ECORA Carbon Credit Certification Program

Document: MOEC002 – Uncertainty Quantification Module

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1. Acronyms and Definitions

Term	Definition
Accuracy	Accuracy of a measurement; closeness between the estimate of a parameter and its true value.
Agriculture, Forestry and Other Land Use (AFOLU)	The sector defined by the IPCC that brings together Agriculture, Forestry, and Other Land Use activities used in the accounting of emission reductions or GHG removals.
Baseline Scenario (BS)	Reference scenario quantified against which the mitigation effects of GHG provided by the project are measured, representing the emissions and/or removals that would occur in the absence of the implementation of the Project Activity, serving as a parameter to calculate the climate benefits generated.
Bias	The systematic difference between the expected value of an estimator and the true value of the parameter to be estimated.
Carbon Dioxide Equivalent (CO_2e)	Standard unit that represents the conversion of other greenhouse gases into CO_2e, to compare the radiative forcing of a greenhouse gas with Carbon Dioxide.
Coefficient of Variation	The coefficient of variation is a measure of relative dispersion that represents the standard deviation of a data set expressed as a percentage of the mean. It is obtained by the ratio between the standard deviation and the mean of the data set.
Confidence interval	A confidence interval is a random interval that contains the parameter (quantity of interest) with a fixed probability, called the confidence level.
Crediting Period	The Crediting Period is the period in which a project is eligible to have its emission reductions or GHG removals verified for UCE issuance.
ECORA Carbon Unit (UCE)	Unit that represents the reduction of emissions to the atmosphere and/or removal from the atmosphere of one metric ton of CO_2e, verified by a VVB and registered in the ECORA Carbon Credit Certification Program. This is the carbon credit certified by the ECORA Carbon Credit Certification Program.

Term	Definition
Estimate	An estimate is the value that the estimator takes for a given sample.
Estimator	An estimator of a parameter of a given population variable is any statistic that, when applied to the observed values in a sample, provides an estimate for the parameter.
GHG Sources	Processes that releases a Greenhouse Gas into the atmosphere.
Greenhouse Gases (GHG)	Gaseous components of the atmosphere, natural or anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds.
Intergovernmental Panel on Climate Change (IPCC)	A UN panel created in 1988 that assesses the science, impacts, and solutions for climate change.
International Organization for Standardization (ISO)	An independent and non-governmental organization responsible for developing and publishing global technical standards that promote quality, safety, efficiency, and best practices in various sectors.
Materiality	Materiality is the concept according to which errors, omissions, or distortions, whether isolated or combined, that may influence decisions regarding registration, verification, issuance of carbon credits, replacement of carbon credits due to reversals, or project compliance must be identified, assessed, and addressed. A value of ± 5% will be considered as material discrepancy, which should be used as a reference for decision-making involving the description of materiality throughout this standard.
Monitoring Period	The Monitoring Period is a time interval within the Credit Period in which a project's emission reductions or GHG removals are verified for UCE issuance.
Monitoring Report (MR)	Document that describes the results of a project for emission reductions and/or GHG removals for a specific Monitoring Period, including general information, ownership, demonstration of additionality, compliance with socio-environmental safeguards, consultation and stakeholder engagement reports, alignment with SDGs, Baseline Scenario, calculations

Term	Definition
	of emission reductions and/or GHG removals, Monitoring Plan, Non-Permanence Risk Report and Mitigation Plan, as well as other information specified in tools, methodologies, and modules of the ECORA Carbon Credit Certification Program. Its preparation must follow the template provided on the ECORA Platform.
Parameter	A parameter is a function of the values of a given variable of the population.
Precision	Closeness between results of repeated measurements of the same variable, reflecting the variability caused by random errors. Better precision means less variability.
Probability Density Function (PDF)	Describes the range and the relative probability of possible values. A PDF can be used to describe uncertainty in the estimate of a quantity that is a fixed constant of not exactly known value, or it can be used to describe inherent variability.
Project	Activity or set of activities aimed at reducing GHG emissions and/or removals compared to the most likely Baseline Scenario. When mentioned in this standard, this term refers to a Fixed Project or a Scalable Project.
Project Activity	Action or set of specific actions within the Project Area that generates emission reductions and/or GHG removals.
Project Area	Project Area is defined by the specific geographic boundaries where ECORA Carbon Units (UCEs) are issued.
Project Design Document (PDD)	Document that describes a GHG emission reduction and/or removal project, including general information, ownership, characterization of the Project Area and other relevant areas, demonstration of additionality, compliance with social and environmental safeguards, stakeholder consultation and engagement reports, alignment with SDGs, Baseline Scenario, calculations of GHG emission reductions and/or removals, Monitoring Plan, Non-Permanence Risk Report and Mitigation Plan, as well as other information specified in tools, methodologies, and modules of the ECORA Carbon Credit Certification Program. Its preparation

