first temporal sample and the higher limit of the confidence interval of the second temporal sample.[3] This approach ignores possible correlation among errors. The red dotted lines

[1] In the context of this paper, a "baseline" is defined as a level of net emissions from REDD+ against which future net emission will be compared for accounting purposes. Note that the same approach has been implemented for Annex 1 countries with the "forest management reference level" concept, to be applied to the second commitment period (2013–2020) of the Kyoto Protocol (Grassi et al. 2012).

[2] According to the Amazon Fund (2011), the calculation of the values of carbon emission reductions from deforestation is equal to (average historical deforestation rate) – (annual deforestation rate), multiplied by the amount of carbon in the biomass. The Amazon Fund adopts a value of 100 tC/ha of biomass, a *conservative* value in relation to data found in the literature (between 130 and 320 tC/ha), but adequate for simplifying the calculations and the understanding of the proposed mechanism.

[3] It is worth noting that the IPCC discusses the RME only for those conditions where samples/plots cannot undergo repeated measurements over time (like destructive soil samples), i.e. where no correlation of errors over time can be expected, and highlight that this suggestion is "in contrast with the procedure indicated for forests" where "repeated measurement can be done on basically the same components".

in the figure within the box show the application of this approach to carbon stock changes.

2) The "trend uncertainty" approach (approach B1 in Grassi et al. 2008). The trend uncertainty represents the uncertainty of the difference of net emissions over time, or in the case of REDD+ it may represent *the difference between actual net emissions* (*in the accounting period*) *and a previously agreed baseline*. Given that an estimate of net emission is the result of an Activity Data (AD, e.g. deforested area) multiplied by the relevant Emission Factor (EF, e.g. loss of carbon per unit of deforested area), the uncertainty of the trend is extremely dependent on whether or not the errors of AD and EF are correlated between the baseline and the accounting period. The basic assumption of IPCC (2003) is that errors of AD are not correlated and errors of EF are fully correlated. A full correlation of errors over time is like saying that, if one measures the diameter of the same tree over time with a biased caliper, the percentage error of the estimate will remain the same. The green dotted lines in the figure within the box show the application of this approach to carbon stock changes, assuming full correlation of EF errors over time. However, it should be noted that the assumption of correlation of EF errors may not always be true; e.g. when a forest inventory is implemented (i.e. a tier 2 or 3 method), EFs are often not fully correlated.

Based on a series of simulations, Grassi et al. (2008) concluded that, by using the RME approach, no or very limited reductions of emissions from deforestation could be conservatively demonstrated, unless a large reduction of deforestation occurred (as compared to a baseline) and uncertainties are low. On the contrary, with the uncertainty of the trend approach, and when full correlation of EF errors may be assumed, conservative reductions of emissions can be demonstrated also with relatively small reductions of deforestation (as compared to a baseline) or with relatively high uncertainties.

Plugge et al. (2012) correctly reiterate the difficulty of implementing the conservativeness concept through the RME approach, but do not consider the uncertainty of the trend and the associated analysis of correlation among errors.

Furthermore, while Grassi et al. (2008) presents different degrees of possible "conservative discounts", based on 50 % and 95 % confidence intervals,[4] Plugge et al. (2012) only focus on the 95 % confidence interval.

Thus, the conclusions of the two papers differ essentially because a unique approach ('RME with 95 % confidence interval') is used in Plugge et al. (2012), while a set of different approaches were compared by Grassi et al. (2008).

2 A realistic and robust approach to implement conservativeness in REDD+ context

Grassi et al. (2008) highlighted the need for further tests on the assumptions and possible refinements to the implementation of the conservativeness principle. Furthermore, the modality of application of this concept was left quite open, i.e.:

[4] The 50 % confidence interval is used when the conservativeness concept is applied in the adjustment procedure during the review of GHG inventories under the Kyoto Protocol (see Grassi et al. 2008 for more details). Given this important precedent, and given that using the 95 % confidence interval may result in overly conservative estimates, we consider the 50 % confidence interval useful when discussing the conservativeness in the REDD+ context.

– Should conservativeness be applied in all circumstances, and to all types of estimates?
– Should uncertainty be taken into account in implementing conservativeness? If yes, which value of uncertainty and which confidence interval should be used?

Below we address these questions, summarizing and further discussing several refinements to the implementation of the conservativeness principle, partly already presented in Bucki et al. (2012).

