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Application of the Oeko-Institut/WWF-US/ EDF methodology for assessing the quality of carbon credits

This document presents results from the application of a methodology, developed by Oeko-Institut, World Wildlife Fund (WWF) and Environmental Defense Fund (EDF), for assessing the quality of carbon credits. The methodology is applied by Oeko-Institut with support by Carbon Limits, Greenhouse Gas Management Institute (GHGMI), INFRAS, Stockholm Environment Institute, and individual carbon market experts. This document evaluates one specific criterion or sub-criterion with respect to a specific carbon crediting program, project type, quantification methodology and/or host country, as specified in the below table. Please note that the CCQI website Site terms and Privacy Policy apply with respect to any use of the information provided in this document. Further information on the project and the methodology can be found here: www.carboncreditquality.org

Sub-criterion:	1.3.2 Robustness of the quantification methodologies applied to determine emission reductions or removals
Project type:	Establishment of natural forest
Quantification methodology:	Gold Standard Methodology for Afforestation/Reforestation (A/R) GHGs Emission Reduction & Sequestration, Version 2.0
Assessment based on carbon crediting program documents valid as of:	15 May 2022
Date of final assessment:	31 January 2023
Score:	2

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Assessment

Relevant scoring methodology provisions

The methodology assesses the robustness of the quantification methodologies applied by the carbon crediting program to determine emission reductions or removals. The assessment of the quantification methodologies considers the degree of conservativeness in the light of the uncertainty of the emission reductions or removals. The assessment is based on the likelihood that the emission reductions or removals are under-estimated, estimated accurately, or over-estimated, as follows (see further details in the methodology):

Assessment outcome	Score
It is very likely (i.e., a probability of more than 90%) that the emission reductions or removals are underestimated, taking into account the uncertainty in quantifying the emission reductions or removals	5
It is likely (i.e., a probability of more than 66%) that the emission reductions or removals are underestimated, taking into account the uncertainty in quantifying the emission reductions or removals OR The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) and uncertainty in the estimates of the emission reductions or removals is low (i.e., up to ±10%)	4
The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) but there is medium to high uncertainty (i.e., ±10-50%) in the estimates of the emission reductions or removals OR It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, but the degree of overestimation is likely to be low (i.e., up to ±10%)	3
The emission reductions or removals are likely to be estimated accurately (i.e., there is about the same probability that they are underestimated or overestimated) but there is very high uncertainty (i.e., larger than ±50%) in the estimates of the emission reductions or removals OR It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, and the degree of overestimation is likely to be medium (±10-30%)	2
It is likely (i.e., a probability of more than 66%) or very likely (i.e., a probability of more than 90%) that the emission reductions or removals are overestimated, taking into account the uncertainty in quantifying the emission reductions or removals, and the degree of overestimation is likely to be large (i.e., larger than ±30%)	1

Information sources considered

1 Gold Standard Methodology for Afforestation/Reforestation (A/R) GHGs Emission Reduction & Sequestration, Version 2.0 (available at: https://globalgoals.goldstandard.org/403-luf-ar-methodology-ghgs-emission-reduction-and-sequestration-methodology/)

2 Gold Standard Land Use & Forests Activity Requirements, Version 1.2.1 (available at: https://globalgoals.goldstandard.org/203-ar-luf-activity-requirements/)

3 Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities (AR-TOOL02, Version 01)

4 Guidelines – A/R Soil Carbon (spreadsheet tool; available here: https://globalgoals.goldstandard.org/guidelines-a-r-soil-carbon/)

5 BioCarbon Fund "Sourcebook for Land Use, Land-Use Change and Forestry Projects", available at: https://winrock.org/wp-content/uploads/2016/03/Winrock-BioCarbon_Fund_Sourcebook-compressed.pdf

6 Martin, A. R., Doraisami, M. and Thomas, S. C. (2018). Global patterns in wood carbon concentration across the world's trees and forests. Nature Geoscience, 11(12). 915–20. DOI:10.1038/s41561-018-0246-x.