Term	Definition
	must follow the template provided on the ECORA Platform.
Project Designer	Individual or legal entity formally designated by the Project Proponent to develop, monitor, and be technically responsible for a project for emission reductions or GHG removals. The Project Designer may be the Project Proponent themselves or a different entity, provided there is a formal delegation of responsibilities. The Project Designer does not hold legal rights over the project or the credits generated, except when they are also the Project Proponent by express legal ownership.
Project Proponent	Individual or legal entity that holds formal authority and responsibility for the design, implementation, and management of the emission reduction or GHG removal project. The Project Proponent is the legal holder of the UCEs at the time of their issuance. May or may not include the Project Designer, as established in the contractual instruments between the parties.
Project Start Date	Date on which the activities that led to the generation of emission reductions or GHG removals began to be implemented.
Quality Management and Control Plan (QMCP)	Set of procedures, reviews, and systematic verifications adopted throughout all stages of a project's Credit Period, from data collection and modeling to validation, verification, and issuance of carbon credits.
Random Error	Random, non-systematic deviation. Statistically, random error is the error that affects precision, producing a random shift of the results in relation to the true value.
Reduction Emission from Deforestation and Degradation of Native Vegetation (REDD)	Category of activities in the AFOLU sector that encompasses native vegetation protection practices aimed at reducing GHG emissions.
Reduction Emission from Planned Deforestation and Degradation of Native Vegetation (REDD/P)	REDD activity category that aims to prevent deforestation and degradation of native vegetation that would be carried out in a planned and regular manner in the Baseline Scenario.
Reduction Emission from Unplanned Deforestation and Degradation of Native Vegetation (REDD/NP)	REDD activity category aimed at preventing deforestation and degradation of native vegetation that would be carried out in an unplanned and irregular manner in the Baseline Scenario.

Term	Definition
Systematic Error	An error that affects accuracy, producing a consistent shift of the results in relation to the true value.
Uncertainty	Lack of knowledge of the true value of a variable that can be described by a Probability Density Function (PDF), characterizing the range and probability of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data, as well as knowledge of underlying processes and inference methods.
Validation and Verification Body (VVB)	Independent technical entity responsible for assessing the adequacy of projects to the requirements of the ECORA Carbon Credit Certification Program based on evidence collected during audit processes.
Variability	Heterogeneity of a variable over time, in space, or among members of a population. Variability is an inherent property of the system or of nature, and not of the analyst.

2. Introduction

The development of projects for carbon credit generation involves different sources of uncertainty associated with the process of quantifying emission reductions and/or removals of Greenhouse Gases (GHG). Identifying and quantifying the sources of uncertainties is fundamental so that the result of the quantification of emission reductions and/or removals of GHG corresponds to the evaluated scenario. Therefore, the Uncertainty Quantification Module aims to define mandatory technical requirements so that the Project Designer incorporates the uncertainties associated with the quantification of emission reductions and GHG removals in carbon credit generation projects.

The Uncertainty Quantification Module establishes the structure that the Project Designer must follow to identify, assess, quantify, address, and report the uncertainties associated with the parameters used in the estimation of emission reductions and/or GHG removals.

The development of this document was based on the following technical references: (1) IPCC (2000) – *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Chapter 6: *Quantifying Uncertainties in Practice*; (2) IPCC (2006) – *IPCC Guidelines for National Greenhouse Gas Inventories, and 2019 Refinement to the 2006 Guidelines*; and (3) ISO 14064-2:2019 – Greenhouse Gases – Part 2: Specification and guidance at the project level for quantification, monitoring, and reporting of emission reductions or increases in GHG removal.

This document is composed of nine Sections, namely: (1) *Acronyms and Definitions* which presents the technical terms, concepts, and abbreviations used throughout the document; (2) *Introduction*: which presents the context of the Uncertainty Quantification Module and its objectives; (3) *Module Structure* which briefly describes the structure of the module; (4) *Applicability*: Defines the scope of use of the module; (5) *Compliance Requirements* which defines the mandatory criteria for quantification, treatment, and reporting of uncertainties; (6) *Quality Management and Control Plan (QMCP)* which indicates the operational procedures for quality control for data collection and documentation; (7) *Quantification of Uncertainties* which presents the method for quantifying uncertainties; (8) *Assumptions for Uncertainty Discounting* which shows the accepted uncertainty values; and (9) *Guidelines for Data Reporting* which explains how data should be archived and reported to ECORA and the Validation and Verification Body (VVB).

3. Module Structure

MOEC002: Uncertainty Quantification Module establishes the guidelines that the Project Designer must follow to identify, assess, quantify, and address the uncertainties associated with the parameters used in the estimates of emission reductions and/or GHG removals.

The document covers: (1) the principles of the Quality Management and Control Plan (QMCP) that must be met by the Project Designer, (2) the method for quantifying uncertainties, with specifications for AFOLU REDD projects, (3) the assumptions for uncertainty discounting, and (4) the guidelines for data reporting.

Regarding the quantification of uncertainties, the document presents the analytical error propagation method, defines the requirements for applying the method, and specifies the application of the method for AFOLU projects classified as Reducing Emissions from Deforestation and Degradation of Native Vegetation (REDD) projects. The Project Designer must follow the premise of conservatism at all stages involving the quantification of uncertainties.

The document contains the guidelines for documentation and reporting of uncertainties associated with emission reductions and/or GHG removals, outlining the minimum requirements required in each document. It also details the requirements that the Project Designer must follow in cases where calculations are performed using spreadsheets or other digital tools. As defined in Section 5.16 of the ECORA Standard document, the Project Designer must report the uncertainties applicable to the Baseline Scenario in the Project Design Document (PDD) and the uncertainties applicable to the *ex-post* scenario in each Monitoring Report (MR).

The Flowchart presented in Figure1 summarizes the logical sequence of the main guidelines addressed in this module and the sequence of variables that the Project Designer must apply to obtain the total project uncertainty.

