BASELINE AND MONITORING METHODOLOGY FOR AVOIDING PLANNED DEFORESTATION OF UNDRAINED PEAT SWAMP FORESTS.

Document Prepared By Terra Global Capital LLC

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Relationship to Approved or Pending Methodologies

Only one other applicable methodology exists for carbon accounting in avoided planned peat swamp conversion. The proposed methodology differs in some key aspects which may limit the adoptability of the existing avoided planned peat swamp conversion methodology. More specifically, this methodology offers more flexibility in estimating the baseline deforestation rates, includes a procedure to apply hierarchical forest transition to model the conversion process, uses geostatistical techniques to interpolate peat depths between sampling points, and allows for some small-scale deforestation and forest to be present in the project area under the baseline scenario. Furthermore, this methodology is developed to be compatible with the new VCS PRC guidelines and uses an internationally accepted definition of peat i.e., containing minimum of 30% organic matter and depth of at least 30 cm (as defined by the Internal Peat Society).

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1. SOURCES

This methodology uses different elements from several approved methodologies and tools. More specifically, this methodology is based on elements from the following methodologies (latest version):

- Approved CDM Methodology - AR ACM0001 Afforestation and reforestation of degraded land
- Approved CDM Methodology - AR AM0006 Afforestation/Reforestation with Trees Supported by Shrubs on Degraded Land

This methodology also refers to the latest approved versions of the following tools or modules:

- VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities. (Available at http://www.v-c-s.org/tool_VT0001.html)
- AR AM Tool 03 Calculation of the number of sample plots for measurements within A/R CDM project activities. (Available at https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.pdf
- Approved VCS Module VMD0014 “Estimation of emissions from fossil fuel combustion (E-FFC)” (Available at http://www.v-c-s.org/methodologies/VMD0014)

Projects that meet the applicability criteria of this methodology will conform to all relevant applicability criteria associated with each of these individual methodologies and tools.

2. SUMMARY DESCRIPTION OF THE METHODOLOGY

This methodology sets out the project conditions and carbon accounting procedures for activities aimed at reducing emissions from deforestation and forest degradation in peat swamp forests and avoiding planned peatland drainage, and therefore falls under the combined AFOLU category of Reducing Emissions from Deforestation and Degradation (REDD) and Conservation of Undrained or Partially Drained Peatland (CUPP) i.e. REDD+CUPP. Only one other applicable methodology exists for REDD+CUPP projects. The proposed methodology differs in some key aspects which may limit the adoptability of the existing avoided planned peat swamp conversion methodology. More specifically, this methodology offers more flexibility in estimating the baseline deforestation rates, includes a procedure to apply hierarchical forest transition to model the conversion process, uses geostatistical techniques to interpolate peat depths between sampling points, and allows for some small-scale deforestation and forest to be present in the project area. Furthermore, this methodology is developed to be compatible with the new VCS PRC guidelines and uses an internationally accepted definition of peat i.e., containing minimum of 30% organic matters and depth of at least 30 cm (as defined by the Internal Peat Society). The main methodological aspects of the methodology are:

- The project area must be a production forest i.e. forest land designated for production purposes.
- Baseline emissions in the project area are calculated based on either legally approved conversion rates or empirically measured historical deforestation rates observed in a reference region similar to the project area.
- **Emissions from non-peat carbon stock** densities are quantified by subtracting carbon densities under the project and baseline scenario. Carbon densities for non-peat components are quantified on permanent sampling plots on forest lands or temporary sampling plots on non-forest lands. **Emissions from peat carbon stock densities** are

quantified by measuring or extrapolating the difference in water table and peat subsidence between the project and baseline scenarios. The total net emission reductions are discounted based on the attained precision of biomass, water table, and peat subsidence measurements. If the emissions cannot be measured with sufficient precision, the project is not eligible.