7 Barbara Bomfim, et al. (in preparation). Is flexibility in REDD+ carbon accounting methods leading to overcrediting?

Assessment outcome

The quantification methodology is assigned a score of 2.

Note: This assessment only applies to removals that have been verified and credited ex-post, i.e., issued as "verified emission reductions" (VERs). For this project type, the Gold Standard allows issuing units for future expected removals from a project (in the form of "planned emission reduction" credits, or PERs). The assessed methodology has specific provisions for estimating future net removals under different scenarios for conservation forestry or rotation harvesting (Source 1, Section 3.6). As this assessment is limited to VERs, the provisions relating to PERs are not considered in this document.

Justification of assessment

Project type

This assessment refers to the following project type:

"Establishment of a forest on non-forest land areas that are ecologically appropriate for forests, excluding naturally non-forested biomes and semi-natural grasslands as well as the boreal region due to albedo-effects. The forest will not be used for any commercial purposes, such as harvesting, but may be used for sustainable subsistence. The tree species composition is based on the natural forest type of the area. This project type does not include the restoration of marine coastal ecosystems, such as mangroves."

This is within the scope of the quantification methodology, as the methodology allows afforestation and reforestation on degraded lands and does not exclude any of the conditions specified for this project type (Source 1). Note that the methodology includes "special considerations" for A/R mangrove projects; these are not considered here because they are excluded from the project type definition.

Selection of emission sources for calculating emission reductions or removals

The Gold Standard Land Use & Forests Activity Requirements (Source 2) provide guidance on defining project boundaries relevant to A/R projects, including the identification of "eligible" and "non-eligible" areas within the project area. This distinction is relevant because some requirements relate only to eligible areas – e.g., soil disturbance must not exceed 10% of eligible land areas (rather than 10% of the entire project area).

The methodology explicitly identifies the following carbon pools that may be relevant to removal accounting within the "project boundary"[1] (Source 1, Table 1, section 3.1):

- Tree biomass (above- & belowground)
- Non-tree biomass (above- & belowground)
- Soil
- Harvested wood
- Litter and lying deadwood

Based on the above, Table 1 indicates whether the methodology addresses sources, sinks, and reservoirs typically included in other afforestation/reforestation methodologies.

Table 1 Assessment of sources, sinks and reservoirs covered

Source, sink, or reservoir	Included in quantification methodology?	Relevant for this assessment?
Above- and below-ground biomass (trees and shrubs)	Yes	Yes. Primary source of removals from the project activity. Also a potential source of emissions at project initiation.
Herbaceous vegetation	Yes, included in the baseline only	Yes. Potential minor source of emissions at project initiation (due to removal during site preparation).
Standing dead carbon (carbon in all portions of dead, standing trees)	Yes (categorized as tree biomass)	Yes. May be a reservoir of additional stored carbon. Also a potential source of emissions at project initiation.
Lying dead wood carbon	No (excluded from accounting)	Yes. Could be a source of emissions at site preparation; could also be a reservoir of additional carbon

[1] The term "project boundary" is not defined. For this assessment, it is interpreted to mean the "accounting boundary" used to determine net removals caused by a project, including leakage that may occur outside the defined project *area*. This is implied by paragraph 3.1.1 of the methodology: "For the calculation of the parameters CO2-removal, Baseline and Leakage, the carbon pools shall be assessed as summarised in table 1."