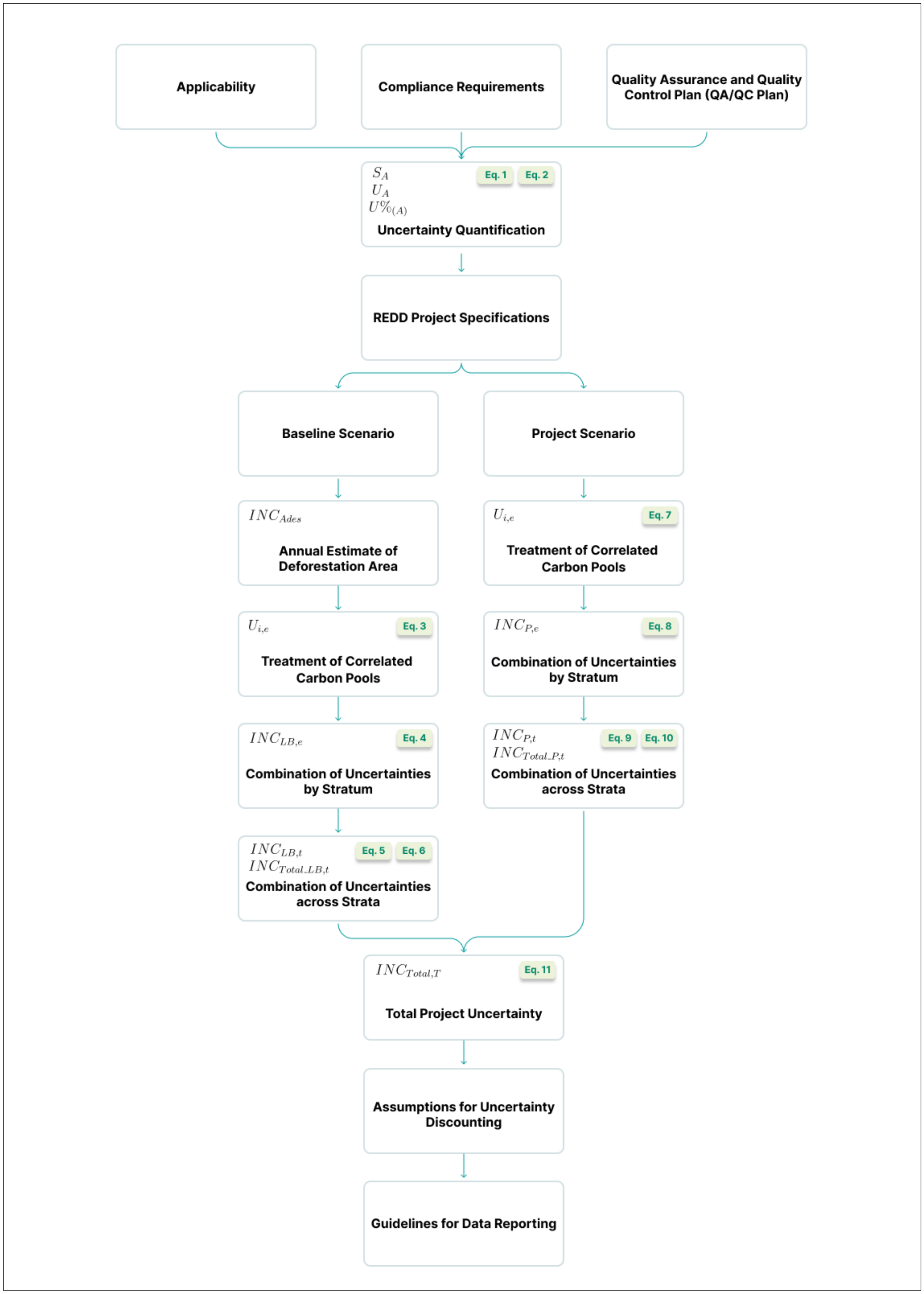

Figure 1. Summary of the module structure.

4. Applicability

This module applies to Agriculture, Forestry and Other Land Use (AFOLU) projects submitted to the ECORA Carbon Credit Certification Program and must be used to identify, assess, quantify, and address the uncertainties associated with the estimates of emission reductions and GHG removals, both in the Baseline Scenario (as per the requirements of Section 7.1.1) and in the Project Scenario (as per the requirements of Section 7.1.2) in order to estimate the Total Project Uncertainty (as per the requirements of Section 7.1.3). The uncertainties must be quantified individually for each material GHG source, reservoir, and sink, in accordance with the materiality concept in Section 5.20 of the ECORA Standard document.

5. Compliance Requirements

The quantitative analysis of uncertainties must be based on the estimate of the two-tailed 90% confidence interval (CI90), applied to each individual source of uncertainty and to the combined total project uncertainty. To obtain the uncertainty results, the Project Designer must consider, at a minimum:

a. Reference scenarios: Uncertainties associated with the definition and modeling of the Baseline Scenario and the Project Scenario;

b. Carbon stocks: uncertainties related to the measurement of carbon reservoirs, including aboveground and belowground biomass, dead wood, litter, and soil carbon;

c. Forest inventory and sampling: uncertainties associated with sampling design, number and distribution of plots, DBH and height measurements, sampling error, and representativeness;

d. Remote sensing and spatial monitoring: uncertainties associated with land use classification, stratification, change detection, and spatial/temporal resolution of the data;

e. Biophysical and auxiliary parameters: uncertainties associated with parameters such as wood density, carbon fraction, root/shoot ratio, expansion factors, and other derived parameters;

f. Emission and removal factors: uncertainties associated with emission factors for CO_2 and non-CO_2 (e.g., CH_4 and N_2O), including environmental variability and use of default values;

g. Estimation models and methods: structural uncertainties arising from assumptions, simplifications, extrapolations, and parameter sensitivity;

h. Measurement and monitoring systems: uncertainties associated with equipment calibration, data collection protocols, data consistency, and possible measurement errors;

i. Assumptions and technical judgment: uncertainties associated with the use of assumptions, proxies, analogous areas, or expert judgment, when applicable.

