BCR TOOL

CONSERVATIVE APPROACH AND UNCERTAINTY MANAGEMENT

BCR carbon credits are measured applying mechanism for managing uncertainty in the baseline quantification and mitigation results

Draft Public Consultation

BIOCARBON CERT®

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1 Introduction

According to the rules and procedures established by BIOCARBON, project holders shall assess and manage uncertainty in a consistent, conservative, and transparent manner. This includes applying appropriate methods to identify sources of uncertainty, quantify their magnitude, and implement measures to avoid overestimation of emission reductions or removals. All project estimates shall be based on data and assumptions that meet minimum quality thresholds and are accompanied by clear documentation of uncertainty levels, sources, and treatment.

This Uncertainty Management Tool provides the technical framework for identifying, assessing, quantifying, and conservatively managing uncertainty in greenhouse gas (GHG) emission reductions and removals across all mitigation activities certified under the BIOCARBON STANDARD. The Tool applies to all sectors and project types, including land-based and engineered interventions.

Uncertainty analysis is a critical component of environmental integrity. Accurate and conservative quantification of mitigation outcomes ensures that all Verified Carbon Credits (VCCs) issued by the program are grounded in robust data and transparent assumptions. This Tool establishes a consistent approach to evaluate the quality of input data, apply appropriate estimation methods, and account for the level of uncertainty in reported results.

The methods described herein draw from recognized best practices, including those established by leading scientific bodies on GHG inventories and emissions quantification. The Tool incorporates both statistical and qualitative approaches for uncertainty estimation and supports the application of simplified methods (e.g., error propagation) as well as advanced techniques (e.g., Monte Carlo simulations), as appropriate to the complexity of the data and models used.

The application of this Tool ensures: (a) Transparency in how uncertainty is identified and managed, (b) Comparability across projects and sectors, (c) Consistency with credible quantification practices for GHG emissions and removals, and (d) Confidence in the accuracy and conservativeness of issued carbon credits.

This document also supports periodic improvement of project methods and data quality by providing a clear basis for monitoring, verification, and future recalculation. It has been published as a Public Consultation Version, inviting feedback from technical experts, practitioners, and stakeholders involved in the implementation and oversight of mitigation activities.

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2 Purpose

The purpose of this Tool is to establish a standardized and science-based framework for the identification, quantification, and management of uncertainty in the estimation of greenhouse gas (GHG) emission reductions and removals under the BIOCARBON STANDARD.

This Tool aims to ensure that all reported mitigation outcomes are based on conservative and transparent assumptions, supported by data and methods appropriate to the context of each project. It provides guidance on how to apply uncertainty estimation techniques, when to apply conservative adjustments, and how to communicate uncertainty in a manner that supports effective verification and credit issuance.

By promoting consistent and conservative treatment of uncertainty, this Tool contributes to the environmental integrity of Verified Carbon Credits (VCCs) issued by the program and strengthens confidence in the robustness of reported results. It also supports continual improvement by establishing requirements for data quality, methodological transparency, and documentation of assumptions.

3 Objectives

The objectives of this tool are:

(a) To define the minimum requirements for the identification, quantification, and conservative treatment of uncertainty in GHG emission reductions and removals reported under the BioCarbon Standard;

(b) To promote consistent application of uncertainty estimation methods across all project types and sectors, ensuring comparability and methodological transparency;

(c) To support the use of appropriate data sources and quantification approaches, including default values, project-specific measurements, and model-based estimations, in a way that reflects their level of reliability and applicability;

(d) To guide the application of conservative adjustments (e.g., uncertainty discounts) where uncertainty exceeds acceptable thresholds, avoiding overestimation of mitigation outcomes;

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(e) To provide clear procedures for documenting and reporting uncertainty, facilitating third-party verification and public traceability;

(f) To encourage continuous improvement of data quality, monitoring practices, and quantification methodologies through regular reassessment of uncertainty assumptions and their impact on crediting.

4 Version

This document constitutes Public Consultation Version. June 17, 2025.

5 General terms

The following general terms apply for this Tool:

(a) "Shall" is used to indicate that the requirement shall be met;

(b) "Should" is used to suggest that, among several possibilities, a course of action recommended as particularly appropriate;

(c) "May" is used to indicate that it is permitted.

6 Normative references

The following normative documents are referenced in this Tool. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IPCC, 2000. Intergovernmental Panel on Climate Change (IPCC), Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Chapter 6: Quantifying Uncertainties in Practice.

IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and 2019 Refinement to the 2006 Guidelines.

ISO 14064-1:2018, Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

ISO 14064-2:2019, Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.

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ISO 14064-3:2019, Greenhouse gases – Part 3: Specification with guidance for the verification and validation of greenhouse gas statements.

7 Scope

This Tool applies to all mitigation activities that intend to generate Verified Carbon Credits (VCCs) under the BIOCARBON STANDARD, regardless of sector, scale, or methodology.

It provides a unified framework for the treatment of uncertainty in the estimation of GHG emission reductions and removals, including but not limited to:

(a) Activities in the Agriculture, Forestry and Other Land Use (AFOLU) sector (e.g., REDD+, afforestation, improved forest management, soil carbon);

(b) Non-AFOLU activities such as renewable energy, energy efficiency, industrial process optimization, waste management, and transportation.

The Tool covers uncertainty related to:

(a) Input data (e.g., activity data, emission/removal factors, model parameters);

(b) Quantification methods (e.g., measurement, modeling, baseline projection);

(c) Sampling, monitoring, and measurement systems;

(d) Aggregation and reporting of emission reductions and removals.

It is applicable throughout the project cycle, including project design, validation, verification, issuance, and renewal of quantification periods.

In cases where emission factors, activity data, and projections used in the quantification are demonstrably consistent with the national GHG inventory and reference scenario, the uncertainty adjustment described in this Tool may be waived. This condition shall be supported with appropriate evidence.