- Potential emissions from primary leakage are monitored and quantified. If applicable, market-effect leakage must be accounted for within each PD, according to the rules set forward within the VCS guidance.
- While assisted *reforestation* is not allowed under the VCS AFOLU guidance for REDD projects, natural reforestation and regeneration must be included in the baseline and project scenarios. This is achieved by applying the empirically observed baseline regeneration and reforestation rates in the reference region to the project and baseline scenarios.
- Assisted natural *regeneration* activities are allowed as a community development activity, but only to the extent that it increases the baseline natural regeneration rate. The quantification of the GHG benefits from assisted natural regeneration follows a different and more detailed procedure than for the quantification of GHG benefits from areas without assisted natural regeneration.
- The methodology is not applicable to grouped projects. However, the project may contain multiple non-contiguous areas. The procedure to account for this is described in section 8.1.1. Describe Spatial Boundaries of the Discrete Project Area Parcels.

2.1 Summary of Major Methodological Steps for the Baseline GHG Emissions, Project GHG Emissions, and Monitoring

The PD contains the *ex-ante* annual net GHG emission reductions due to project activities (NERs) and an estimate of the *ex-ante* VCUs that are issued after transferring a portion of the NERs to the buffer pool according to the buffer withholding percentage. The actual NERs and VCUs are calculated *ex-post* based on data collected during monitoring and reported in a monitoring report. The calculation of emission reductions is based on the following principles:

- This methodology separates emission reductions from avoided deforestation, emission reductions from avoided peat conversion, and carbon uptake through assisted natural regeneration (ANR) because different carbon accounting methods, accuracy thresholds and discounting procedures are applicable on each of these sources:
    - The calculation of **non-peat related emission reductions from avoiding deforestation** is based on a classification and stratification of the land in discrete classes or forest strata according to the land use and land cover (LULC) or forest type and density. By analyzing transitions from forest classes to non-forest classes, the emissions related to deforestation can be quantified.
    - The calculation of **emission reductions from avoided peat conversion** is based on (1) measurements of the water table in the project area, and (2) the expected drainage level under project scenario.
    - The accounting for greenhouse gas benefits from **assisted natural regeneration** (ANR) activities are calculated completely separated using the most recent version of the approved consolidated CDM methodology AR-ACM0001: “Afforestation and Reforestation of Degraded Land”.
- Significant methane, nitrous oxide and fuel-CO_2 emissions from project and community development activities must be subtracted from the NERs.
- The project must implement activities to minimize any potential emissions from forest degradation from local communities living in or near the project area. Only significant emissions need to be retained in the final calculations.

2.1.1 GHG Sinks and Emissions under the Baseline Scenario

Under this methodology, the most plausible baseline scenario under the CDM modalities and procedures, paragraph 22 is option (c) (see section 6). The calculation of the emissions from deforestation in the project area under the baseline scenario is based on a combination of (1) forest conversion rates from legally recognized documents, or forest conversion rates from a historical remote sensing analysis, (2) biomass inventories to measure the emissions of the non-peat carbon pools after the project area would have been converted, and (3) measurements of the peat depth in the project area and the depth of the water table after conversion to quantify the emissions from the peat carbon pool.

2.1.2 GHG Emissions and Sinks under the Project Scenario in the Project Area

For the *ex-ante* calculations of the project's GHG emissions, it is assumed that under the project scenario, (1) no conversion takes place inside the project area, but selective logging is allowed under certain applicability criteria, (2) no change in biomass density occurs, apart from areas where sustainable logging is taking place and areas where assisted natural regeneration is performed, and (3) no changes in water table occur. The carbon accounting for the areas on which assisted natural regeneration activities take place must follow the latest version of approved CDM methodology AR-ACM0001.

2.1.3 GHG Emissions under the Project Scenario outside the Project Area (Leakage)

Under this methodology, leakage from shifting of the planned deforestation is calculated by monitoring the planned deforestation activities of the (most likely) deforestation agent in the project area. Leakage from shifting of the extraction of forest products by local communities is calculated by assessing the local supply of forest products that was foregone due to project.