The principle of conservativeness must be applied at all stages of this Module. When there is a lack of empirical data or reference sources accepted by the ECORA Carbon Credit Certification Program, the Project Designer must use expert elicitation to select and interpret methods, fill data gaps, and define uncertainty values. In these cases, the Project Designer must follow the guidance in the IPCC Guidelines for National GHG Inventories (2006) and its 2019 Refinement (or the most current at the time of application of this module), especially Volume 1, Chapter 2 – Approaches to Data Collection and Annex 2A.1, which establish the formal elicitation procedures. The selection of experts, the method adopted, and the rationale for the assumptions must be properly documented. The uncertainty ranges derived from expert judgment must be expressed through probability distributions or confidence intervals.

The acceptable sampling error for carbon measurement estimates must follow the guidelines and requirements defined in MOEC001: ECORA Carbon Measurement in Vegetation Module, with respect to each estimated reservoir.

The uncertainties associated with classification errors must be quantified and incorporated into the calculation of total uncertainty, meeting the criteria of 90% CI and a maximum range of ±20%.

The accuracy of the maps used in the project must be demonstrated through a confusion matrix, including producer accuracy (omission errors), user accuracy (commission errors), and overall accuracy, as described in the applied methodology.

If the uncertainty of a parameter is unknown, the Project Designer may not assign 0% uncertainty by default. One of the following approaches must be adopted:

a. Quantify the uncertainty through statistical evaluation, independent validation, confusion matrix, error propagation, sensitivity analysis, or comparison with reference data;

b. Apply the IPCC Expert Elicitation Protocol (as described in this Section) when there is insufficient empirical data, in order to derive a technically justified probability distribution or uncertainty interval;

c. Use standard uncertainty factors or conservative default values from recognized sources, including IPCC, national inventories, FREL/FRL, peer-reviewed scientific literature, product technical documentation, official databases, or comparable studies.

All data used to obtain the uncertainties associated with GHG removals and/or reductions of a project must undergo the procedures of the Quality Management and Control Plan (QMCP), as described in Section 6 of this document. The Project Designer must report the results obtained in a reproducible and auditable manner.

6. Quality Management and Control Plan (QMCP)

This section presents the guidelines that the Project Designer must follow for selecting the sources of data used in the projects and the procedures that must be adopted to minimize the uncertainties associated with emission reductions and/or net GHG removals, in accordance with the principle of conservativeness.

The QMCP must be detailed in the PDD, implemented during monitoring, and made available to the VVB. Its application must be demonstrated through evidence in the MR.

To minimize uncertainties, the Project Designer must adopt, whenever possible, local values specific to the project context, according to the hierarchy of sources:

a. Primary sources (primary field data, including inventories conducted according to recognized technical protocols appropriate to the type of Project Activity);
b. Data from the officially consolidated national inventory in the country. For projects in Brazil, the Project Designer must use the most recent version of the National Inventory of Anthropogenic Greenhouse Gas Emissions and Removals;
c. Regional data obtained from scientific articles indexed in the SciELO, Web of Science, and Scopus platforms, accompanied by technical justification for use in the local context;
d. Emission factors and *default* data from the IPCC;
e. Expert judgment, exclusively when no empirical data is available, following the formal elicitation procedures described in Section 5.

The justification for the choice of data source must be presented in the PDD.

In cases where primary data is collected and the Project Area presents heterogeneity, the Project Designer must stratify the area into homogeneous units according to the guidelines of MOEC001. Stratification must be carried out with the aim of reducing within-class variability, increasing the accuracy of estimates, and minimizing sampling error, contributing to the reduction of uncertainties associated with estimates of emission reductions and GHG removals.

In the absence of specific local data, the choice of reference values must follow the principle of conservativeness.

The Project Designer must identify, quantify, and, when applicable, correct potential systematic biases in data, measurements, models, and classifications. When bias quantification is not possible, duly justified conservative adjustments must be applied.

To ensure accuracy, verifiability, and consistency of emission reduction and/or GHG removal estimates between monitoring cycles, the Project Designer must establish and maintain documented Quality Management and Control procedures that include, at a minimum, but are not limited to:

a. Standardized methods for measurement and recording of field data;
b. Training and qualification procedures for teams involved in data collection and analysis;
c. Calibration and periodic verification procedures for measuring instruments;
d. Methods for verifying plot consistency and criteria for correcting technical errors;
e. Methods for detecting inconsistencies, transcription errors, and outliers.

Updated versions of the procedures must be made available to the VVB during validation and at each periodic verification.