This Tool is to be used in conjunction with:

(a) The applicable methodology and its associated modules or tools;

(b) The BioCarbon Monitoring, Reporting and Verification (MRV) guidelines;

(c) The BioCarbon Validation and Verification Manual.

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In case of conflict between this Tool and a methodology or project document, this Tool shall prevail unless otherwise approved by the Standard.

8 Principles of uncertainty management

The following principles shall guide the identification, quantification, treatment, and reporting of uncertainty in the estimation of GHG emission reductions and removals:

Conservativeness

All estimates shall apply conservative assumptions, parameters, and models to avoid overestimation of mitigation outcomes. Where uncertainty is significant, results shall be adjusted downward based on predefined thresholds or discount factors as specified in this Tool.

Transparency

All input data, assumptions, formulas, models, and calculation steps used in uncertainty assessment shall be clearly documented, justified, and made available for third-party validation and public scrutiny. Methodologies shall include the necessary templates to enable transparent replication of uncertainty-related calculations.

Consistency and reproducibility

The same methods for estimating uncertainty shall be applied consistently across similar project types and over time. Results must be reproducible by independent reviewers, using the same data sources and procedures disclosed in the project documentation.

Credibility and data quality

The uncertainty assessment shall be based on the best available data. When multiple data sources exist, the most reliable and representative one shall be used. The source, scope, and limitations of each input shall be explicitly stated. The hierarchy of data sources and associated uncertainty discount factors (for example, project-specific vs. national vs. IPCC defaults) shall be applied in accordance with this Tool.

Continuous Improvement

Project developers and methodology developers shall reassess uncertainty estimates periodically as better data, models, or techniques become available. Lessons from monitoring, verification, and stakeholder input shall inform future revisions of uncertainty assumptions and procedures.

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9 Classification and sources of uncertainty

Uncertainty in GHG mitigation estimates arises from various sources that affect both baseline and project scenarios. Understanding the origin and nature of these uncertainties is essential to apply appropriate quantification methods and ensure that estimates remain conservative, credible, and verifiable.

Uncertainty shall be assessed at the level of individual input parameters and across the overall quantification approach, using either deterministic or probabilistic techniques as outlined in this Tool.

The main categories of uncertainty are described in the following sections.

9.1 Emission and removal factors

Uncertainties in emission or removal factors may result from measurement limitations, environmental variability, the use of generalized or default values, or assumptions about technology or management practices. These factors should be assessed for their representativeness and alignment with project conditions.

9.2 Activity data

Activity data refer to the extent or intensity of relevant human or natural processes (e.g., area affected, energy consumed, livestock numbers). Uncertainty may arise from measurement errors, inconsistent data collection methods, extrapolation from small samples, or lack of current information.

Where official or statistical data are used, their uncertainty shall be documented and, where possible, cross-checked or validated through independent sources or consistency checks.

9.3 Monitoring and measurement systems

Errors may be introduced through equipment calibration, sampling protocols, data processing procedures, or limitations in temporal or spatial resolution. These uncertainties should be addressed through quality assurance/quality control (QA/QC) procedures and described transparently.

9.4 Modeling and estimation methods

Models used to estimate GHG emissions or removals (such as allometric equations, soil carbon models, or baseline projection algorithms) may introduce structural uncertainty based on model assumptions, parameter sensitivity, or extrapolation. Model uncertainty shall be evaluated through sensitivity analysis or scenario comparisons when applicable.

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9.5 Expert judgment

When data are unavailable or incomplete, expert judgment may be used to estimate values or uncertainty ranges. In such cases, the selection of experts, elicitation method, and logical basis for assumptions must be documented. Where feasible, uncertainty ranges derived from expert judgment shall be expressed using a probability distribution or confidence interval.

9.6 Correlation and dependency

Some parameters may be interrelated (e.g., biomass and soil carbon; activity data used in both baseline and project scenarios). Where such dependencies exist, they shall be clearly identified and treated appropriately in the aggregation of uncertainty, especially under probabilistic approaches.

10 Quantification of uncertainty

Uncertainty shall be quantified for all parameters that significantly influence the estimation of greenhouse gas emission reductions or removals. Project holders shall assess the combined uncertainty of baseline and project scenario estimates using either a simplified deterministic method (Tier 1) or a probabilistic method (Tier 2), as defined in this Tool.

The selected approach shall be appropriate to the complexity of the project, the availability and quality of data, and the methodological framework applied.

10.1 Tier 1: Error propagation method

The Tier 1 method applies simplified statistical rules to combine uncertainties across parameters. It is suitable when the underlying uncertainties can be expressed using approximate confidence intervals and are assumed to be independent.

10.1.1 Rule A – Addition of uncertain quantities

When the total is calculated as the sum of components, the combined uncertainty is computed as the square root of the sum of squared uncertainties of the components, expressed in absolute terms.

10.1.2 Rule B – Multiplication of uncertain quantities

When the total is calculated by multiplying components (e.g. emission factor × activity data), the relative uncertainties (as percentages) are combined using the square root of the sum of their squares.

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10.1.3 Confidence interval

Unless otherwise stated, a two-sided 90 percent confidence interval shall be used. The relative half-width of the interval, expressed as a percentage of the mean estimate, shall be used to assess whether conservative adjustments are required, in accordance with section 10.

10.1.4 Limitations and assumptions

The Tier 1 method assumes that uncertainties are normally distributed and uncorrelated. In cases of skewed distributions or known correlations between parameters, a more detailed assessment using Tier 2 is recommended.

10.2 Tier 2: Probabilistic approach

Tier 2 involves the use of Monte Carlo simulation or other suitable techniques to estimate the probability distribution of emission reductions or removals, based on defined input distributions for each parameter.

This method allows for:

(a) Use of non-normal or asymmetric probability distributions;

(b) Explicit treatment of correlation between parameters;

(c) More precise estimation of the confidence interval for the final result.

Guidance for Monte Carlo analysis is provided in section 12 of this Tool.