		stored due to the project activity.
Litter and duff carbon (carbon in dead plant material)	No (excluded from accounting)	Yes. Could be a source of emissions at site preparation; could also be a reservoir of additional carbon stored due to the project activity.
Soil carbon	Optional	Yes. Could be source of emissions from site preparation activities. The methodology requires accounting for soil carbon if soil disturbance from site preparation affects 10% or more of project area.
Carbon in in-use forest products	No (excluded from accounting)	No. No harvesting assumed in assessed project type.
Forest product carbon in landfills	No (excluded from accounting)	No. No harvesting assumed in assessed project type.
Mobile combustion emissions from site preparation activities	No (considered insignificant – Source 1, paragraph 3.8.4)	Yes. Could be significant source of emissions, depending on scale.
Burning of woody biomass as part of site preparation	Yes – but excluding litter and lying dead wood (Source 1, paragraph 3.8.2)	Yes. May result in significant emissions of CO_2 and CH_4. CO_2 emissions are accounted for as carbon stock losses, so not separately included in this source.
Mobile combustion emissions from ongoing project operation and maintenance	No	No. Likely insignificant since the assessed project type involves no harvesting.
Stationary combustion emissions from ongoing project operation and maintenance	No	No. Not likely to differ from baseline.
Emissions from clearing of forest land **outside** the project area	Yes, included in methodology requirements to account for leakage.	Yes. Significant potential source of leakage. Afforestation on land currently used for grazing or growing crops may cause displacement of these activities to other lands, leading to a reduction in carbon stocks on those lands (e.g., due to clearing of trees and shrubs).
Emissions/removals from changes in harvesting on forest land outside the project area	No	No. No harvesting is assumed in the assessed project type.

The methodology defines a reasonably comprehensive GHG assessment boundary for this project type. Some possibly significant (though not large) sources of emissions are omitted. These include:

- Mobile combustion emissions from road buildings and site preparation activities

- Emissions (CO_2, CH_4, and N_2O) from the burning of litter and lying deadwood biomass during site preparation

Determination of baseline emissions/removals

Baseline scenario identification and modeling

It is not clear from the methodology how the baseline scenario is to be identified.

The Land Use & Forests Activity Requirements document (Source 2) indicates that *additionality* for A/R projects may be determined using the CDM A/R 'Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities.' However, it is not clear that this tool must be used to identify a baseline scenario in addition to demonstrating additionality. There is no explicit requirement in the methodology (Source 1) or in the Gold Standard Land Use & Forests Activity Requirements (Source 2) to use the CDM A/R tool to identify the baseline scenario. Furthermore, use of this tool is not required in all cases – A/R projects may also be deemed additional if they meet specified "positive list" eligibility conditions (Source 2, paragraph 3.1.16 (b)).

Paragraph 2.1.2 (f) of the methodology (Source 1) - which is under the scope and applicability section - states:

> "The most likely scenario without the project (baseline scenario) shall be defined for the project area. This scenario shall not show any significant increase of the Baseline biomass ('tree' and 'non-tree')."

Section 3.4 of the methodology, which covers "selection and justification of the baseline scenario," states only the following (in its entirety):

> "The Baseline is the estimated carbon stock that would occur in the baseline scenario. The baseline scenario describes the activities that would occur in the absence of the proposed project."

No further guidance is given. It is thus unclear what methodological approaches should be used to identify the baseline scenario.

Moreover, the second sentence of paragraph 2.1.2 (f) is ambiguous. It could mean that projects that would be expected to have significant growth in biomass in the baseline are ineligible. But it could also be interpreted to mean that projects must not model any growth in baseline biomass (even if there would be). Further on, the methodology states (Source 1, paragraph 3.3.3 (c)):

> **With the applicability conditions** this methodology assumes no significant increase in the Baseline, so the Baseline is only deducted in year 1 (t=1). (*emphasis added*)

This suggests that, in fact, projects that would have significant baseline biomass growth are not eligible. However, "significant" in this case is defined by the methodology to mean >5% of total expected removals for the project over its entire crediting period (the "long-term CO_2 removal or fixation," Source 1, footnotes 2 and 3). This could therefore be a source of overestimation of net removals.

Based on these considerations, the following sources of potential overestimation can be identified:

OE1 **Lack of requirements and guidance for identifying the baseline scenario:** The lack of any specific requirements and guidance for identifying the baseline scenario could lead to

arbitrary or biased selection of a scenario that underestimates baseline removals. For example, there is no explicit requirement to consider whether some degree of tree planting could occur in the baseline due to changes in practice or legal requirements. The methodology assumes that there will be no baseline tree planting or natural seeding of new trees and non-tree vegetation, and it does not account for any natural growth in existing trees.[2] This could lead to overestimation of net removals if the baseline is specified incorrectly.