The Project Designer must maintain evidence that allows independent verification of data and calculations, including at a minimum:

a. Complete records of field measurements;

b. Calculation spreadsheets containing means, standard deviations, coefficients of variation, and applicable confidence intervals;

c. Documentation of the uncertainty calculation method, including parameters and assumed distributions;

d. Calibration records and metrological traceability, when applicable;

e. Documentation of the uncertainty assessments performed.

In cases where the application of QMCP procedures does not eliminate structural, conceptual, or measurement biases, these biases must be identified, quantified, and corrected.

7. Uncertainty Quantification

This section presents the method for quantifying uncertainties, with specifications for AFOLU REDD type projects.

Uncertainty quantification must be assessed using the analytical error propagation method. Analytical error propagation is the statistical method used to estimate the combined uncertainty associated with calculations of emission reductions and/or GHG removals through the first-order Taylor expansion. This method integrates the individual uncertainties of each parameter and expresses the total uncertainty in absolute and percentage terms.

Error propagation should be applied when:

a. The coefficient of variation of each key parameter, cited in section 5 of this document, must satisfy CV ≤ 0.30;

b. The relationship between the parameters in the final calculation is linear or approximately linear;

c. The variables are independent or show low statistical correlation ($|r| < 0.30$);

d. The probability distributions of the input parameters are approximately symmetrical.

When known structural correlations exist between parameters, for example, between aboveground biomass and belowground biomass, whose estimate can be derived through root expansion factors applied to aerial biomass, the Project Designer must explicitly include the covariance terms in the combined uncertainty estimate, so as to reflect the statistical dependence between these variables.

In the absence of empirical information on correlation, independence between the variables may be assumed, provided that such a hypothesis is technically justified and documented.

The calculation of the standard error and the uncertainty associated with the parameters used in the estimation of emission reductions and/or GHG removals is essential to ensure the statistical consistency of the results. For the calculation, two main steps must be followed, namely (1) Determination of the standard error (S_A) and (2) Calculation of absolute and percentage uncertainty:

1 - Determination of the standard error (S_A)

The determination of the standard error for each estimate, denoted by S_A, must be calculated based on:

a. Sample variability (for example: forest inventories); or

b. The uncertainty associated with the data source used.

2- Calculation of absolute and percentage uncertainty

To assess the absolute and percentage uncertainty of S_A. The uncertainty of this estimate is assessed as the half-tail of the 90% two-tailed confidence interval, obtained by Equation 1:

$$\boldsymbol{U_A = t_{\alpha=10\%} * S_A} \quad (1)$$

Where:

$U_A =$ Absolute uncertainty;

S_A = Standard error;

$t_{\alpha=10\%}$= the value *t* corresponding to a 90% two-tailed confidence interval;

A = mean value of the variable (e.g., mean biomass, area, etc.).

The percentage uncertainty is expressed by Equation 2:

$$\boldsymbol{U\%_{(A)} = 100 * t_{\alpha=10\%} * \frac{S(A)}{A}} \quad (2)$$

Where:

$U\%_A =$ Percentage Uncertainty (%);

S_A = Standard error;

$t_{\alpha=10\%}$= the value *t* corresponding to a 90% two-tailed confidence interval;

A = mean value of the variable (e.g., mean biomass, area, etc.)

The Project Designer must incorporate the uncertainty percentages resulting from The percentage uncertainty is expressed by Equation 2 into the uncertainty calculations of the Baseline Scenario and the Project Scenario, applying the propagation rules presented in this Section 7 of this document. All calculations must be documented in auditable spreadsheets, containing values, formulas, standard deviations, coefficients of variation, and confidence intervals used.

Below are specifications for quantifying uncertainty for Reduction of Emissions from Deforestation and Degradation of Native Vegetation (REDD) type projects.

7.1. Specifications for REDD Type Projects

For AFOLU Planned Reduction Emissions from Deforestation and Degradation of Native Vegetation (REDD/P) and Unplanned Reduction of Emissions from Deforestation and Degradation of Native Vegetation (REDD/NP) type projects, the Project Designer must assess the uncertainties associated with the processes of annual estimation of the Deforestation Area in the Baseline Scenario and the variations in carbon stocks both in the Baseline Scenario and in the Project Scenario.

Below are the details for quantifying uncertainty in the estimates of the Baseline Scenario, the Project Scenario, and the Total Project.

7.1.1. Uncertainty in Baseline Scenario Estimates

For the quantification of uncertainties in the Baseline Scenario, the Project Designer must consider all carbon pools and GHG sources defined by the methodology used. The estimates of carbon stocks in each carbon pool and GHG emission source must be accompanied by an uncertainty estimate.

The uncertainty of the Baseline Scenario must be quantified hierarchically in four steps: (1) estimation of the annual uncertainty of the Deforestation Area; (2) treatment of correlated reservoirs, when applicable; (3) combination of uncertainties at the level of each stratum; and (4) combination of uncertainties between the strata of the Project Area.

Step 1 — Calculation of the Annual Estimate of the Deforestation Area

The uncertainty associated with the annual estimate of the deforestation area INC_{Ades}, in the Baseline Scenario must be considered in the quantification of the project's total uncertainty and applied in theThe estimate of the total accumulated uncertainty in the Baseline Scenario is given by Equation 6, which refers to the estimate of the total accumulated uncertainty in the Baseline Scenario.