10.3 Aggregation of uncertainties

Regardless of the tier applied, the combined uncertainty shall reflect all relevant sources of uncertainty identified in section 9. It shall include uncertainties from both baseline and project scenarios and shall be expressed as a percentage of the net GHG benefit. Project holders shall document all calculations and assumptions used to derive the final uncertainty value.

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11 Thresholds, adjustments and rounding requirements

This section establishes mandatory thresholds for acceptable uncertainty levels and defines the procedures to apply conservative adjustments and rounding rules. These requirements shall be applied consistently to all methodologies and mitigation activities under the BIOCARBON STANDARD.

11.1 Quantification of the confidence interval

Project holders shall quantify the uncertainty associated with both baseline and project scenario estimates using a two-sided 90 percent confidence interval. The result shall be expressed as a relative half-width, calculated as a percentage of the estimated value (e.g. ±X%).

The combined uncertainty shall be assessed over the net GHG emission reductions or removals resulting from the difference between baseline and project estimates.

11.2 Adjustment for high uncertainty

If the calculated relative half-width of the 90 percent confidence interval exceeds 30 percent, the excess shall be deducted from the estimated GHG benefit as a conservative adjustment.

Example:

Net GHG estimated (before adjustment): 1,000 tCO_2e

Relative half-width of 90% confidence interval: 38%

Adjustment: (38 – 30)% × 1,000 = 80 tCO_2e

Adjusted GHG result: 920 tCO_2e

This adjustment shall be applied before issuance or rounding of Verified Carbon Credits (VCCs).

11.3 Exemption based on consistency with national data

If the data and parameters used to quantify GHG reductions or removals are demonstrated to be fully consistent with the national GHG inventory and reference scenario, including emission factors, activity data, and projection methods, then the conservative adjustment defined in section 11.2 shall not apply.

Such consistency shall be explicitly documented in the methodology or project design documentation.

11.4 Rounding rule

The final number of Verified Carbon Credits (VCCs) eligible for issuance shall be rounded down to the nearest whole metric ton of CO_2 equivalent prior to issuance.

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This rounding step shall be performed after any uncertainty adjustment has been applied.

11.5 Transparency and replicability

Project holders shall provide supporting spreadsheets or calculation modules that enable independent verification of:

(a) the confidence interval calculation;

(b) the application of the adjustment (if applicable);

(c) the final rounding step.

These elements are mandatory for methodology approval and shall remain unchanged in subsequent revisions unless modified by the Program through a formal public consultation process.

12 Advanced methods (Tier 2 – probabilistic approach)

Where appropriate and feasible, uncertainty may be assessed using a probabilistic approach. Tier 2 methods allow for a more accurate representation of uncertainty through the use of probability distributions, scenario variability, and correlation structures among input parameters.

This approach is recommended when:

(a) Input data are non-normally distributed or highly skewed;

(b) Multiple sources of uncertainty interact in non-linear ways;

(c) Key variables are known to be correlated, or

(d) Tier 1 results approach critical thresholds for conservativeness.

12.1 Overview of Monte Carlo analysis

Monte Carlo simulation is a statistical method that estimates the uncertainty in a result by randomly sampling input variables from their probability distributions. It produces a probability distribution for the final GHG estimate, from which confidence intervals and conservative values can be derived.

Monte Carlo simulations generally follow these steps:

(a) Define distributions for all key input variables (e.g. activity data, emission factors);

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(b) Specify correlation between variables if applicable;

(c) Run multiple simulations, each time selecting random input values and calculating GHG outcomes;

(d) Aggregate results to estimate the mean and confidence intervals of the total emission reductions or removals.

12.2 Selection and justification of probability distributions

Project holders shall define appropriate probability distributions for all uncertain input variables. These may include normal, lognormal, triangular or uniform distributions, depending on the nature of the data and variability observed.

Distributions shall be based on:

(a) Measured data and statistical analysis (preferred);

(b) Peer-reviewed literature or national databases;

(c) Expert judgment (when no empirical data are available, following the protocol in Annex F).

Assumptions about the shape, range, and mean of distributions shall be justified and documented.

12.3 Treatment of correlation and dependency

If input variables are known or likely to be correlated (e.g. forest biomass and soil carbon), these dependencies shall be explicitly addressed in the simulation. Software used for simulation shall allow specification of correlation coefficients or rank correlation matrices.

If correlation is not specified, the default assumption shall be that inputs are independent.

12.4 Software and computational tools

Monte Carlo simulations shall be conducted using appropriate software platforms that allow transparent definition of input distributions and reproducible processing. Examples include, but are not limited to:

(a) Excel-based add-ins (e.g. @Risk, Crystal Ball);

(b) R, Python or other open-source statistical tools;

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(c) Custom-built models, provided they are publicly documented.

All simulation files, input assumptions, and raw outputs shall be available for verification.

12.5 Convergence and sampling size

A sufficient number of iterations shall be conducted to ensure stability of results. The recommended minimum is 1,000 iterations, or until the estimated mean and 90 percent confidence interval do not vary by more than ±1 percent across three successive runs.

Project holders shall report convergence diagnostics and provide a histogram or cumulative distribution function (CDF) of the simulation results.

13 Sector-specific applications

Uncertainty management shall reflect the specific characteristics and data requirements of each sector. This section outlines considerations and requirements specific to land-based mitigation activities and other sectors covered by the BIOCARBON STANDARD.

13.1 Agriculture, forestry and other land use (AFOLU)

AFOLU projects often involve biological processes, spatial variability, and measurement limitations that contribute to higher inherent uncertainty. To address these requirements, project holders shall follow the provisions described in the following sections.

13.1.1 Data quality and discount factors

When estimating GHG removals or avoided emissions based on biomass, soil carbon, or similar parameters, project holders shall apply discount factors linked to the origin and quality of input data, following the tiered structure presented in Annex B.

Discounts shall be applied unless the project demonstrates consistency with national GHG inventory parameters and justifies the reliability of site-specific data.

