

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:	ACR Afforestation and Reforestation of Degraded Lands, Version 1.2
Date of final assessment:	08 November 2022
Score:	3

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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	4
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 $\pm 10\%$)	
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., $\pm 10\text{-}50\%$) in the estimates of the emission reductions or removals	3
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 $\pm 10\%$)	
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 $\pm 50\%$) in the estimates of the emission reductions or removals	2
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 ($\pm 10\text{-}30\%$)	
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 $\pm 30\%$)	1

Information sources considered

- 1 American Carbon Registry *Methodology for the Quantification, Monitoring, Reporting, and Verification of Greenhouse Gas Emissions Reductions and Removals from Afforestation and Reforestation of Degraded Land v1.2*, May 2017 (available at:

<https://americancarbonregistry.org/carbon-accounting/standards-methodologies/afforestation-and-reforestation-of-degraded-lands>)

- 2 *American Carbon Registry Standard*, Version 7.0, December 2020 (available at: <https://americancarbonregistry.org/carbon-accounting/standards-methodologies/american-carbon-registry-standard>)
- 3 Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities (AR-TOOL02, Version 01)
- 4 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)
- 5 Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity (AR-TOOL15, Version 02.0)
- 6 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)
- 7 Guidance on application of the definition of the project boundary to A/R CDM project activities (EB44 repan16, version 01)
- 8 Demonstration of eligibility of lands for A/R CDM project activities (AR-TOOL19, version 02.0)
- 9 Tool for testing significance of GHG emissions in A/R CDM project activities (AR-TOOL04, version 01)
- 10 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003 (https://www.ipcc-nggip.iges.or.jp/public/gpoglulucf/gpoglulucf_files/GPG_LULUCF_FULLL.pdf)
- 11 Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity (AR-TOOL08, version 04.0.0)
- 12 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities (AR-TOOL14, version 04.2)
- 13 Calculation of the number of sample plots for measurements within A/R CDM project activities (AR-TOOL03, version 02.1.0)
- 14 CDM Guidelines on conservative choice and application of default data in estimation of the net anthropogenic GHG removals by sinks (version 02)

The *Erratum and Clarifications* for the ACR methodology were not considered in this assessment, because they do not pertain to the project type being assessed (they only clarify the length of crediting period and how the methodology applies where aggregation or a “programmatic development approach” – equivalent to PoAs – are pursued).

Assessment outcome

The quantification methodology is assigned a score of 3.

Justification of assessment

Note: The ACR methodology for afforestation and reforestation of degraded lands is based on a prior CDM A/R methodology (AR-ACM0001, Version 5.0.0), and relies on many CDM quantification and assessment tools for A/R projects (Sources 11-14). Some of the same potential sources of over- and under-estimation that apply to the CDM AR-ACM0003 methodology also apply to the ACR methodology. However, the ACR methodology includes modifications that address or avoid some potential sources of over-estimation (e.g., by requiring use of regeneration monitoring areas) or introduce potential new sources (e.g., by allowing discretionary use of national, regional, or global data for some parameters, despite indicating “preferred” alternatives.) Where relevant, areas where the ACR methodology aligns with or differs from AR-ACM0003 are noted in this 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).

Selection of emission sources for calculating emission reductions or removals

The ACR methodology requires following the CDM tools for defining a project boundary (Source 7) and demonstrating eligibility of land area(s) included within the project boundary (Source 8). The ACR Standard (Source 2) also stipulates requirements for defining project boundaries relevant to A/R projects. The ACR methodology explicitly identifies the following carbon pools that may or must be accounted for within the project boundary (Source 1, section 2.1):

- Above-ground biomass
- Below-ground biomass
- Dead wood
- Litter
- Soil organic carbon
- Wood products
- Emissions from burning of woody biomass at the time of site preparation

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	No	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 (or no, if conservative or insignificant)	Yes. May be a reservoir of additional stored carbon. Also a potential source of emissions at project initiation.
Lying dead wood carbon	Yes (or no, if conservative or insignificant)	Yes. Could be a source of emissions at site preparation; could also be a reservoir of additional carbon stored due to the project activity.
Litter and duff carbon (carbon in dead plant material)	Optional (the methodology considers litter to be <i>a priori</i> insignificant, but it may be included at project developer's discretion)	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	Yes, if site preparation disturbs > 10% of project area. Optional, if exclusion would be conservative or insignificant.	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	Optional	No. No harvesting assumed in assessed project type.
Forest product carbon in landfills	Optional	No. No harvesting assumed in assessed project type.
Mobile combustion emissions from site preparation activities	No	Yes. Could be significant source of emissions, depending on scale.
Burning of woody biomass as part of site preparation	Yes (CH ₄ emissions only)	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	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 sources of emissions, such as mobile combustion emissions from road buildings and site preparation activities, are not addressed (see further discussion of project emissions/removals, below).