OE2 **No ongoing requirements to account for changes in legal requirements, common practice, or effects of NDC/LEDS in determining baseline emissions.** Related to this, once a project is undertaken, the methodology requires no ongoing checks or adjustments to the baseline related to changes in legal requirements, common practice, or any policies coming into effects for meeting NDC or LEDS targets. Instead, as noted above, baseline carbon stocks are assumed to be constant and simply deducted in year 1 of the project. Failure to account for changing circumstances that might affect the baseline could lead to significant overestimation, especially over longer time periods.

OE3 **No requirement to account for baseline carbon stock growth.** Under the methodology, it is acceptable to identify a baseline scenario under which growth in baseline biomass occurs, such that baseline removals are up to 5% of long-term (projected) project removals. However, the methodology allows such baseline growth to be ignored. Therefore, the methodology in principle allows up to 5% overestimation of net removals due to having an underestimated baseline.

OE4 **Possibility to assume no baseline production of long-term wood products (when in fact there would have been).** The methodology assumes that no baseline production of wood products will occur from trees within the project area. This may be reasonable for most A/R projects on degraded lands, but may not be a plausible assumption for all reforestation projects. Where this is identified as a plausible component of the baseline scenario, it should arguably be required to consider this. The exclusion of baseline wood products may thus lead to a potential over-estimation of net removals (though the risk and magnitude of overestimation are likely to be low).

Measurement and quantification of baseline carbon stocks

For the purpose of estimating baseline and project carbon stocks, the methodology requires stratification of the project area into “modeling units” (MUs), which are “distinct parts of the planting area where carbon stocks can be quantified based on applying a forest growth-model” and which “normally have homogeneous characteristics in their growth patterns, silvicultural treatment and planting date” (Source 1, Section 1). This stratification is separate from stratification by vegetation type, which must also be done to estimate baseline carbon stocks in tree and non-tree biomass (Source 1, Section 3.5.2) – and may also be done to estimate project carbon stocks (Source 5).

U1 **Guidance for conducting biomass inventories**. The methodology contains minimal guidance for conducting a forest inventory, instead referring users to the BioCarbon Fund /

[2] Based on the language in paragraph 3.3.3 (c), cited above. Paragraph 3.6.4 of the methodology indicates that “[e]xisting ‘tree biomass’ from the carbon stock of the Baseline that is not removed shall be reflected in the growth-model” for calculating net CO_2 removals. However, it is not clear how this is supposed to be interpreted, and other parts of the methodology suggest that no increase in baseline carbon stocks is assumed.

Winrock “Sourcebook for Land Use, Land-Use Change and Forestry Projects” (Source 5). This guidebook was published in 2005. Chapter 6-8 of the guidebook appear to offer reasonably robust guidelines for conducting forest inventories. However, the guidelines are not highly prescriptive; they describe general approaches for stratification and selection of carbon pools, for example, but do not require a particular approach or choice. This assessment did not undertake a full review of these guidelines, so specific provisions that may lead to over- or under-estimation of removals have not been identified. The non-prescriptive nature of the Guidelines introduces uncertainty with regard to the overall quantification of removals.

As noted above, the methodology effectively assumes no growth in baseline carbon stocks, which could be a source of overestimation of a project’s net removals (OE2). Another source of potential overestimation, however, is the flexibility allowed in choosing “default” values used to estimate baseline biomass in different carbon pools.

OE5 **Possibility to choose advantageous values and methods for quantifying *baseline* carbon stocks in trees and woody biomass.** The methodology states that, for the baseline, “scientifically based project-specific, regional or national default values shall be found which state ‘tree’ and ‘non-tree’ biomass” for different vegetation types (Source 1, paragraph 3.5.2 (b)). Paragraph 3.10.2 indicates default parameters that “shall” be used for baseline biomass estimates “when no rigorous scientific information is available.” These defaults appear to be conservative (i.e., they would tend to overestimate baseline biomass). However, it is possible that project developers could choose more advantageous national or regional values over these defaults (or vice versa), depending on circumstances. Paragraph 3.10.5 suggests that project developers could also select “more precise IPCC defaults when available in place of GS defaults … with no justification required.” However, for the baseline, paragraph 3.5.2 (c) seems to contradict this, stating that IPCC values may be used only “if no other values are available.” These provisions appear somewhat contradictory. Since project developers may freely choose among national, regional, or methodology-supplied (GS) defaults, however, this is assessed to be a potential source of underestimation of baseline carbon stocks, and therefore overestimation of net removals caused by a project.