Firstly, we propose to restrict the possible application of the conservativeness principle to those estimates of emission reductions which do not fully comply with IPCC methodological guidance in terms of completeness or accuracy of the estimates. Here we focus on the accuracy of the EF, e.g. when tier 1 values of carbon stock per unit of deforested area are used for a "key category".[5] The rationale behind this approach is that tier-1 estimates are assumed to have inherently larger uncertainties than tier 2 or 3 estimates; i.e. while tier-1 cannot *a priori* be assumed bias, due to larger uncertainties the risk of overestimating significantly emission reductions (thus the risk of receiving significant credits not associated to real emission reductions), is expected to be higher.[6] Treating equally estimates which fulfill IPCC guidance and those that do not would be unfair. This approach is fully in line with the spirit of the current UNFCCC guidance on reporting, reviewing and accounting GHG inventories of Annex 1 countries.[7] A review team may "adjust" the estimate of an Annex 1 country (through the application of a conservative factor) only if the GHG inventory does not follow the IPCC guidance. Similarly, we believe that if a REDD+ country uses adequate methods to estimate emissions there is no reason to apply conservative discounts. In practice, conservativeness could be applied to those countries having the capacity to assess AD (changes in forest area) following IPCC guidance, but without a proper forest inventory to estimate country-specific EFs (carbon stocks per unit of deforested area). In that case, the use of tier-1 EFs could be the only option for the country to estimate REDD+ emissions. Given the relatively good access to remote sensing data for estimating forest area changes, and the very limited number of countries which are already prepared to apply tier 2 or 3 methods for carbon stocks (Romijn et al. 2012), we believe that our approach could be of interest in a large number of cases.

Secondly, we believe that uncertainty should somehow be taken into account for implementing conservativeness in a scientifically robust way. Various sources of uncertainty may be recognized in the REDD+ context (e.g. see Pelletier et al. 2012). For the scope of this comment, we note that the conservative correction of tier-1 values could be easily implementable using the uncertainties provided by the IPCC for each tier-1 value, and using the 50 % confidence interval. The rationale behind this approach is to be consistent with the procedure already used in the context of Kyoto Protocol review process (see UNFCCC 2006 and the conservative factors therein). As compared to the current review and accounting

[5] According to IPCC (2003, 2006), tiers express the level of methodological complexity and accuracy of estimates (tier 1 uses default IPCC parameters for carbon stocks, disaggregated by broad forest and soil types, while tier 3 uses country-specific and highly disaggregated values of carbon stocks). Key categories are the most important categories in the overall country GHG budget, and it is good practice to estimate them with tier 2 or 3 methods (taking into account national circumstances). In the REDD+context, emissions from deforestation are very likely to be always key categories.

[6] Although the assumption of tier 1 being more uncertain may be considered generally valid, this assumption needs to be checked in each specific case. If tier 1 can be shown to be already conservative (e.g. see the case of Panama described by Pelletier et al. 2012), no further conservative discount would be justifiable.

[7] In UNFCCC context, reporting refers to the inclusion of GHG estimates in a national GHG inventory. Methods used should follow IPCC guidance. Then, these estimates are reviewed by a team of international experts. After passing the review, the estimates can be used in accounting, i.e. to calculate the contribution toward a target (e.g. emissions from deforestation relative to an agreed baseline).

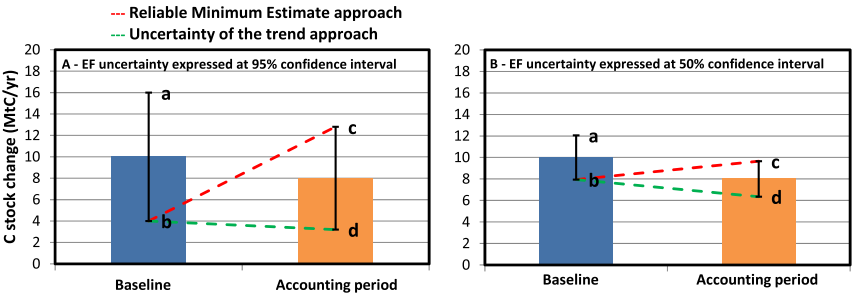
rules, a novelty of our approach is noting that, when the same EFs are used both in the baseline and in the accounting period, a full correlation of errors always occurs. Under this specific condition, the trend uncertainty approach can be implemented with a lot of advantages as compared to the RME approach (see the example in the box).