Like CDM AR-ACM0003, the ACR methodology requires accounting for methane emissions from combustion of woody biomass during site preparation activities. Unlike AR-ACM0003, however, N₂O emissions from such combustion are excluded from quantification, on the grounds that they are “negligibly small” (Source 1, Table 1).

Carbon in herbaceous vegetation (which could be released due to site preparation) is not included in the project boundary requirements (Source 1, Table 1). Although not stated explicitly, the methodology treats carbon in herbaceous vegetation as insignificant (similar to AR-ACM0003).

Carbon stocks in both lying and standing dead wood may be excluded from accounting if project developers can show that they are insignificant (using the CDM “tool for testing significance of GHG emissions in A/R CDM project activities” – Source 9) or can demonstrate using “transparent and verifiable information” that the project is likely to increase carbon in this pool relative to the baseline scenario. While procedures and criteria for the latter option are not defined, the approach is nevertheless more conservative than CDM AR-ACM0003, for example, which allows optional exclusion of these reservoirs without a justification.

A similar approach is indicated for carbon stocks in litter (Source 1, Table 1). However, the methodology notes in a footnote (Source 1, footnote 2, p. 13) that the ACR Standard considers litter to be *a priori* insignificant, suggesting that projects may automatically exclude this pool at their discretion. Section 2.5.1.3 of the ACR methodology also indicates that quantification of carbon in litter is only necessary “if selected in Table 1.” Because of this implied exemption, discretionary exclusion could be a source of overestimation for some projects (see further discussion of project emissions/removals, below).

Determination of baseline emissions/removals

Baseline scenario identification and modeling

Like the CDM AR-ACM0003 methodology, the ACR methodology requires project owners to conduct an assessment of possible baseline scenario alternatives – and identify a baseline scenario – using the CDM “Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities” (Source 3). Alternatives must include continuation of pre-project land use, forestation without being registered as a project activity (i.e., BAU forestation), and BAU increase in forest cover (partial forestation) due to legal requirements or common practice activities (paragraph 9 of the tool).

- U1 Despite the requirement to identify a baseline scenario, there is no discussion of how baseline *carbon stock* estimation should be informed by the baseline scenario identified. The presumption seems to be that projects will simply model any growth in pre-existing biomass (including trees), net of any potential losses (e.g., due to continuation of pre-existing loss drivers like fuelwood collection or selective harvesting). In the main section prescribing methods to estimate baseline carbon stocks (Source 1, section 2.4), for example, there is no mention of the possibility of baseline tree planting activities and how these are to be modelled. While project owners may model such activity in good faith, the lack of clear guidance creates uncertainty in how these scenarios would be addressed.
- U2 Likewise, the primary baseline quantification guidance does not mention reflecting changes in legal requirements, common practice, or anticipation of the possible effects of meeting NDC or LEDS targets. This could lead to significant overestimation, especially over longer time periods. However, this potential oversight **is to some extent remedied by a separate requirement to establish “regeneration monitoring areas”** (Source 1, section 3.3). These areas are used as control areas to verify, on ongoing basis, the validity of baseline assumptions about tree growth and regeneration in the absence of the project activity. Under the ACR methodology, “[i]f the observed number of seedlings per hectare exceeds the baseline estimate by more than 10% and by more than 10 trees per hectare, the baseline scenario ... must be modified to better reflect the observed values.” In principle, the requirement to use these monitoring areas could capture any baseline tree planting activity or natural regeneration that might have occurred due to changing legal requirements, policy, or common practice (as well as any natural regeneration that diverges from initial assumptions, regardless of policy or practice changes). However, the methodology does not explicitly address these issues, and there are limited prescriptive requirements around how regeneration monitoring areas should be defined and selected (e.g., the methodology indicates only that such areas must be “similar to” the project area in characteristics such as soil type, slope, aspect, and distance to seed sources. **Because it is not clear how well the use of regeneration monitoring areas would work in practice to capture deviations from baseline assumptions, the net effect is unknown.**
- OE1 One potential flaw with the prescribed approach for using regeneration monitoring areas is that these areas must only be re-assessed at intervals of 10 years (Source 1, Section 3.3) and any revisions to baseline assumptions that result from this reassessment are strictly forward-looking – that is, baseline revisions “will not be applied retroactively to credits already verified and issued in earlier years.” While this provision is understandable from the perspective of providing assurances to project owners and credit holders, it could still lead to

over-crediting in years before it is discovered that the original baseline assumptions were inaccurate.