The methodology is unclear about how to convert baseline biomass estimates into CO_2 values. Paragraph 3.5.3, for example, provides a simple formula expressing how to calculate the baseline tonnes of CO_2 / hectare, but does not refer to how biomass estimates should be converted to CO_2. Presumably, the guidance in Sections 3.9 and 3.10 should be followed. The key factor here would be the value used for the fraction of carbon in tree biomass. The methodology prescribes a carbon fraction for tree biomass of 0.5 tC/tdm (Source 1, Section 3.10.1). Studies indicate that this is too high for many tree species (Martin et al. 2018). This would therefore be a potential source of overestimation of baseline carbon stocks. However, since the same factor must be used for project carbon stock estimates, the predominant effect will be an overestimation of net removals, as addressed further below (OE10).

Determination of project emissions/removals

The methodology quantifies project-case removals by quantifying the increase in carbon stocks in carbon pools that must be considered in this methodology: trees and non-tree biomass (Source 1, Section 3.6). In addition, the methodology requires accounting for certain project emissions associated with site preparation before tree planting occurs (although some potential sources are omitted).

Site preparation emissions

The methodology requires accounting for site preparation emissions from clearing and burning of existing biomass (Source 1, Section 3.8.2). However, the accounting method is highly simplified: the method is simply to assume emissions equal to 10% of the estimate for pre-existing carbon stocks on the project land area. This is assumed to "account for N_2O and CH_4 emissions that are released during the burning process." The following caveats apply:

UE1 **Use of 10% default factor to estimate emissions from burning biomass at site preparation**. The 10% factor appears conservative in most cases, because it would overestimate total CO_2e emissions for many/most land areas and biomass types (although it may underestimate them for others).[3] The effect for a typical project may therefore be underestimate total net removals (because site preparation emissions are overestimated), albeit with some significant variability.

OE6 **Possibility to choose a lower factor for estimating emissions from burning biomass at site preparation**. The methodology allows project developers to apply a lower factor "when justified based on relevant literature and other sources." This introduces a potential opportunity for gaming, if validation and verification entities or program staff fail to interrogate the accuracy of a chosen factor. Use of a too low adjustment factor could underestimate project emissions and therefore lead to overestimation of net removals.

OE7 **Exclusion of carbon in litter and lying dead wood (which could be emitted during site preparation)**. Projects are not required to account for carbon in litter and lying dead wood (Source 1, Table 1). Therefore, any carbon in these pools that is released through burning – and any associated CH_4 and N_2O emissions – will not be explicitly accounted for. This could lead to underestimation of project emissions and underestimation of net removals (the significance of which may depend on the project area).

Other potential sources of overestimation include:

OE8 **Exclusion of mobile combustion emissions from site preparation**. The methodology does not require accounting for mobile combustion emissions from site preparation activities (Source 1, Section 3.8.4). For some projects, this exclusion could be a significant source of overestimation of net removals.

OE9 **No requirement to account for soil disturbance emissions from site preparation**. If a project is implemented on organic soils or wetlands, then soil disturbance on greater than 10% of the tree planting area(s) results in ineligibility (Source 1, paragraph 2.1.1 (e)).[4] However, there appear to be no restrictions on soil disturbance for projects occurring on other soil types. In all cases, accounting for changes in soil carbon is optional (Source 1, Table 1). Thus, it is possible that a project could disturb soil on up to 100% of the project area due to site preparation activities and it would not have to account for any soil carbon released. This could be a significant source of overestimation of net removals for some projects.

[3] Based on a quick review of FAO data: https://www.fao.org/faostat/en/#data/GI/metadata

[4] Note that this condition applies to areas on which trees are planted within the project area, not the entire project area. This may be an important qualification, which is overlooked in other methodologies (e.g., project developers could specify a large project area, but only disturb soils on a much smaller area where trees are planted).