Example of conservativeness applied to a REDD+ country-case

A country aims to prepare estimates for a REDD+ "baseline" (i.e. a level of net emissions from REDD+ against which future net emissions will be compared for accounting purposes). This country assumes the historical emissions for the period 2005-2010 as baseline. The future accounting period will be 2015-2020. The emissions from deforestation in this country are "key categories" and should be estimated with tier 2 or 3 methods, according to IPCC guidance. The country has the capacity to assess AD (activity data, i.e. changes in forest area) following IPCC guidance, but does not yet have a proper forest inventory to estimate country-specific EFs (emission factors; i.e. carbon stocks per unit of deforested area). The only possibility for estimating emissions in the baseline is to multiply the measured AD (2005-2010) by the IPCC tier-1 EFs, disaggregated by broad forest types.

Let us assume the following numbers:

- AD: 100 kha/yr in 2005-2010 (historical period used for the baseline) and 80 kha/yr 2015-2020 (accounting period).
- EF: 100 t C/ha (assumed from IPCC tier-1). This value is assumed constant in the baseline and the accounting period. The uncertainty of this EF is assumed to be 60% when expressed at the 95% confidence interval (CI, i.e. the interval within which there is a 95% chance to find the true value) and about 20% when expressed at the 50% CI.
- C stock changes (AD x EF): 10 MtC/yr in the baseline, 8 MtC/yr in the accounting period.



The figure shows the values of C stock changes (and the corresponding uncertainties) for the country-case above. In the absence of any conservative discount, the country could claim 2 MtC/yr of credits (i.e. emissions in the baselines minus emissions in the accounting period). However, given that a very uncertain tier-1 EF was used, the credibility of such claim could be questioned. Therefore, the country could consider two possible approaches to implement the conservativeness principle, at two difference levels of CIs (95% and 50%):

- The Reliable Minimum Estimate (RME), which compares the difference between the lower limit of the confidence interval of the baseline and the higher limit of the confidence interval of the accounting period (b-c. This approach ignores possible correlation among errors.
- The uncertainty of the trend (b-d), which considers the fact that the errors of the EFs are fully correlated between the baseline and the accounting period.

From the figure it is clear that, under the conditions of the example, the RME would never allow for credits. On the contrary, since full correlation of EF may be assumed, the uncertainty of the trend approach would allow the country to claim 1.6 MtC/yr of credits with the 50% CI. Note that the same result would be obtained by multiplying 80 tC/ha (the lower limit of the 50% CI of the EF) by 20 kha/yr (the difference of deforestation rate between the baseline and the accounting period). Thus credits would be discounted by 20%, but their credibility would be increased, because a scientifically defensible approach (similar to that implemented in the Kyoto Protocol review process) has been applied to reduce the risk of overestimating the emission reduction.

It is worth noting that our approach to implement conservativeness is potentially implementable both in the context of a future UNFCCC REDD+ approach and within other REDD+ initiatives. Our approach is entirely consistent with the logic behind simpler approaches, such as that applied by the Amazon fund. The difference is that we propose the theoretical background of a more elaborated approach, where in the absence of a country-specific and detailed forest inventory it may be possible to use highly uncertain

tier-1 IPCC carbon stock values (disaggregated by forest type) in combination with a conservative discount to reduce the risk of overestimation of emission reductions. This approach, which builds on Grassi et al. (2008) proposal, is similar to what Bucki et al. (2012) tested in a case-study and to what Norway proposed in its submission to UNFCCC (Norway 2012, p.8). The added value of our approach lies in its defensibility (i.e. the conservative discount is based on IPCC uncertainty values) and in the consistency with the spirit of UNFCCC review and accounting rules. As shown by the example in the box, this approach can allow a country to claim emission reduction credits even when relatively small reductions of deforestation occurred (as compared to a baseline) or when uncertainties are relatively high, in contrast with the conclusions by Plugge et al. (2012).

3 Conclusions

If REDD+ aims to reduce emissions from deforestation and forest degradation globally, it should aim to be accessible to all.