- OE 2 The ACR methodology notes that “changes in carbon stock of above-ground and below-ground biomass of non-tree vegetation” (as well as dead wood and litter) “may be conservatively assumed to be zero for all strata in the baseline scenario.” This assumption could be plausible for projects on land that is in the process of degrading, but no rationale is provided for why this is conservative as a general assumption. To the contrary, a conservative approach might require using optimistic assumptions about net growth in these pools in the baseline scenario. It seems possible, however, that the authors of the methodology meant to suggest that it is conservative to assume there will be *no difference* in baseline vs. actual carbon in these pools (since the methodology notes they may be “conservatively” assumed to not change in the project case as well, apart from disturbance by site preparation activities). This would be conservative because reforestation/afforestation activities would typically enhance carbon in these pools over time relative to the baseline.

However, it should be noted that **according to the terms of the methodology as written**, a project developer might “conservatively” assume zero change for these pools in the baseline, while measuring and monitoring any increases due to the project, thus (potentially) over-estimating total removals. The equations and procedures for estimating baseline carbon stocks (section 2.4) refer only to carbon in trees and long-term wood products, and omit any reference to baseline carbon in other carbon pools (except briefly in the introduction to section 2.4), whereas the procedures for measuring project-case carbon (section 2.5) explicitly include formulas for estimating carbon in these other pools. **This lack of specificity in the methodology related to baseline carbon stocks in non-tree vegetation could therefore potentially lead to an over-estimation of carbon removals.**

- OE3 The methodology also permits the assumption that no baseline production of wood products will occur from trees within the project area. This may be reasonable for many A/R projects on degraded lands, but may not be a plausible assumption for all reforestation projects. Project developers have the *option* to estimate baseline harvesting and include this in their baseline carbon pool estimates (Source 1, section 2.4.3). Where this is identified as a plausible component of the baseline scenario, it should arguably be required and not optional. This provision may thus lead to a potential over-estimation of net removals.
- OE4 The methodology allows considerable flexibility in determining when a “steady state” would be reached in the baseline scenario, at which point there is assumed to be no net increase in baseline carbon stocks (i.e., zero ongoing baseline removals). Specifically, project owners may, “on a project specific basis,” determine when a steady state would have been reached “on the basis of transparent and verifiable information” from a variety of potential sources. In the absence of such information, the default is assumed to be 20 years. Without any further assessment or validation, however, project owners could choose this default under conditions when a steady state might occur further into the future, or make a case that the steady state would occur sooner. Either option could result in an underestimation of baseline removals and therefore overestimation of net removals due to the project.

Measurement and quantification of baseline carbon stocks

For estimating both baseline and project carbon stocks, the ACR methodology requires appropriate stratification by tree and vegetation type when developing inventories (Source 1, section 2.3).

Although stratification requirements and guidelines are provided in the context of baseline carbon stock estimation, the methodology notes that stratification approaches may differ for baseline and project-case estimates, due to differing vegetation and tree-species mixes. This is an appropriate approach. However, the methodology provides significant flexibility in quantifying baseline carbon stocks and removals.

OE5 The methodology allows flexibility in choosing methods to estimate both initial carbon stocks (including use of default parameters; Source 1 sections 2.4.1 and 2.4.2) and biomass increments over time (including use of IPCC approximation tables; Source 10.) Furthermore, several parameters used in baseline quantification (whose values are not monitored, e.g., values for tree growth rates, wood density, and carbon loss rates) may be quantified using a range of data sources, from local or national data to regional or global (IPCC) data sets (Source 1, section 2.8). The range in values that may be used (depending on data availability and discretion of the project developer) could be significant, leading to potentially significant variation in quantification among projects. The methodology indicates that locally and regionally specific data are “preferred,” but there is no hard requirement to use preferred alternatives, meaning that project developers could, in principle, adopt less accurate but more favorable parameter values. As one example, a range of studies suggest that use of different allometric equations could lead to significant under- or over-estimation of above-ground biomass in trees (Ngomanda et al. 2014; Alvarez et al. 2012; Chave et al. 2014; Temesgen et al., 2015; Fonseca et al., 2012; Pati et al., 2022). Use of different methods for initial carbon stocks and biomass increments over time could be a source of over- or under-estimation, depending on actual tree species present and methods used. However, since project developers can essentially choose from a broad range of values, there is a risk that they will choose favourable values and methods, contributing to underestimation of baseline carbon stocks and removals, and therefore an over-estimation of net removals due to the project.