Quantification of project carbon stocks and removals

Project carbon stocks are quantified to determine a project's net removals. Although it is not stated explicitly, issuance of VERs is presumably based on the quantified increment in net removals achieved between verifications. Baseline carbon stocks and project emissions are deducted in year 1, so net removals are achieved once project carbons stocks exceed these year 1 deductions.

The methodology refers users to the BioCarbon Fund / Winrock "Sourcebook for Land Use, Land-Use Change and Forestry Projects" (Source 5) for guidance on how to conduct forest inventories. As noted above, it is unclear whether use of this guidance – given its potential flexibility – might result in over- or under-estimation of carbon stocks and net removals (U1). In addition:

UE2 **Use of confidence deduction where stem volume sample error is >20%**. The methodology requires that stem volume estimates (derived from a forest inventory) achieve a maximum error of +/-20% at a 90% confidence interval. A deduction is applied if the standard error is greater than 20%, equal to the difference between the error and 20%. For example, if the standard error is 23%, a 3% deduction would be applied to estimated stem volume. This deduction helps guard against overestimation of removals; however, it does not completely eliminate potential overestimation due to sampling errors.

Estimates of stem volume biomass derived from a forest inventory must be converted to carbon stock estimates (denominated in tonnes of CO_2) using straightforward conversions involving wood density estimates, biomass expansion factors (BEF), and root-to-shoot ratios (Source 1, Section 3.9). However – except for the carbon fraction value – the methodology is not highly prescriptive about what values must be used for some of these factors, instead offering general guidance. We assess these provisions to have the following implications:

OE10 **Prescribed use of a value of 0.5 for the carbon fraction tree biomass**. The methodology prescribes a value of 0.5 tC/tdm for the carbon fraction of tree biomass (Source 1, Section 3.10.1). At least one study suggests that using a ratio of 0.5 could significantly overestimate carbon stocks in a variety of tree species (especially angiosperms) in different climate zones (Martin et al. 2018). The prescribed use of 0.5 could result in overestimation of removals by 5% or more for many projects.

U2 **Ambiguity around parameter values used for quantifying *project* carbon stocks in trees and woody biomass.** The methodology provides conservative default values for wood density, BEF, and root-to-shoot ratios to be used "when no rigorous scientific information is available" (Source 1, Section 3.10.2). However, the methodology also refers to IPCC national inventory values for these parameters (Source 1, Sections 3.10.3-4) and notes that "If preferred, project developers may also select the more precise IPCC defaults when available in place of the GS defaults for factors relating to tree and nontree biomass with no justification required" (Source 1, Section 3.10.5). Since IPCC factors could be more precise and yet still overestimate some of these parameter values relative to project-specific circumstances, there is a risk that project developers will choose favourable IPCC values, even where "rigorous" project-specific information is available. The methodology is not clear about whether IPCC default may be used only when more accurate data are not available. This could contribute to overestimation of project carbon stocks and removals, and therefore an over-estimation of net removals due to the project – especially since no justification is required. However, because of the ambiguity, this provision is assessed to have an uncertain effect.

UE3 **Requirement to use parameter values that "when aggregated" lead to conservative calculation**. Section 3.9.8 of the methodology stipulates that, "When aggregated together, the factors shall lead to a conservative calculation approach. This means that in the consideration and calculation of uncertainties: a. the CO_2 removal shall not be overestimated, AND b. the Baseline and Leakage shall not be underestimated." (Note: this provision potentially applies to leakage estimates, because the same factors may be used in estimating carbon stocks on land areas affected by leakage.) In principle, this guards against potential overestimation of net removals, by encouraging underestimation of project carbon stocks and overestimation of baseline and leakage carbon stocks. As a general prescription, it is hard to evaluate how effective this provision is in practice, given the many assumptions and provisions of the methodologies that may lead to overestimation of net removals.

Note that the methodology indicates that these parameters do not need to be monitored (Source 1, Section 3.6.3). However, the methodology also notes that the appropriate BEF may change over time depending on the age of trees (Source 1, paragraph 3.9.7 (e)). This discrepancy is probably immaterial, but it would be more robust to explicitly require these parameters to be checked at every verification.