A snowball does not need to be perfectly round to start rolling down. Similarly, we believe that the conservativeness principle may help to address uncertain estimates in the initial phases of most REDD+ initiatives. Conservativeness may be applied in many different ways. The possible approach which we propose here, i.e. to apply conservative discounts to those estimates which may be assumed to be inherently more uncertain (e.g. when tier-1 carbon stock factors are used), may represent a fair and realistic approach to:

- Help broaden the participation to REDD+, allowing also those countries with limited forest monitoring capacity to join, i.e. those capable of assessing changes in forest area following IPCC guidance but without a proper forest inventory to estimate the amount of carbon per unit of area. In these cases, and in the absence of any better alternative, our proposal would allow the use of tier-1 IPCC carbon stocks with limited conservative discounts.
- Increase if needed the credibility of emission reductions estimated with highly uncertain tier-1 IPCC carbon stocks (the conservative discount significantly decreases the risk of undue credits, i.e. not associated to real emission reductions), while maintaining strong incentives for further increasing the accuracy of the estimates, i.e. to move to higher tiers.

Acknowledgments The views expressed in this paper may not in any circumstances be regarded as stating the official position of the European Commission. We thank Michael Bucki for useful comments to the paper.

References

Amazon Fund (2011). Activity report 2011 – basic concepts. (http://www.amazonfund.gov.br/FundoAmazonia/export/sites/default/site_en/Galerias/Arquivos/Relatorio_Atividades/RAFA_2011_INGLES_CADERNO_1.pdf)

Bucki M, Cuypers D, Mayaux P, Achard F, Estreguil C, Grassi G (2012) Assessing REDD+ performance of countries with low monitoring capacities: the matrix approach. Environmental Research Letters 7:014031

GOFC-GOLD (2012) A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in

forests remaining forests, and forestation. GOFC-GOLD Report version COP18-1, (GOFC-GOLD Project Office, Natural Resources Canada, Alberta, Canada), http://www.gofc-gold.uni-jena.de/redd

Grassi G, Monni S, Federici S, Achard F, Mollicone D (2008) Applying the conservativeness principle to REDD to deal with the uncertainties of the estimate. Environmental Research Letters 3:035005

Grassi G, den Elzen MGJ, Hof AF, Pilli R, Federici S (2012) The role of the land use, land use change and forestry sector in achieving annex I reduction pledges. Climatic Change 115(3–4):873–881

Herold M, Skutsch M (2011) Monitoring, reporting and verification for national REDD+ programmes: two proposals. Environmental Research Letters 6:014002

IPCC (2003) In: Penman J et al (eds) Good practice guidance for land use, land-use change and forestry *IPCC National GHG Inventories Programme*. IGES, Japan

IPCC (2006) In: Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (eds) IPCC guidelines for national GHG inventories *IPCC National GHG Inventories Programme*. IGES, Japan

Köhl M, Baldauf T, Plugge D, Krug J (2009) Reduced emissions from deforestation and forest degradation (REDD): a climate change mitigation strategy on a critical track. Carbon Balance and Management 4:10. doi:10.1186/1750-0680-4-10

Meridian Institute (2011) *Modalities for REDD C Reference Levels*: *Technical And Procedural Issues* ed A Angelsen, D Boucher, S Brown, V Merckx, C Streck and D Zarin (prepared for the Government of Norway, available at: www.redd-oar.org/links/RLreport.pdf)

Norway (2012) Submission to the UNFCCC on views on results based finance for REDD+ http://unfccc.int/files/bodies/awg-lca/application/pdf/norway_submission_on_results-based_finance_for_redd+_final.pdf

Pelletier J, Kirby KR, Potvin C (2012) Significance of carbon stock uncertainties on emission reductions from deforestation and forest degradation in developing countries. Forest Policy and Economics 24:3–11

Plugge D, Baldauf T, Köhl M (2012) The Global Climate Change Mitigation Strategy REDD: Monitoring Costs and Uncertainties Jeopardize Economic Benefits. Climatic Change. doi:10.1007/s10584-012-0524-3

Romijn E, Herold M, Kooistra L, Murdiyarso B, Verchot L (2012) Assessing capacities of non-Annex I countries for national forest monitoring in the context of REDD+. Environmental Science & Policy 19–20:33–48

UNFCCC (2006) Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol, UN-FCCC/KP/CMP/2005/8/Add.3 Decision 20/CMP.1 (http://unfccc.int/files/meetings/cop_11/application/pdf/cmp1_12__good_practice_guidance_art5_2.pdf)

UNFCCC (2012) Decisions adopted by COP17, on Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels, UN-FCCC/CP/2011/9/Add.2 Decision 12/CP17