Determination of project emissions/removals

The ACR methodology quantifies net project-case removals by quantifying the change (increase) in carbon stocks in required and selected carbon pools: trees, non-tree vegetation, dead wood, litter, and soils (Source 1). In addition, the methodology requires accounting for certain project-case emissions associated with site preparation before tree planting occurs (although some potential sources are omitted).

Note: Net removals due to the project are calculated as the difference between (1) the *increment* in actual (project case) carbon stocks and any increment assumed in baseline carbon stocks over a given reporting period. This is equivalent to the difference between project-case removals and baseline removals achieved over the reporting period (Source 1, Section 2.7). Any project-case emissions must be subtracted from net removals to determine creditable emission reductions/removals (although this is not made entirely clear in Section 2.7.1 of the methodology, which provides the formula for calculating the quantity of credits that may be issued).

Site preparation emissions

Accounting for site preparation emissions from clearing and burning of existing biomass is required. The ACR methodology requires accounting for loss of shrubs due to site preparation using the CDM tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities” (Source 12). The methodology is not explicit about quantification of any loss in dead wood due to site preparation; however, tracking of carbon in dead wood is required unless it

can be demonstrated that: (1) carbon in these pools is insignificant (using Source 9); or (2) carbon in these pools is unlikely to be lower over time in the project case than it would have been in the baseline scenario (Source 1, Table 1).

OE6 As noted above, any loss of carbon in litter due to site preparation is excluded by default, unless project owners choose to include it. The methodology considers carbon in litter to be *a priori* insignificant. However, exclusion could result in (slight) underestimation of project emissions and therefore overestimation of net reductions/removals.

If biomass is burned during site preparation activities, then non-CO₂ emissions from combustion of biomass must be estimated using the CDM tool “Estimation of non-CO₂ GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity” (Source 11).

OE7 However, N₂O emissions from combustion of onsite woody biomass during site preparation may be ignored. The methodology indicates that these emissions are “negligibly small.” This contrasts with CDM AR-ACM0003, which requires accounting for both methane and N₂O emissions. Excluding N₂O emissions could result in slight overestimation of net emission reductions/removals.

OE8 Finally, in line with the CDM AR-ACM0003 methodology, the ACR methodology does not require accounting for mobile combustion emissions from site preparation activities. The CDM AR-ACM0003 methodology considers these sources to be insignificant; however, significance may depend on site-specific circumstances. Exclusion could therefore be a source of overestimation of net reductions/removals.

Quantification of project carbon stocks and removals

The ACR methodology allows use of multiple methods for estimating carbon stocks, including a Forest Vegetation Simulator model developed by the US Forest Service. All methods require appropriate stratification of carbon pools to be measured. Sample plots required for each method must be determined using the CDM tool “Calculation of the number of sample plots for measurements within A/R CDM project activities” (Source 13).

The methodology allows project developers to “conservatively” assume zero net change in project-case non-tree vegetation carbon, except where site preparation results in emissions from this pool. However, this would only be conservative if non-tree vegetation carbon stocks in the project-case are in fact likely to increase – see discussion under OE2, above. If zero net change is not assumed, projects may estimate carbon in non-tree vegetation using the CDM tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities” (Source 12).

OE9 As with baseline estimation, several parameters used in quantification whose values are not monitored (e.g., values for tree growth rates, wood density, and carbon loss rates) may be quantified using a range of data sources, from local or national data to regional or global (IPCC) data sets (Source 1, section 2.8). The range in values that may be used (depending on data availability and project discretion) could be significant, leading to potentially significant variation in quantification among projects. The methodology indicates that locally and regionally specific data are “preferred,” but there is no hard requirement to use preferred alternatives, meaning that project developers could, in principle, adopt less accurate but more favorable parameter values. (By contrast, the CDM AR-ACM0003 methodology prescribes default values for many of these same parameters, which may improve consistency – and avoid gaming - at the expense of accuracy.)