13.1.2 Use of default values

Project holders may use default values (e.g. emission factors, root-to-shoot ratios, basic wood density) when project-specific or national values are unavailable. In such cases:

(a) Values shall be selected conservatively (e.g. using the lower bound of a range for carbon stocks);

(b) Priority shall be given to geographically and ecologically relevant data sources;

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(c) The selection rationale shall be documented.

13.1.3 Stratification and sampling

AFOLU projects shall apply spatial stratification where relevant, to improve the accuracy and reduce the uncertainty of sampling. Sampling design shall be statistically valid and appropriate for the spatial heterogeneity of the project area.

13.1.4 Carbon stock change estimation

Where change in carbon stocks is calculated as the difference between two measurements (e.g. t1 and t2), project holders shall:

(a) Use either independent or paired plot remeasurement methods;

(b) Quantify uncertainty using appropriate equations (see Annex A);

(c) Apply conservative adjustments if the relative uncertainty exceeds 10 percent, as specified in section 10.

13.2 Non-AFOLU sectors

In energy, transport, and waste sectors, uncertainty is typically lower due to more standardized measurement systems and monitoring equipment. Nevertheless, project holders shall:

(a) Quantify uncertainty in key parameters such as fuel consumption, baseline energy use, or waste generation,

(b) Document the accuracy class or calibration certificates of monitoring devices,

(c) Apply Tier 1 or Tier 2 methods, as appropriate to data availability and project complexity.

Where national regulations, grid data, or industry benchmarks are used, their uncertainty shall be transparently assessed and documented.

14 Documentation and reporting requirements

All uncertainty assessments shall be documented in a transparent and verifiable manner to support validation, verification, and program-level review. Project holders shall prepare and maintain complete records of all assumptions, data sources, calculation procedures, and results related to uncertainty quantification.

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14.1 General requirements

Project holders shall include the following in the Project Document (PD) and Monitoring Report (MR), as applicable:

(a) A description of all parameters with associated uncertainty levels;

(b) The method used to combine individual uncertainties (e.g. Tier 1 or Tier 2);

(c) The final combined uncertainty as a percentage of the net GHG benefit;

(d) Any conservative adjustments applied due to exceeding uncertainty thresholds;

(e) The final number of Verified Carbon Credits (VCCs) after adjustment and rounding.

Where the data used meet the criteria for exemption from the conservativeness deduction due to full consistency with the national GHG inventory and reference scenario, project holders shall document this condition clearly in the Project Document or Monitoring Report. The justification shall include supporting evidence demonstrating alignment in emission factors, activity data, and projection parameters.

14.2 Spreadsheet and tool requirements

Project holders shall provide supporting spreadsheets or calculation files that:

(a) Allow replication of uncertainty calculations;

(b) Clearly identify input data, formulas, and intermediate results;

(c) Include embedded documentation or references for all parameters and distributions;

(d) Allow verification of adjustments and rounding procedures.

Templates and guidance are provided in Annex G of this Tool.

14.3 Expert judgment

Where expert judgment is applied, the justification and elicitation process shall be documented following the protocol outlined in Annex F. The documentation shall include:

(a) Expert qualifications and affiliation;

(b) The variables estimated using expert judgment;

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(c) The elicitation method used (e.g. fixed probability, percentiles);

(d) The resulting distribution or confidence interval;

(e) Supporting evidence and assumptions.

14.4 Versioning and traceability

Any revision to uncertainty assumptions or calculation methods shall be documented, justified, and traceable across project versions. For recurring quantification periods, updated calculations shall be clearly distinguished from prior submissions.

15 Review, reassessment and version control

This section defines the requirements for reviewing and updating uncertainty assessments over time. All changes to uncertainty-related assumptions, data sources, or calculation methods shall be documented, justified, and tracked.

15.1 When reassessment is required

Project holders shall reassess uncertainty estimates in the following cases:

(a) Updates to the methodology or applicable modules that affect input parameters, models, or calculation procedures;

(b) Availability of new data sources (e.g. national inventory data, local measurements, scientific publications);

(c) Changes to the monitoring approach, sampling design, or measurement equipment;

(d) Extension or renewal of the quantification period;

(e) Significant deviation between ex-ante and ex-post measurements.

Reassessment may also be recommended by the Program as part of continuous improvement or category-level updates.

15.2 Documentation of changes

Any revision to uncertainty inputs or calculation procedures shall be:

(a) Documented in the Monitoring Report (MR) or revised Project Document (PD);

(b) Clearly marked as an update to prior submissions;

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(c) Accompanied by an explanation of the rationale and expected impact on the results;

(d) Supported by updated spreadsheet tools, if applicable.

Versioning of files, tables, and model versions shall be implemented to ensure full traceability.

15.3 Methodological consistency

Revisions to uncertainty assumptions shall remain consistent with the applicable version of this Tool and with the methodology under which the project is registered. If a new version of this Tool becomes mandatory, project holders shall apply it from the effective date specified by the Program.

Transitional guidance may be issued where needed to support orderly implementation of updated requirements.

16 References

AEA (1998). Technology, Treatment of Uncertainties for National Greenhouse Gas Emissions, Report AEAT 2688-1, 1998.

Cullen, A. C., & Frey, H. C. (1999). Probabilistic Techniques in Exposure Assessment: A Handbook for Dealing with Variability and Uncertainty in Models and Inputs. Plenum Press.

Frey, H. C., & Rhodes, D. S. (1996). Characterizing, Simulating, and Analyzing Variability and Uncertainty: An Illustration of Methods Using an Air Toxics Emissions Example. Human and Ecological Risk Assessment, 2(4), 762–797.

Morgan, M. G., & Henrion, M. (1990). Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis. Cambridge University Press.

Wackerly, D. D., Mendenhall III, W., & Scheaffer, R. L. (1996). Mathematical Statistics with Applications. Duxbury Press.

United States Environmental Protection Agency (US EPA), Guiding Principles for Monte Carlo Analysis, EPA/630/R-97/001, 1997.