In cases where the estimate of deforestation area is derived from a suppression plan approved within the scope of environmental licensing, the Project Designer may consider the associated uncertainty as immaterial, provided that the following conditions are cumulatively met:

a. The suppression plan clearly indicates the total area authorized for conversion;
b. Presents georeferenced maps in accordance with applicable accuracy requirements;
c. Specifies the annual area or suppression schedule; and
d. Demonstrates technical, legal, and operational capacity for the implementation of suppression.

In these cases, the decision to treat the uncertainty as immaterial must be properly justified and documented in the PDD.

In the case of REDD/NP projects, the uncertainty regarding the estimate of deforestation area is provided by ECORA, as described in Appendix C of the document MEEC002 – REDD/NP Methodology, and must be considered in the quantification of the total uncertainty of the Baseline Scenario, according to the requirements of this Module.

Step 2 — Treatment of Correlated Reservoirs

When there is correlation between carbon reservoirs resulting from structural relationships, for example, when belowground biomass, dead wood, or litter are estimated as proportions of aboveground biomass, the Project Designer must initially quantify the combined uncertainty of these correlated reservoirs, according to Equation 3. The application of this approach requires that the assumptions of linearity, proportionality, and dependence among reservoirs be technically justified and documented.

$$U_{i,e} = \sqrt{(U_{BAc,e})^2 + \frac{\left(R_{Bab,e} * U_{RBab,e}\right)^2 + \left(R_{MM,e} * U_{RMM,e}\right)^2 + \left(R_{SE,e} * U_{RSE,e}\right)^2}{(1 + R_{Bab,e} + R_{MM,e} + R_{SE,e})^2}} \qquad (3)$$

Where:

$U_{i,e}$ = Combined uncertainty of the correlated reservoirs in the stratum and for the Baseline Scenario in stratum “e” (%);

$U_{BAc,e}$ = Percentage uncertainty in aboveground biomass stocks in the Baseline Scenario in stratum “e” (%);

$R_{Bab,e}$= Ratio of belowground biomass/aboveground biomass in stratum “e” (dimensionless); (if applicable)

$U_{RBab,e}$ = Percentage uncertainty in belowground biomass stocks in the Baseline Scenario in stratum “e” (%);

$R_{MM,e}$ = Ratio of dead wood biomass/aboveground biomass in stratum “e” (dimensionless); (if applicable)

$U_{RMM,e}$ = Percentage uncertainty in dead wood stocks in the Baseline Scenario in stratum “e” (%);

$R_{SE,e}$ = Litter/aboveground biomass ratio in stratum “e” (dimensionless); (if applicable)

$U_{RSE,e}$ = Percent uncertainty in litter stocks in the Baseline Scenario in stratum “e” (%);

This value should be treated as a single uncertainty term in the subsequent step 3, replacing the individual uncertainty percentages of the reservoirs that make up the correlated block.

Step 3 — Combination of Uncertainties by Stratum

When there is no correlation between carbon reservoirs resulting from structural relationships the Project Designer must, for each stratum of the Project Area identified by the index ("e"), estimate the uncertainty from the combination of uncertainties associated with the carbon reservoirs and GHG sources belonging to that stratum "e". The combination must be performed according to Equation 4:

$$INC_{LB,e} = \frac{\sqrt{\sum_{i=1}^{n}\left(U_{i,e} \; * \; E_{i,e}\right)^2}}{\sum_{i=1}^{n} E_{i,e}} \tag{4}$$

Where:

$INC_{LB,e}$ = Percentage uncertainty of the combination of carbon reservoirs and GHG sources in the Baseline Scenario, for stratum "e" (%);

$U_{i,e}$ = Individual percentage uncertainty in carbon stocks in reservoirs and GHG sources, in the Baseline Scenario, in stratum "e" (%); (Equation The percentage uncertainty is expressed by Equation 2);

$E_{i,e}$ = Carbon stock or GHG source "i" in the Baseline Scenario, in stratum "e" (tCO_2e);

e = index of the considered Strata "e" (1, 2, 3, ...) dimensionless;

i = index of the carbon reservoirs and GHG sources considered in stratum "e".

Step 4 — Combination of Uncertainties between Strata

Next, the total uncertainty of the Baseline Scenario is obtained by combining the uncertainties of each stratum, weighted by the respective carbon stocks and GHG sources according to Equation 5:

$$INC_{LB,t} = \frac{\sqrt{\sum_{e=1}^{n}\left(INC_{LB,e} \; * \; E_e\right)^2}}{\sum_{e=1}^{n}(E_n)} \tag{5}$$

Where:

$INC_{LB,t}$ = Total uncertainty in the combined carbon stocks and GHG sources for the Baseline Scenario up to year "t" (%);

$INC_{LB,e}$ = Percentage uncertainty of the combination of carbon reservoirs and GHG sources in the Baseline Scenario, for stratum "e" (%); (Equation 4);

E_n= Sum of the carbon stock or GHG source in the Baseline Scenario, in stratum "e" (tCO_2e);

e = index of the considered Strata "e" (1, 2, 3, ...) dimensionless.

The estimate of the total accumulated uncertainty in the Baseline Scenario is given by Equation 6:

$$INC_{Total\_LB,t} = \sqrt{(INC_{Ades,t})^2 + (INC_{LB,t})^2} \tag{6}$$

Where:

$INC_{Total\_LB,t}$ = Accumulated uncertainty in the Baseline Scenario up to year t (%);

$INC_{Ades,t}$ = Accumulated uncertainty of the Annual Estimate of the Deforestation Area in the Baseline Scenario in year t (%);

$INC_{LB,t}$ = Total uncertainty in the combined carbon stocks and GHG sources in the Baseline Scenario (%);

t = time in years elapsed since the Start Date of the Credit Period.