As noted under OE5, above, a range of studies suggest that use of different allometric equations, for example, could lead to significant under- or over-estimation of above-ground biomass in trees (Ngomanda et al. 2014; Alvarez et al. 2012; Chave et al. 2014; Temesgen et al., 2015; Fonseca et al., 2012; Pati et al., 2022). Another potentially significant element is the carbon fraction of tree biomass. The ACR methodology indicates a “preference” for using species-specific ratios of carbon mass to biomass in trees (Source 1, Section 2.8). However, it does not exclude choosing an IPCC default value of 0.5. 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). Since project developers can essentially choose from a range of values, there is a risk that they will choose favourable values and methods, contributing to overestimation of project carbon stocks and removals, and therefore an over-estimation of net removals due to the project.

- U3 Quantification of soil carbon is not required unless site preparation activities result in soil disturbance across 10% or more of the project area. If a project is implemented on organic soils or wetlands, then soil disturbance on greater than 10% of the project area results in ineligibility – Source 1, section 1.4. These requirements are common across other A/R methodologies (including CDM AR-ACM003 and the Climate Action Reserve Forest Project Protocol). They assume that if soil disturbance occurs on less than 10% of the project area, emissions will be insignificant (even for projects on organic soils). This may not be true in all cases; further research is needed to examine this question. The net effect is therefore deemed uncertain.
- U4 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 CDM “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities” (Source 6). Under this tool, estimation of the increase in soil organic carbon (SOC) is based on the assumption that “implementation of an A/R CDM project activity increases the SOC content of the lands from the pre-project level to the level that is equal to the steady-state SOC content **under native vegetation.**” The approach uses default reference levels for SOC in different types of soils and regions under native vegetation. Initial SOC is determined using these same defaults, adjusted using additional default discount factors to determine (typical) starting SOC values based on baseline land use, management, and nutrient input regimes. This is a highly “standardized” approach (little to no actual measurement is involved). This reduces costs given the significant effort required to measure SOC. However, whether the results are conservative is difficult to determine without knowing more about project-specific circumstances. For the project type being assessed here (which involves planting of native tree species, as assumed in Source 6), it could be reasonably accurate. However, the overall effect is difficult to assess without knowing project-specific circumstances.
- UE1 Finally, Section 3.5 of the AC methodology stipulates that “while applying the methodology” (e.g., in quantifying both baseline and project-case emissions and removals) project developers shall ensure that – where uncertainties exist – they apply the CDM “Guidelines on conservative choice and application of default data in estimation of the net anthropogenic GHG removals by sinks” (Source 14). All else equal, this could result in underestimation of net removals/reductions. However, the ACR methodology’s guidance here is minimal, and less explicit than other A/R methodologies that prescribe the application of uncertainty discounts (for example) to ensure conservative quantification of net removals. In particular,

the ACR methodology indicates only that project developers “should” select values that lead to *accurate* quantification, and use conservative estimates only where uncertainty is “significant.” The effect of this element is therefore deemed to be low (and could, in practice, serve mainly to avoid substantial *overestimation* associated with other elements identified above).

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. Under the ACR methodology, leakage must be calculated using the CDM tool for “Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity” (Source 5).

- U5 Under the tool, agricultural activities are assumed to be displaced to other forested land areas on a one-for-one basis. That is, if 10 hectares of land in the project area were previously used for cropland, then it is assumed that 10 hectares of forest land will be cleared elsewhere to accommodate the displacement of cropping activity. This may or may not be conservative, depending on circumstances. On the margin, net agricultural activity may decline if there are costs associated with shifting to other land areas, which could lead to less than one-for-one displacement of other forest land. On the other hand, if receiving land areas are less productive, this could lead to clearing of *more* forest land than the area that was planted in trees. The actual net effect would be hard to determine without knowing project-specific circumstances (and even so, may be hard to estimate). This approach is therefore deemed to introduce considerable uncertainty.
- OE10 Some exceptions are made for displacement of grazing activities, e.g., displacement of project area grazing to other grassland areas that are capable of supporting more intense grazing. These exceptions are reasonable. However, determining to where pre-existing grazing activities are displaced may be subject to uncertainty (it may be difficult to monitor in some cases), which could make application of these exceptions somewhat subjective. Because of this, allowing such exceptions could in some cases lead to overestimation of net removals.
- U6 The amount of carbon that is emitted from receiving land areas is determined either through direct measurement (assuming project proponents can determine where these areas are located) or through use of IPCC default numbers for average forest carbon stocks in different regions and countries (i.e., using Table 3A.1.4 of the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003)). Again, it is difficult to determine *a priori* whether the approach is conservative. There could easily be uncertainty in trying to determine precisely where agricultural activities are displaced to, and therefore whether a measurement approach is accurate or conservative. When using defaults, however, it is difficult to know without further information whether they would be conservative for a specific project. The effect of this element is therefore uncertain.