2.1.4 Monitoring Methodology

During the crediting period, all data and parameters that are included in the monitoring tables further in this document must be recorded with the frequency specified. Monitoring has four components: (1) measuring the forest conversion rate within the project area, (2) measuring carbon stock densities per LULC class using field sampling techniques and, (3) measuring the peat depth and the depth of the water table, (4) tracking all GHG emissions from emission sources and (4) monitoring the forest conversion rate outside of the project area by the pre-project deforestation agents.

3. DEFINITIONS

The definitions below are consistent with or complement the definitions in the VCS AFOLU Requirements. The definitions contained in the Program Definitions document from the VCS shall always have precedence over the definitions introduced in this section.

3.1 Definitions Regarding Geographical and Temporal Boundaries

- The **project area** is the geographical area where the project participants will implement activities to reduce deforestation. The project area may be contiguous or consist of multiple smaller adjacent and non-adjacent project areas (referred to as **discrete project area parcels**) and conforms to the definition of "forest" set forward by the VCS Program Definitions.

- The **reference region** is the region from which historical land-use change trends are obtained. This information is required to the evolution of future land-use change in the absence of project activities (i.e. baseline scenario). Before the start of the project (i.e. during the **historical reference period**) the reference region includes the project and leakage areas. After the project has started (i.e. during the crediting period) the reference region excludes the project and leakage areas to serve as a reference for determining deforestation and forest degradation rates in the absence of project activities.
- The **baseline validation period** is the period during which the *ex-ante* calculation of net GHG emissions under the baseline scenario is validated. After the baseline validation period expires, a new *ex-ante* baseline needs to be calculated and validated by a VCS verifier.

3.2 Definitions Regarding Classification and Transition of Land Use and Land Cover

- In this methodology, units of land are allocated to different **land use and land cover** (LULC) classes. The LULC classification system must be hierarchical in nature. At the highest level, the definitions from the IPCC GPG-LULCF 2003 for cropland, grassland, settlement, wetland and other land must be followed. A definition of “forest” is included in the VCS Program Definitions.
- A forest LULC class may be further divided into **forest strata** according to the carbon stock density, native forest type, past and future management, landscape position, biophysical properties, and the degree of past disturbance. The minimum mapping unit set forward in the forest definition must also be applied to forest strata. The process of sub-dividing the broad forest LULC class into more narrow forest strata is defined as **forest stratification**.
- A **land transition** is a change from one LULC class or forest stratum into another within one geographical area. This methodology considers four main categories of transitions.
    - **Forest regeneration (RG)** is the persistent increase of canopy cover and/or carbon stocks in an existing forest due to natural succession or human intervention, and falls under the IPCC 2003 Good Practice Guidance land category of forest remaining forest.
    - **Increased forest cover** is the transition of non-forest land into forest land, and encompasses both reforestation and natural succession.
        - **Reforestation (RF)** is the human-induced increase in forest cover (e.g., from cropland to forest, or grassland to forest), and is defined in the VCS Program Definitions.
        - **Natural succession** is a natural increase in forest cover without any human intervention. Natural succession is included in the baseline and project scenarios. Natural succession and increase in forest cover are likely results of decrease in deforestation rate due to project activities.

3.3 Other definitions relevant within the scope of this methodology

- **Peat** is organic soil with at least 30% organic matter and a minimum thickness of 30 cm.
- **Tropical peat swamp** is defined as land containing peat in the tropical or subtropical zone (lying within latitudes 35° North and South). A **tropical peat swamp forest** is then defined as land qualifying as forest located on tropical peat swamp.
- **Timber harvesting for local and domestic use**. The extraction of timber wood for direct use within the project area and by the households that are living within the project area, without on-sale of the timber
- **Commercial timber harvesting**. The extraction of timber wood for further sale on regional/global timber markets outside of the project area or transferred to non-project participants.