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Annex A. General requirements on uncertainty management and conservative rounding

This annex consolidates the program-level rules applicable to methodologies under the BioCarbon Standard regarding the quantification of uncertainty, conservative deductions, and rounding. These provisions are mandatory and shall be followed by the project holders.

A.1. Quantification of Uncertainty

Project holders shall quantify the uncertainty of baseline and project emissions or removals by calculating a two-sided 90 percent confidence interval, based on the best available data and statistical techniques. The relative half-width of this interval shall be computed as a percentage of the estimated value.

A.2. Conservativeness Adjustment

If the calculated relative half-width exceeds 30 percent, the excess percentage shall be deducted from the estimated emission reductions or removals to ensure environmental integrity and maintain conservativeness.

A.3. Rounding Rule

The final net quantity of Verified Carbon Credits (VCCs) eligible for issuance shall be rounded down to the nearest whole metric ton of CO_2-equivalent prior to issuance.

A.4. Transparency and Reproducibility

Methodologies shall provide accompanying spreadsheets or calculation modules that allow for independent replication of:

(a) the confidence interval calculation,

(b) the conservativeness deduction (if applicable),

(c) and the rounding step.

These provisions ensure that all credited mitigation outcomes reflect a high degree of statistical confidence and conservativeness, in line with recognized best practices for uncertainty management in GHG accounting.

If the data and parameters applied to estimate the reduction or removal of GHG emissions shall be consistent with the emission factors, activity data, projection of GHG emissions, and the other parameters used to construct the inventory national of GHG

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and the national reference scenario. If this is the case, then it is unnecessary to apply the percentages defined for the discount factor for managing uncertainty.

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Annex B. Equations and error propagation (Tier 1)

This annex presents the equations used to calculate combined uncertainty using the Tier 1 approach, in accordance with the IPCC Good Practice Guidance. These formulas shall be applied when using a deterministic (non-probabilistic) method for combining uncertainty across parameters.

Two main rules are used, depending on whether the parameters are added (e.g. emissions from multiple sources) or multiplied/divided (e.g. emission factor × activity data).

B.1 Addition of uncertain quantities (Rule A)

When multiple uncertain quantities are added (e.g. total emissions from multiple sources), the **absolute uncertainties** are combined and is calculated as follows:

$$U_{total} = \sqrt{(U_1)^2 + (U_2)^2 + \cdots + (U_n)^2}$$

Where:

U_{total}	the combined uncertainty (same units as the inputs, e.g. tCO_2e)
U_1, U_2,..., U_3	the absolute uncertainties of each individual term

This rule applies when the result is a sum or difference, and uncertainties are expressed in absolute units.

B.2 Combined uncertainty for multiplication or division (Rule B)

When the result is the product or quotient of uncertain variables (e.g. emission = activity data × emission factor), the **relative uncertainties** (percentages) are combined using:

$$U_{total} = \sqrt{(U_{r1})^2 + (U_{r2})^2 + \cdots + (U_{rn})^2}$$

U_{total}	the combined relative uncertainty (as a percentage)
U_{r1}, U_{r2},..., U_{r3}	the uncertainties of each individual term in the sum

This rule applies when the result is a product or quotient, and all inputs are independent.

B.3 Confidence interval

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Uncertainty shall be expressed as a two-sided 90 percent confidence interval, unless otherwise specified.

To calculate the relative half-width:

$$Relative\ uncertainty\ = \left(\frac{Upper\ bound\ - Lower\ bound}{2 \times Mean\ estimate}\right)x100$$

This value is used to determine whether conservative adjustments are required (see Section 13 of the Tool).

B.4 Example (illustrative)

Given:

- Activity data = 10,000 MWh ± 5%
- Emission factor = 0.45 tCO_2/MWh ± 3%

Using Rule B (multiplication):

$$U_{total} = \sqrt{(5)^2 + (3)^2} = \sqrt{25+9} = \sqrt{34} \approx 5.83\%$$

Total emissions = 10,000 × 0.45 = 4,500 tCO_2
Uncertainty = ±5.83% × 4,500 = ±262.5 tCO_2

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Annex C. Methods for estimating uncertainty in forest carbon stock changes (AFOLU)

The following methods describe approaches for estimating uncertainty in tree carbon stock changes based on sample plot measurements. These procedures are applicable to AFOLU projects involving the estimation of aboveground and/or belowground tree biomass through repeated field measurements. This includes activities such as afforestation, reforestation, natural regeneration (ARR), improved forest management (IFM), and certain REDD+ interventions where biomass accumulation is directly monitored.

Two approaches are provided below:

(a) Estimation based on independent carbon stock measurements at two points in time, and

(b) Direct estimation of change from plot re-measurement.

Note: These methods are not applicable to projects focusing on soil carbon or non-tree biomass components (e.g. grasses, crops) and are not designed for REDD+ activities that model avoided deforestation without field-based measurement of biomass accumulation.

C.1 Difference of two independent stock estimations

Change in carbon stock in trees is estimated as the difference between two successive and independent carbon stock estimations.

This is method is efficient when the correlation between the plot biomass values on the two occasions is absent or weak (e.g. when there has been harvest or disturbance in a stratum after the first estimation, resulting in spatial re-distribution of tree biomass in the stratum).