7.1.2. Uncertainty in Estimates of the Project Scenario

For REDD projects, the Project Scenario represents the non-occurrence of deforestation as foreseen in the Baseline Scenario. In cases where there are no remediations in the Project Scenario for carbon reservoirs or GHG sources, the introduction of new sources of uncertainty in the Project Scenario is not considered, since the uncertainties associated with carbon stocks have already been considered in the quantification of the Baseline Scenario.

If the project conducts new field inventories during monitoring, the uncertainties must be propagated among the reservoirs and strata, using a 90% confidence interval, applying the same equations for uncertainty quantification used for the uncertainty estimate in the Baseline Scenario, presented in Section 7.1.1 of this document and described again below.

Step 1 – Treatment of Correlated Reservoirs

When there is correlation between carbon reservoirs resulting from structural relationships, for example, when belowground biomass, dead wood, or litter are estimated as proportions of aboveground biomass, the Project Designer must initially quantify the combined uncertainty of these correlated reservoirs, according to Equation 7. The application of this approach requires that the assumptions of linearity, proportionality, and dependence among reservoirs be technically justified and documented.

$$U_{i,e} = \sqrt{(U_{BAc,e})^2 + \frac{\left(R_{Bab,e} * U_{RBab,e}\right)^2 + \left(R_{MM,e} * U_{RMM,e}\right)^2 + \left(R_{SE,e} * U_{RSE,e}\right)^2}{(1 + R_{Bab,e} + R_{MM,e} + R_{SE,e})^2}} \tag{7}$$

Where:

$U_{i,e}$ = Combined uncertainty of the correlated reservoirs in the stratum and for the Project Scenario in stratum “e” (%);

$U_{BAc,e}$ = Percentage uncertainty in aboveground biomass stocks in the Project Scenario in stratum “e” (%);

$R_{Bab,e}$= Ratio of belowground biomass/aboveground biomass in stratum “e” (dimensionless); (if applicable)

$U_{RBab,e}$ = Percentage uncertainty in belowground biomass stocks in the Project Scenario in stratum “e” (%);

$R_{MM,e}$ = Ratio of dead wood biomass/aboveground biomass in stratum “e” (dimensionless); (if applicable)

$U_{RMM,e}$ = Percent uncertainty in dead wood stocks in the Project Scenario in stratum “e” (%);

$R_{SE,e}$ = Litter/aboveground biomass ratio in stratum “e” (dimensionless); (if applicable)

$U_{RSE,e}$ = Percent uncertainty in litter stocks in the Project Scenario in stratum “e” (%);

This value should be treated as a single uncertainty term in the subsequent step 2, replacing the individual uncertainty percentages of the reservoirs that make up the correlated block.

Step 2 – Combination of Uncertainties by Stratum

When there is no correlation between carbon reservoirs resulting from structural relationships the Project Designer must, for each stratum of the Project Area identified by the index ("e"), estimate the uncertainty from the combination of uncertainties associated with the carbon reservoirs and GHG sources belonging to stratum "e". The combination must be performed according to Equation 8:

$$INC_{P,e} = \frac{\sqrt{\sum_{i=1}^{n}\left(U_{i,e} * E_{i,e}\right)^2}}{\sum_{i=1}^{n} E_{i,e}} \tag{8}$$

Where:

$INC_{P,e}$= Percentage uncertainty of the combination of carbon reservoirs and GHG sources in the Project Scenario, for stratum "e" (%);

$U_{i,e}$ = Individual percentage uncertainty in carbon stocks in reservoirs and GHG sources, in the Project Scenario, in stratum "e" (%); (Equation The percentage uncertainty is expressed by Equation 2);

$E_{i,e}$ = Carbon stock or GHG source "i" in the Project Scenario, in stratum "e" (tCO_2e);

e = index of the considered Strata "e" (1, 2, 3, ...) dimensionless;

i = index of the carbon reservoirs and GHG sources considered in stratum "e".

Step 3 – Combination of Uncertainties between Strata

Next, the total uncertainty of the Project Scenario is obtained by combining the uncertainties of each stratum, weighted by the respective carbon stocks and GHG sources according to Equation 9:

$$INC_{P,t} = \frac{\sqrt{\sum_{e=1}^{n}\left(INC_{P,e} * E_e\right)^2}}{\sum_{e=1}^{n}(E_n)} \tag{9}$$

Where:

$INC_{P,t}$= Total uncertainty in combined carbon stocks and GHG sources for the Project Scenario up to year "t" (%);

$INC_{P,e}$= Percentage uncertainty of the combination of carbon reservoirs and GHG sources in the Project Scenario, for stratum "e" (%); (Equation 8)

E_n= Sum of the carbon stock or GHG source in the Project Scenario, in stratum "e" (tCO_2e);

e = index of the considered Strata "e" (1, 2, 3, ...) dimensionless;

t = time in years elapsed since the Start Date of the Credit Period.