- **Participating community**. A local community of individuals and households who are permanently living adjacent to the project area, and who are participating in project activities and directly benefit from project activities through increased livelihoods and improved forest resources.
- **Assisted natural regeneration.** Any silvicultural activity that accelerates regeneration over natural regeneration rates. Examples of such activities include thinning to stimulate tree growth, removal of invasive species, coppicing, and enrichment planting.
- A **production forest** is a forest used for production of various commodities, including timber.
- A **jurisdiction** is the legislative territory where power to govern or legislate permits for land and forest concessions is exercised.

4. APPLICABILITY CONDITIONS

Project proponents must demonstrate that project conditions meet the following list of criteria. Note that in case the project area consists of multiple discrete project parcels, each discrete parcel must meet all applicability criteria of this methodology.

Criteria related to conditions on the land before project implementation:

1. Land in the project area (a) is in the tropical region, (b) qualifies as a forest for at least 10 years before the project start date, and (c) must be a natural forest but may be in a state of partial degradation caused by one or more of the following (legally sanctioned or illegal) drivers of deforestation/degradation:
    - Conversion of forest patches to settlements
    - Conversion of forest patches by households for small-scale cropping (excludes commercial agriculture)
    - Small-scale timber logging. Small scale is defined as less than 5% of the biomass stocks.
    - Collection of fuel-wood or green wood for charcoal production
    - Commercial timber harvesting

   This methodology takes into consideration that peat swamp forests may be under a dual threat by (1) planned conversion by corporate entities, but also (2) small-scale deforestation from e.g., settlements, conversion for subsistence farming, rubber tapping, and small-scale logging. This methodology provides guidance and procedures to manage such small scale deforestation drivers.

2. The project area is (1) legally designated as forest that can be converted to non-forest or production forest with lower biomass than the original forest by all relevant regional and national authorities, and (2) effectively at threat of conversion as demonstrated by either (2a) sufficient and necessary permit(s) to legally convert the project area by an identified agent of deforestation or (2b) the existence of three conversion permits on other areas within the union of a 250-km buffer around the project area and the jurisdiction with decision-making authority on concession permitting.

3. The baseline rate of conversion of the project area can be quantified as following, separately for each of the conversion strata[1], (subsequent options may only be used if prior options are not applicable).

   (a) If the project proponent can produce documentary evidence that demonstrates a legally approved conversion rate by an identified agent of deforestation, this rate must be used in the carbon accounting for the project. The document used must have all necessary legal approvals and permits.

   (b) If no such documentary evidence exists, or no specific deforestation agent can be identified, the rate of conversion by the most likely deforestation agent can be determined based on the historical conversion rate by this most-likely deforestation agent in an area similar to the project area ("reference region"). The reference region must consist of at least three areas under the same conversion stratum as the project area within the union of a 250-km buffer around the project area and the jurisdiction with decision-making authority on concession permitting.

   (c) If option (b) is not applicable, then a conversion rate from the literature may be used for each of the project conversion strata on the condition that it can be demonstrated that this rate (i) is conservative, (ii) is not older than 10 years, (iii) and is from the same country. Section 8.1.2.3 contains further procedures to verify these conditions.

Criteria related to conditions on the land after project implementation

4. Project proponents shall demonstrate that they have planned conservation activities so that the threat of conversion is reduced. A description of the conservation activities must be presented at every verification.

5. If one or more of the degradation drivers outlined in Applicability Criterion 1 have been active in the past five years in the project area, one or more of the following project activities must be implemented, designed in collaboration with the local communities.

   - Supporting alternative livelihood options targeting the communities active in the forest
   - Forest patrolling activities
   - Fire controls
   - Supporting the use of fuel-efficient stoves
   - Establishment of sustainable fuel-wood lots
   - Agricultural intensification.

6. Development of new drainage or continuation/maintenance of active drainage canals within the project boundary is not eligible.