In addition, the following elements should be noted:

U3 **Standardized approach to determining soil organic carbon increases**. Project developers may optionally include estimates of soil carbon (e.g., if they expect the project may significantly enhance the soil carbon pool). If project developers choose to include quantification of soil carbon, they must use the Gold Standard "Guidelines – A/R Soil Carbon" (Source 4), which is a spreadsheet tool based on the CDM "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities" (AR-TOOL16, Version 01.1.0). The robustness and accuracy of the Gold Standard tool has not been assessed. Like the CDM tool, however, it appears to apply a highly standardized approach (where little to no actual measurement is involved). This reduces costs given the significant effort required to measure SOC. However, whether the tool is likely to result in over- or underestimation is difficult to assess without knowing project-specific circumstances. Given that SOC varies significantly between different sites, this introduces uncertainty.

UE4 **Exclusion of project-case accounting for carbon in non-tree biomass, litter, and lying dead wood**. The methodology excludes accounting for carbon in litter and lying dead wood, as well as carbon in non-tree biomass in the project case (Source 1, Table 1). While the former could result in some underestimation of site preparation emissions (see OE7), these exclusions could also result in some underestimation of net project removals, since carbon in these pools is likely to grow over time (relative to the baseline) under an A/R project.

Determination of leakage emissions

Leakage associated with reforestation projects can occur if reforestation displaces other land uses, e.g., by converting agricultural land to forest land, leading to a displacement of agricultural production.

OE 12 **Possible exclusion of market-based leakage accounting**. The Gold Standard methodology nominally requires accounting only for activity shifting leakage, not market leakage (Source 1, Section 3.1.3). However, the methodology nevertheless requires accounting for displacement of timber harvesting, agricultural activities, and livestock grazing, which could have both "activity shifting" and market components. The methodology

is not prescriptive about the methods that must be used to estimate leakage, making it difficult to assess how the exclusion of “market” leakage could be interpreted. However, to the extent that project developers may argue that some portion of leakage would be due to market effects, rather than direct (local) displacement, this nominal exclusion could result for some projects in a significant underestimation of leakage and overestimation of net removals.

OE13 **Lack of specific methods for estimating leakage**. The methodology does not prescribe methods for determining the extent of activity displacement. Instead, it indicates that activity displacement factors (indicating the percent of an activity that will be displaced to other areas with tree cover) are to be determined by “credible estimations or a representative survey” (Source 1, Section 3.7.5). Furthermore, the methodology provides no guidance on how to estimate average carbon stocks on land to which activities are displaced, suggesting only that if such lands cannot be identified, “the average stock of ‘tree biomass’ of a natural forest in the project’s host-country” may be used. In some cases, however, pre-project activities could be shifted globally, including to lands that have much higher carbon stocks. The lack of specificity how leakage due to displacement should be determined could allow for project-specific estimates that tend to underestimate leakage and overestimate net removals.

Summary and conclusion

Table 2 summarizes this assessment of the Gold Standard methodology. For each of the elements discussed above it summarizes the potential impact on net removal quantification.

Table 2 Relevant elements of assessment and qualitative ratings

Element	Fraction of projects affected by this element[5]	Average degree of under- or overestimation where element materializes[6]	Variability among projects where element materializes[7]
Elements likely to contribute to overestimating emission reductions or removals			
OE1 Lack of requirements and guidance for identifying the baseline scenario	Medium (for many projects, assumption of flat baseline carbon stocks may be appropriate/valid)	Medium	High
OE2 No ongoing requirements to account for changes in legal requirements, common practice, or effects of NDC/LEDS in determining baseline emissions	Medium	Medium	High
OE3 No requirement to account for baseline carbon stock growth	High	Low	Medium
OE4 Possibility to assume no baseline production of long-term wood products (when in fact there would have been)	Low	Low	Low
OE5 Possibility to choose advantageous values and methods for quantifying	High	Low	High

5 This parameter refers to the likely fraction of individual projects (applying the same methodology) that are affected by this element, considering the potential portfolio of projects. “Low” indicates that the element is estimated to be relevant for less than one third of the projects, “Medium” for one to two thirds of the projects, “High” for more than two third of the projects, and “All” for all of the projects. “Unknown” indicates that no information on the likely fraction of projects affected is available.