The estimate of the total accumulated uncertainty in the Project Scenario is given by Equation 10:

$$INC_{Total\_P,t} = \sqrt{(INC_{Ades,t})^2 + (INC_{P,t})^2} \tag{10}$$

Where:

$INC_{Total\_P,t}$ = Accumulated uncertainty in the Baseline Scenario up to year t (%);

$INC_{Ades,t}$ = Accumulated uncertainty of the Annual Estimate of the Deforestation Area in the Baseline Scenario in year t (%);

$INC_{P,t}$ = Total uncertainty in the combined carbon stocks and GHG sources in the Baseline Scenario (%);

t = time in years elapsed since the Start Date of the Credit Period.

The leakage calculation of the methodologies MEEC001: REDD/P Methodology and MEEC002: REDD/NP Methodology is considered conservative. Therefore, the uncertainty related to leakage does not need to be quantified.

7.1.3. Total Project Uncertainty

The total project uncertainty corresponds to the combined uncertainty of the estimates of the Baseline Scenario and the Project Scenario and must be calculated by Equation 11:

$$INC_{Total,t} = \sqrt{\frac{(\Delta C_{LB,t} * INC_{Total\_LB,t})^2 + (\Delta C_{P,t} * INC_{Total\_P,t})^2}{(\Delta C_{LB,t} + \Delta C_{P,t})}} \quad (11)$$

Where:

$INC_{Total,t}$ = Cumulative uncertainty for Project Activities up to year t (%);

$\Delta C_{LB,t}$ = Net GHG emissions in the Baseline Scenario up to year t (tCO_2e);

$\Delta C_{P,t}$ = Net GHG emissions in the Project Scenario up to year t (tCO_2e);

$INC_{Total\_LB,t}$ = Accumulated uncertainty in the Baseline Scenario in REDD projects up to year t (%);

$INC_{Total\_P,t}$= Total uncertainty in combined carbon stocks and GHG sources in the Project Scenario (%);

t = time in years elapsed since the Start Date of the Credit Period.

The Project Designer must deduct the result of the uncertainty from the value of the project's emission reduction and/or GHG removal estimates, according to the guidelines in Section 8.

8. Assumptions for Uncertainty Discounting

The ECORA Uncertainty Module establishes an uncertainty tolerance limit of up to 15%.

As established in Section 5.15 of the ECORA Standard, the Project Designer must follow the following guidelines for uncertainty discounting:

a. When the total uncertainty is ≤ 15%, no deduction will be applied to net GHG reductions;

b. When the total uncertainty is > 15% and ≤ 30%, a deduction corresponding to the percentage that exceeds the 15% tolerance limit will be applied, to be deducted from net GHG reductions before the issuance of ECORA Carbon Units (UCE);

c. When the total uncertainty is greater than 30%, the project must undergo mandatory methodological review, and the issuance of UCE is prohibited until the causes of the high uncertainty are technically corrected and the total uncertainty is reduced to a value equal to or less than 30%.

Therefore, if:

$$INC_{Total,t} \leq 15\%, \quad então: \quad INC_{Ded,t} = 0\%$$

or

$$15\ \% < INC_{Total,t} \leq 30\%, \quad então: \quad INC_{Ded,t} = INC_{Total,t} - 15\%$$

Where:

$INC_{Total,t}$= Cumulative uncertainty for Project Activities up to year t (%);

$INC_{Ded,t}$ = Uncertainty deduction to be applied in the calculation of UCEs up to year t (%);

t = time in years elapsed since the Start Date of the Credit Period.

The uncertainty deduction ($INC_{Ded,t}$) must be applied to net GHG reductions before the issuance of UCEs in the applied methodology.

The percentage uncertainty deduction can be converted into an absolute discount, in tCO_2e, according to Equation 12:

$$D_{inc,t} = RLT_t * \frac{INC_{ded,t}}{100} \tag{12}$$

Where:

$D_{inc,t}$ = Uncertainty discount to be applied to net GHG reductions up to year “t” (tCO_2e);

RLT_t= Total net GHG emission reductions in year “t” (tCO2e);

$INC_{Ded,t}$ = Uncertainty deduction to be applied in the calculation of UCEs up to year t (%);

t = time in years elapsed since the Start Date of the Credit Period.

9. Guidelines for Data Reporting

The Project Designer must maintain complete, consistent, and verifiable records of all technical decisions, data used, statistical methods applied, and results obtained during the quantification of uncertainty.

In the Project Design Document (PDD) and in each Monitoring Report (MR), the Project Designer must present:

a. The complete list of parameters considered in the uncertainty analysis, with their respective levels of uncertainty;

b. The method used to combine individual uncertainties;

c. The total uncertainty expressed as a percentage;

d. Adjustments used in the treatment of uncertainties, when applicable;

e. The final quantity of ECORA Carbon Units (UCE).

The Project Designer must present reproducible, verifiable, and auditable results and keep the following data archived, which must remain available during the Project Credit Period and for at least five years after the last issuance of UCE:

a. Input data including images, inventories, auxiliary parameters, and complete metadata;

b. The versions of the files submitted to the ECORA platform, keeping records of dates and formats;

c. The technical justifications related to the adopted parameters, methodological choices, and assumptions used;

d. The evidence of data quality and consistency, including accuracy assessments and stratum validation;

e. The version history, including changes in data, parameters, and platform versions.

The technical documentation must be maintained and archived under the responsibility of the Project Designer, entered and updated in the ECORA digital platform, and made available to the Validation and Verification Body (VVB) during validation and verification processes or whenever formally requested.

10. References

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