7. If the area that is hydrologically connected to the project area in which peat is present extends beyond the project area boundary, it is required to establish a buffer zone around the project area with peat. It must be ensured that no draining occurs in this buffer zone. It is allowed that the buffer zone extends beyond the project area boundary if legally binding agreements are put in place with land owners of the land outside the project area to ensure that no draining occurs in the buffer zone. However, if such agreements cannot be established, the buffer zone must be

[1] A conversion stratum is a subset of the project area on which the land sanctioning, conversion threat and the future allowable land-uses are identical.

established inside the project boundary. In the event that land owners in the buffer zone violate the agreement and begin drainage activities in the buffer zone, the buffer zone shall be immediately redrawn inside the project boundary and credits shall be calculated using the updated buffer zone from the moment the violation occurs and impacts emissions in the project area. The width of the buffer zone must be established using the procedures in Section 5.3.

8. Harvesting of timber is allowed on the following conditions.
    a) The emissions related to the loss of biomass during harvesting ("harvest emissions") are duly accounted for and subtracted from the emission reductions.
    b) For every verification period, the harvest emissions are smaller than the net emission reductions without harvesting generated during that verification period, so that no "negative credits" are generated.
    c) Selective harvesting shall not significantly affect the hydrology of the peat layer and cause peat decomposition. Harvest activities do not require the development or maintenance of drainage canals in the project area
9. The magnitude of activity-shifting leakage by communities present within the project area or using the project area is quantified through a rigorous monitoring plan consisting of rural appraisals, remote sensing analysis and biomass inventories in the project area. The exact procedures for doing so are included in this methodology.

Other criteria

10. The maximum quantity of GHG emission reduction claimed by the implemented project from peat component shall not exceed the net GHG benefits generated by the project 100 years after the start date. This condition must be verified using the procedures in Section 8.4.4.

5. PROJECT BOUNDARY

5.1 Gases

This methodology requires accounting of emissions of all three biogenic greenhouse gases (CO_2, N_2O and CH_4) from sources not related to changes in carbon pools, henceforward referred to as "emission sources" (Table 2)[2]. Project proponents may omit certain emission sources, but only if they can prove that their contributions are insignificant. The VCS defines significant sources as those accounting for more than 5% of the total GHG benefits generated.

[2] Nitrous oxide emissions from forest fires (excluding controlled burning as a silvicultural activity) are excluded from the GHG accounting.

Table 1. GHG emissions from sources not related to changes in carbon pools ("emission sources") to be included in the GHG assessment.

	Potential Emission Source	Gas	Include?	Justification/Explanation
Baseline	Removal of live biomass	CO_2	No	Emissions are related to changes in carbon pools
		CH_4	No	Negligible
		N_2O	No	N_2O emissions from fire are conservatively excluded.
	Burning of peat	CO_2	Yes	Emissions are related to changes in carbon pools
		CH_4	Yes	Major source of emissions under the baseline scenario
		N_2O	No	Major source of emissions under the baseline scenario
	Peat oxidation from drainage	CO_2	Yes	Major source of emissions under the baseline scenario
		CH_4	No	Negligible
		N_2O	No	Negligible
Project	Increased area of rice production systems	CO_2	No	Not applicable
		CH_4	Yes	Potentially major source
		N_2O	No	Not applicable
	Increased fertilizer use for agricultural intensification	CO_2	No	Not applicable
		CH_4	No	Not applicable
		N_2O	Yes	Potentially major source
	Removal of biomass to prepare assisted natural regeneration	CO_2	Yes	Potentially major source
		CH_4	Yes	Potentially major source if controlled burning is used
		N_2O	No	N2O emissions from burning are insignificant