Under this method, the change in carbon stock and the associated uncertainty are estimated as follows:

$$\Delta C_{TREE} = C_{TREE,t2} - C_{TREE,t1}$$

$$\mu_{\Delta C} = \frac{\sqrt{\left(\mu_1 \ x \ C_{TREE,t1}\right)^2 + \left(\mu_2 \ x \ C_{TREE,t2}\right)^2}}{|\Delta C_{TREE}|}$$

Where:

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ΔC_{TREE}	=	Change in carbon stock in trees during the period between two points of time t_1 and t_2; t CO_{2e}
$C_{TREE,t1}$	=	Carbon stock in trees as estimated at time t_1; t CO_{2e} Note 1. At the first verification $C_{TREE,t1}$ is set equal to the carbon stock in the pre-project tree biomass (i.e. $C_{TREE,t1}$=$C_{TREE,lb}$). However, this may be set equal to zero, if all of the conditions specified under paragraph 10 of the Tool are met. Note 2. . Even if $C_{TREE,t1}$ was made conservative at the time of previous verification, it is the estimated (undiscounted) value of $C_{TREE,t1}$ that is used here.
$C_{TREE,t2}$	=	Carbon stock in trees as estimated at time t_2; t CO_{2e}
$\mu_{\Delta C}$	=	Uncertainty in ΔC_{TREE}
μ_1, μ_2	=	Uncertainty in $C_{TREE,t1}$ y $C_{TREE,t2}$ respectively

C.2. Direct estimation of change by re-measurement of sample plots

This method is applicable only in ex-post estimation of change in carbon stock in trees for monitoring of project activities. Under this method, the same sample plots are measured on two successive occasions and the plot-level change in biomass is obtained by subtracting the plot biomass on the first occasion from the plot biomass on the second occasion.

This is method is efficient when there is a significant correlation between the plot biomass values on the two occasions (e.g. when there has been no harvest or disturbance in a stratum and therefore no significant spatial re-distribution of biomass has occurred in the stratum after the first estimation).

Under this method, the change in carbon stock and the associated uncertainty are estimated as follows:

$$\Delta C_{TREE} = \frac{44}{12} \times CF_{TREE} \times \Delta B_{TREE}$$

$$\Delta B_{TREE} = A \times \Delta b_{TREE}$$

$$\Delta b_{TREE} = \sum_{i=1}^{M} w_i \times \Delta b_{TREE,i}$$

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$$\mu_{\Delta C} = \frac{t_{VAL} \times \sqrt{\sum_{i=1}^{M} w_i{}^2 \times \frac{s_{\Delta,i}^2}{n_i}}}{|\Delta b_{TREE}|}$$

Where:

ΔC_{TREE}	=	Change in carbon stock in trees between two successive measurements; t CO2e
CF_{TREE}	=	Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$ A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value.
ΔB_{TREE}		Change in tree biomass within the biomass estimation strata; t d.m.
A		Sum of areas of the biomass estimation strata; ha
Δb_{TREE}		Mean change in tree biomass per hectare within the biomass estimation strata; t d.m. ha^{-1}
w_i		Ratio of the area of stratum i to the sum of areas of biomass estimation strata (i.e. $w_i = {A_i}/{A}$); dimensionless
$\Delta b_{TREE,i}$		Mean change in carbon stock per hectare in tree biomass in stratum i; t d.m. ha^{-1}
$\mu_{\Delta C}$		Uncertainty in ΔC_{TREE}
t_{VAL}		Two-sided Student's t-value for a confidence level of 90 per cent and degrees of freedom equal to n – M, where n is total number of sample plots within the tree biomass estimation strata, and M is the total number of tree biomass estimation strata
$s_{\Delta,i}^2$		Variance of mean change in tree biomass per hectare in stratum i; (t d.m. ha-1)^2
n_i		Number of sample plots, in stratum i, in which tree biomass was re-measured

Under this method, the change in carbon stock and the associated uncertainty are estimated as follows:

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$$\Delta b_{TREE,i} = \frac{\sum_{p=1}^{n_i} \Delta b_{TREE,p,i}}{n_i} \quad \text{Equation (7)}$$

$$s_{\Delta,i}^2 = \frac{n_i \times \sum_{p=1}^{n_i} \Delta b_{TREE,p,i}^2 - \left(\sum_{p=1}^{n_i} \Delta b_{TREE,p,i}\right)^2}{n_i \times (n_i - 1)} \quad \text{Equation (8)}$$

Where:

$\Delta b_{TREE,i}$	=	Mean change in carbon stock per hectare in tree biomass in stratum i; t d.m. ha^{-1}
$\Delta b_{TREE,p,i}$		Change in tree biomass per hectare in plot p in stratum i; t d.m. ha^{-1}
$s_{\Delta,i}^2$	=	Variance of mean change in tree biomass per hectare in stratum i; (t d.m. ha-1)^2
n_i	=	Number of sample plots, in stratum i, in which tree biomass was re-measured

For both of the above cases (sections C.1 and C.2), if $\mu_{\Delta C}$ is greater than 10 per cent, ΔC_{TREE} is made conservative by applying uncertainty discount according to the following procedure.

Uncertainty discount factors

Uncertainty	Discount (% of μ)	How applied
μ ≤ 10%	0%	Estimated mean = 60±9 t d.m/ha i.e. μ=9/60x100 = 15% Discount=25%x9=2,25 t d.m/ha Discounted conservative mean: In baseline=60±2,25=62,25 t d.m/ha In project=60-2,25=57,75 t d.m/ha
10 < μ ≤ 15	25%	
15 < μ ≤ 20	50%	
20 < μ ≤ 30	75%	

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Annex D. Data quality discount tables

This annex defines standardized discount factors to be applied to estimated GHG removals or avoided emissions when input data are of limited quality or general applicability. These discounts shall be used to manage uncertainty conservatively in AFOLU projects, particularly for carbon stock estimations based on biomass, soil carbon, and related parameters.

Discounts shall be applied unless the project holder demonstrates that the data and estimation methods are consistent with national GHG inventory parameters and are not subject to additional uncertainty discounting, as defined in section 13 of this Tool.