6 This parameter refers to the likely average degree / magnitude to which the element contributes to an over- or underestimation of the total emission reductions or removals for those projects for which this element materializes (i.e., the assessment shall not refer to average over- or underestimation resulting from all projects). “Low” indicates an estimated deviation of the calculated emission reductions or removals by less than 10% from the actual (unknown) emission reductions or removals, “Medium” refers to an estimated deviation of 10 to 30%, and high refers to an estimated deviation larger than 30%. “Unknown” indicates that it is likely that the element contributes to an over- or underestimation (e. g. overestimation of emission reductions in case of an omitted project emission source) but that no information is available on the degree / magnitude of over- or underestimation. Where relevant information is available, the degree of over- or underestimation resulting from the element may be expressed through a percentage range.

7 This refers to the variability with respect to the element among those projects for which the element materializes. “Low” means that the variability of the relevant element among the projects is at most ±10% based on a 95% confidence interval. For example, an emission factor may be estimated to vary between values from 18 and 22 among projects, with 20 being the mean value. “Medium” refers to a variability of at most ±30%, and “High” of more than ±30%.

baseline carbon stocks in trees and woody biomass			
OE6 Possibility to choose a lower factor for estimating emissions from burning biomass at site preparation	Unknown	Low	High
OE7 Exclusion of carbon in litter and lying dead wood (which could be emitted during site preparation)	High	Low	High
OE8 Exclusion of mobile combustion emissions from site preparation	All	Low	Low
OE9 No requirement to account for soil disturbance emissions from site preparation	Medium	Medium	High
OE10 Prescribed use of a value of 0.5 for the carbon fraction tree biomass	Medium	Low	Medium
OE12 Possible exclusion of market-based leakage accounting	Unknown	Medium	Medium
OE13 Lack of specific methods for estimating leakage	Unknown	Low-Medium	High
Elements likely to contribute to underestimating emission reductions or removals			
UE1 Use of 10% default factor to estimate emissions from burning biomass at site preparation	High	Low	High (but probably a small number of cases where it would result in overestimation of removals)
UE2 Use of confidence deduction where stem volume sample error is >20%	Unknown	Low	Unknown
UE3 Requirement to use parameter values that "when aggregated" lead to conservative calculation	All	Unknown	Unknown
UE4 Exclusion of project-case accounting for carbon in non-tree biomass, litter, and lying dead wood	All	Low	Medium
Elements with unknown impact			
U1 Guidance for conducting biomass inventories	All	Unknown (difficult to assess)	Unknown
U2 Ambiguity around parameter values used for quantifying *project* carbon	High	Medium	High

stocks in trees and woody biomass			
U3 Standardized approach to determining soil organic carbon increases	Unknown	Low	Medium

There are multiple methodology elements that could result in overestimation of removals from the project activity, whereas only few elements that may lead to underestimation. Moreover, among the elements leading to potential overestimation, several could have a significant effect:

- The lack of requirements and guidance related to identifying the baseline scenario (and/or ascertaining that the assumption of zero growth in baseline carbon stocks is appropriate)
- Lack of a requirement to model baseline carbon stock growth (even though projects are eligible if expected growth is up to 5% of total expected net removals)
- Flexibility in choice of parameters used to estimate biomass and carbon stocks (both baseline and project case)
- Use of a 0.5 carbon fraction value in all projects
- No requirement to account for soil disturbance emissions from site preparation
- Lack of clear requirements and guidance for how to determine leakage emissions

Overall, we estimate that it is likely that the removals are overestimated and that the degree of overestimation is likely to be medium (±10-30%). Moreover, there is significant uncertainty in the total removals (but likely to be lower than ±50%). Based on this assessment, the Gold Standard quantification methodology is assigned a score of 2 overall.