Summary and conclusion

The following Table 2 summarizes the assessment of the ACR methodology. For each of the elements discussed above it derives the potential impact on removal quantification.

Table 2 Relevant elements of assessment and qualitative ratings

Element	Fraction of projects affected by this element ¹	Average degree of under- or overestimation where element materializes ²	Variability among projects where element materializes ³
Elements likely to contribute to overestimating emission reductions or removals			
OE1 Lack of retroactive baseline revisions from reassessment of regeneration monitoring areas	Low	Low to Medium	Medium (depends on length of time between monitoring area reassessments)
OE2 Possibility to assume zero net change in baseline carbon in non-tree vegetation, dead wood, and litter, while measuring increases in these carbon pools under the project	All	Low (since these typically are not major carbon pools)	Low
OE3 Possibility to assume no baseline production of long-term wood products (when in fact there would have been)	Low	Low	Low
OE4 Flexibility in specifying when a “steady state” of zero baseline carbon removals is reached	All	Low-Medium	Medium (depends on baseline removal potential)

¹ 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.

² 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.

³ 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 $\pm 10\%$ 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 $\pm 30\%$, and “High” of more than $\pm 30\%$.

OE5 Possibility to choose advantageous values and methods for quantifying <i>baseline</i> carbon stocks in trees and woody biomass	High	Medium	High
OE6 Exclusion of carbon in litter (which could be emitted during site preparation)	High	Low	Low
OE7 Exclusion of N ₂ O emissions when calculating emissions from combustion of woody biomass at site preparation	High	Low	Low
OE8 Exclusion of mobile combustion emissions from site preparation	High	Low	Low
OE9 Possibility to choose advantageous values and methods for quantifying <i>project</i> carbon stocks in trees and woody biomass	High	Medium	High
OE10 Possible exclusion of leakage accounting if project area grazing is displaced to land capable of supporting higher intensity grazing	Low	Unknown	Medium
Elements likely to contribute to underestimating emission reductions or removals			
UE1 Requirement to apply conservative assumptions wherever uncertainty is “significant” associated methodological elements or values used	All	Low	Unknown
Elements with unknown impact			
U1 Lack of guidance for how to model baseline scenarios involving active tree planting	Low (based on the assumption that, among projects with significant tree planting in the baseline, few would try to register)	Unknown (difficult to estimate because guidance is lacking)	Medium (there could be varying degrees of baseline planting activity – though presumably within a limited range for truly additional projects)
U2 Use of regeneration monitoring areas to capture possible deviations from baseline scenario assumptions	All	Unknown (not clear how well monitoring areas would work in practice to correct for baseline deviations)	High

U3 Exclusion of soil carbon accounting if site preparation disturbance affects 10% or less of project area	Low	Unknown	Unknown
U4 Standardized approach to determining soil organic carbon increases	Unknown	Low	Medium
U5 Methods to determine leakage emissions	Unknown	Medium	High
U6 Methods for determining carbon emitted from land to which grazing is displaced	Unknown	Unknown	Medium

Based on this summary, the ACR quantification methodology is assigned a score of 3 overall. There are multiple methodology elements that could result in overestimation of removals from the project activity. The combined effect of many of these is likely to be low. However, there may be significant potential for bad faith “gaming” of *some* elements by project developers to result in significant overestimation. The potential for this gaming is reduced by the requirement that project developers should use accurate or conservative assumptions and values (Section 3.5 of the methodology). However, the ACR methodology is not as explicit about the application of conservative quantification methods compared to other methodologies. Where the ACR methodology appears superior to other A/R methodologies is in requiring the use of “regeneration monitoring areas,” which provide a means to ground-truth baseline carbon stock assumptions. Since uncertainty around baseline carbon is a significant source of uncertainty in quantifying net removals for this project type – especially over longer time periods – requiring these control areas is a useful and important way to improve accuracy.