D.1. Discount factors by data source and estimation approach

Source of the estimation model and data/parameters	**Discount factor (%)**
Project-specific above-ground and below-ground biomass data, and density values of the project	0
Project-specific above-ground biomass data and (R:S)[i] for below-ground biomass factor	5
Regional above-ground and below-ground biomass data	10
Regional above-ground data[ii] and (R:S) factor for below-ground biomass	15
National data for above-ground and below-ground biomass	15
National data for above-ground and (R:S) factor for below-ground biomass	20
Above-ground and below-ground biomass data from other countries or regions with similar environmental conditions (climate-soils)	25
Above-ground biomass data and (R:S) factor for below-ground biomass from other countries or regions with similar environmental conditions (climate-soils)	30
Project-specific density values and factor (R:S) for below-ground biomass	15
IPCC density values and factor (R:S) for below-ground biomass	10
Volume equations from other countries or IPCC data, in areas with similar environmental conditions (climate-soils), IPCC density, and (R:S) factor for below-ground biomass	Up to 30

Notes:
(i) The R:A ratio refers to root-to-shoot ratio used to estimate belowground biomass
The discount shall be applied to the net GHG results prior to rounding and credit issuance

D.2. Application

The appropriate discount factor shall be selected based on the lowest-quality data tier used in the estimation chain.

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The discount shall be expressed as a percentage deduction from the estimated GHG benefit (in tCO_2e).

Multiple discount sources shall not be compounded; the highest applicable discount shall prevail.

If uncertainty is quantified explicitly through confidence interval analysis (per Section 13), and already adjusted through conservativeness deductions, these quality-based discounts may be waived, provided justification is documented.

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Annex E. Monte Carlo simulation – process and example

This annex outlines the general process and basic requirements for implementing a Tier 2 uncertainty assessment using Monte Carlo simulation. This method is appropriate when input parameters follow non-normal distributions, are correlated, or when Tier 1 methods are insufficient to capture the structure of uncertainty.

E.1 Process overview

Monte Carlo simulation involves repeated random sampling from input probability distributions to calculate a distribution of possible results for net GHG emission reductions or removals.

The typical steps are as follows:

Define input distributions

Specify the probability distribution (e.g. normal, lognormal, triangular) for each key input variable (e.g. emission factor, activity data, biomass increment rate), including:

(a) Mean (or most likely value),

(b) Lower and upper bounds,

(c) Justification for the selected distribution type.

Specify correlation (if applicable)

Identify any correlations between variables (e.g. biomass and density) and define their strength using correlation coefficients or rank correlation matrices.

Configure the simulation

Use appropriate software to model the GHG estimation equation and input distributions. Set the number of iterations (typically ≥1,000).

Run simulations

For each iteration, the model randomly samples values for each input and computes the corresponding result. After many iterations, the model generates a probability distribution of the output (e.g. net tCO_2e).

Analyze outputs

Determine:

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(a) Mean and median values;

(b) Confidence interval (typically the 5th and 95th percentiles);

(c) Relative half-width of the 90% confidence interval;

(d) Histogram or cumulative distribution function (CDF).

Apply adjustment if required

If the relative half-width of the confidence interval exceeds 30%, a conservativeness deduction shall be applied, as defined in Section 13 of this Tool.

E.2 Example (simplified)

Objective: Estimate uncertainty in GHG removals from forest growth over one year.

Inputs

Mean annual biomass growth: 6.5 t dry matter/ha/year

→ Lognormal distribution ($\mu = 6.5$, $\sigma = 1.2$)

Carbon fraction of biomass: 0.47 (fixed)

Project area: 1,000 ha (fixed)

Equation

$$GHG\ removals = Growth \times Carbon\ Fraction \times Area \times \frac{44}{12}$$

Simulation

- 5,000 iterations using random sampling of biomass growth
- Emissions estimated per iteration, output stored

Result

Mean estimate: 11,332 tCO_2e

90% confidence interval: 9,880 to 12,640 tCO_2e

Relative half-width

$$\frac{(12{,}640 - 9{,}880)}{2 \times 11{,}332} \approx 12.2\%$$

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→ No deduction required

E.3 Software options

Monte Carlo simulation may be performed using:

(a) Excel-based tools with add-ins (e.g. @Risk, Crystal Ball);

(b) Open-source platforms (e.g. R, Python with NumPy and SciPy);

(c) Custom-built models, provided they are documented and reviewable.

Simulation files and assumptions shall be submitted as part of the Monitoring Report or validation information and data for review.

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Annex F. Sample uncertainty calculations by sector

This annex presents illustrative examples of how to apply uncertainty quantification in different sectors under the BioCarbon Standard. These examples are simplified for clarity and are not exhaustive.

F1. AFOLU example (ARR activities)

Project context

An ARR project aims to restore degraded forest over 500 hectares. Biomass carbon accumulation is monitored using field plots.

Parameter	**Value**	**Uncertainty (%)**	**Source**
Average aboveground biomass gain	6.8 t d.m./ha/year	±15	Field sampling, regional eq.
Carbon fraction of biomass	0.47	±0 (fixed)	IPCC default
Root-to-shoot ratio (R:S)	0.28	±20	IPCC default (Tier 1)
Project area	500 ha	±0 (fixed)	Geospatial measurement

Step 1. Estimate carbon stock change

Total biomass = 6.8 x 1.28 = 8.704 t.d.m./ha/year

Total C = 8.704 x 0.47 = 4.091 t C/ha/year

GHG result = 4.091 x 500 x (44/12) = 75,006 tCO_2e/year

Step 2. Combine uncertainty (Tier 1 – Rule B)

$$U_{total} = \sqrt{(15)^2 + (20)^2} = \sqrt{625} = 25\%$$

Uncertainty (tCO_2e) = 25% x 75,006 = 18,751

Final result

Estimated GHG result: 75,006 tCO_2e/year

90% Cl: ±25% → 56,255 to 93,757 tCO_2e

Relative half-width: 25%

→ No deduction required, but close o threshold

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F.2. Non-AFOLU example – Fuel switch from heavy fuel oil to natural gas

Project context

A ceramics production facility replaces its heavy fuel oil (HFO) burners with high-efficiency natural gas burners. The switch reduces the carbon intensity of thermal energy generation while maintaining the same energy output.

Quantification period: 1 year

Parameter	Value	Uncertainty (%)	Source
Annual energy demand	2,000 MWh	±2%	Calibrated energy meter
Emission factor (HFO, baseline)	267 kg CO_2/MWh	±5%	National inventory
Emission factor (natural gas, project)	202 kg CO_2/MWh	±4%	National inventory

Step 1. Estimate net GHG emission reductions

Baseline emissions = 2,000 x 267 = 534,000 kg CO_2 = 534 tCO_2

Project emissions = 2,000 x 202 = 404,000 kg CO_2 = 404 tCO_2

GHG results = 534 – 404 = 130 tCO_2

Step 2. Combine uncertainty (Tier 1, Rule B)

Here we combine relative uncertainties from both emission factors and the energy data. For net GHG reductions, we calculate propagated uncertainty from both baseline and project scenarios.

$$U_{baseline} = \sqrt{(2)^2 + (5)^2} = \sqrt{29} = 5.39\%$$

$$U_{project} = \sqrt{(2)^2 + (4)^2} = \sqrt{20} = 4.47\%$$

Since both values are subtracted, the uncertainties are combined as absolute values:

$$U_{GHG} = \sqrt{(0.0539\ x\ 534)^2 + (0.0447\ x\ 404)^2} = \sqrt{(28.8)^2 + (18.1)^2} = \sqrt{1{,}229{,}4} \approx 35.1\ tCO_2$$

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Step 3. Result with confidence interval

$$Relative\ uncertainty\ = \left(\frac{35.1}{130}\right) \times 100 \approx 27.0\%$$

Then, express the 90% confidence interval

130 − 35.1 = 94.9 tCO_2 (lower limit)

130 + 35.1 = 165.1 tCO_2 (upper limit)

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Annex G. Expert judgment protocol and documentation template

This annex establishes the procedure and minimum requirements for the use of expert judgment in the quantification of uncertainty, in cases where empirical data are not available or are insufficient. It also provides a template for documenting the elicitation process to ensure transparency, reproducibility, and credibility.

G.1 Purpose and applicability

Expert judgment may be used to:

(a) Estimate values for parameters lacking direct measurement;

(b) Define uncertainty ranges (e.g. lower and upper bounds of a confidence interval);

(c) Select appropriate probability distributions;

(d) Support model assumptions or boundary conditions.

Use of expert judgment shall be limited to cases where no suitable empirical data, literature sources, or national statistics are available. It shall be considered a last resort and subject to full documentation.

G.2 Elicitation protocol

Project holders shall follow a structured elicitation process that includes the following steps:

Motivation

Define the purpose of the expert input and explain the context of its application (e.g. parameter used in the baseline model, data gap in biomass estimation).

Structuring

Clearly describe the quantity to be estimated, including:

(a) Variable name and units;

(b) Temporal and geographic context;

(c) Assumptions and conditions.

Conditioning

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Provide all relevant supporting materials (e.g. related studies, partial data, analogous cases) to help the expert form a well-grounded estimate.

Encoding

The expert shall provide a best estimate (e.g. mean or most likely value) along with upper and lower bounds representing a two-sided 90% confidence interval. If applicable, the expert may also define the shape of a probability distribution (e.g. triangular, normal, lognormal).

Verification

The expert's responses shall be reviewed for internal consistency and clarity. Feedback shall be provided to confirm that the documented information accurately reflects the expert's intent.

G.3 Documentation template

Each use of expert judgment shall be documented using the following template:

Field	**Description**
Expert name and affiliation	Full name, institution or company
Date of elicitation	Date of interview or submission
Parameter name	Variable name and units
Purpose/context	Why expert input is needed; where it is used
Best estimate	Most likely value or mean
Lower bound (90% CI)	Value with 5% probability of being exceeded downward
Upper bound (90% CI)	Value with 5% probability of being exceeded upward
Distribution type (if applicable)	Normal, lognormal, triangular, etc.
Basis for judgment	Supporting evidence or logic
Review by project holder	Signature and date of person who reviewed and accepted the input
Comments	Additional notes if needed

G.4 Quality control and review

All expert judgments are subject to validation by the VVB. They shall be accompanied by the completed documentation form and any additional information requested. Where

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expert input is a key driver of GHG benefit estimation, reviewers may require additional justification or independent verification.

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Annex H. Uncertainty reporting table (adapted from IPCC Table 6.1)

This annex provides a standardized table for reporting uncertainty at the parameter and project level. Project holders shall use this template when applying the Tier 1 (error propagation) approach for estimating the combined uncertainty in GHG emission reductions or removals.

H.1. Table structure

#	Parameter or source	Value	Units	Relative uncertainty (%)	Uncertainty type	Source of data	Used in (baseline/project/both)
1	**Activity data (e.g. fuel use)**	120,000	Liters	5	Input	On-site meter	Project
2	**Emission factor (diesel)**	2.68	kg CO_2/liter	3	Input	National inventory	Both
3	**Carbon fraction**	0.47	t C/t biomass	0	Fixed	IPCC default	Both

H.2. Project-level uncertainty summary

Calculation	Value	Units
Estimated net GHG benefit	321.6	tCO_2e
Combined uncertainty (U_{total})	5.83	%
Uncertainty (tCO_2e)	18.75	tCO_2e
90% confidence interval (CI)	[302.9, 340.3]	tCO_2e
Relative half-width of CI	5.83	%
Deduction applied (if any)	0.0	tCO_2e
Final GHG benefit after deduction	321.6	tCO_2e
Rounded VCCs eligible for issuance	321	tCO_2e

H.3. Instructions for use

- Use one row per uncertain input parameter (activity data, emission factor, etc.).
- Classify the uncertainty as Input, Model, or Fixed.
- Enter data sources clearly (e.g. "On-site measurement", "IPCC default", "Regional study").

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- Uncertainty values shall reflect a two-sided 90% confidence interval.
- Use Section 11 (Tier 1) for calculating combined uncertainty.
- The "Final GHG benefit after deduction" reflects any deduction applied as per Section 12.
- The "Rounded VCCs" shall follow the rounding rule defined in Section 11.4.

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History of document

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