5.2 Carbon Pools

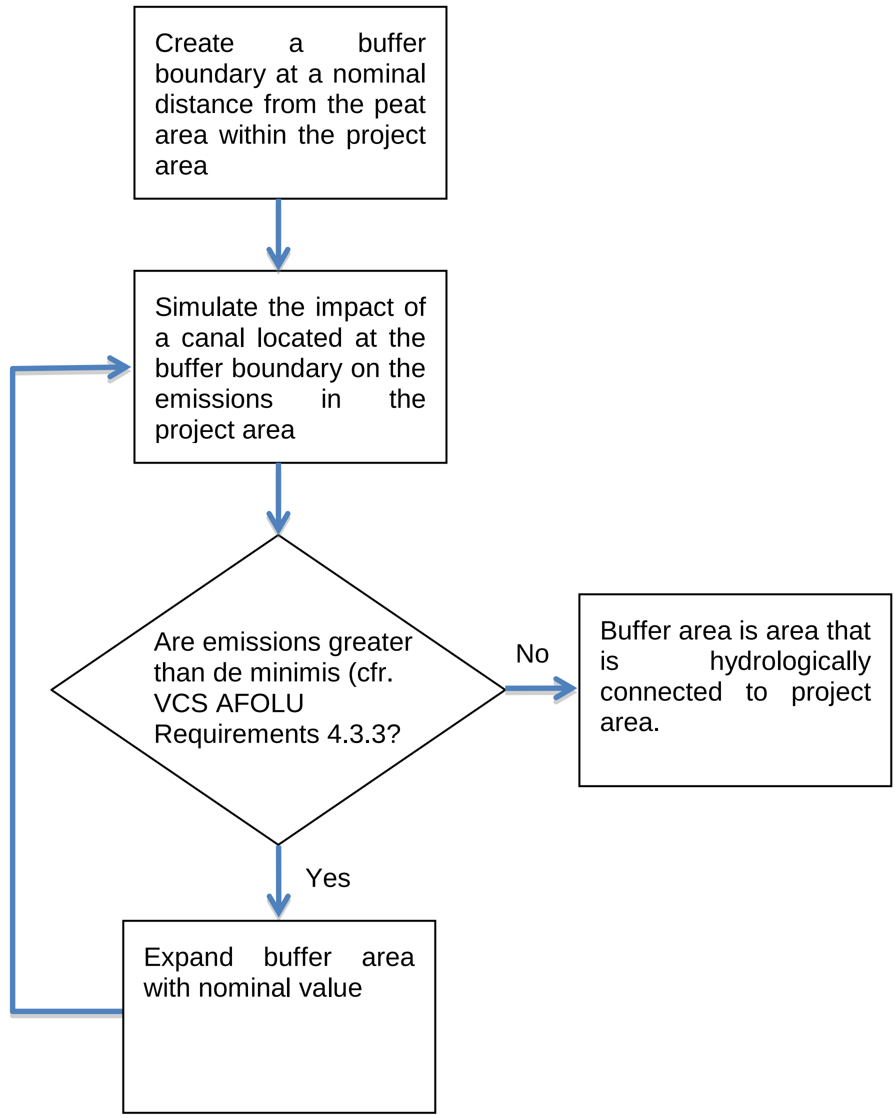
Table 2 summarizes the carbon pools that must be included in projects following this methodology.

Table 2. Selected Carbon Pools

Carbon Pool	Included?	Justification/ Explanation of Choice
Above-ground tree biomass	Included	Major carbon pool affected by project activities
Above-ground non-tree biomass	Included	Change expected to be positive or insignificant under the applicability criteria.
Below-ground biomass	Included	Major carbon pool affected by project activities
Dead wood	Included	Major carbon pool affected by project activities
Litter	Excluded	Insignificant carbon pool.
Soil organic carbon (including peat)	Included	Major carbon pool affected by project activities
Long-lived Wood products	Included	Logging may have been present under baseline conditions. Therefore, halting logging may decrease carbon stored in long-lived wood products.

5.3 Spatial and Temporal Boundaries

The spatial boundaries of the project area must be unambiguously defined in the PD. The project area may be contiguous or consist of multiple adjacent or non-adjacent parcels, "discrete project area parcels". A map indicating the extent of the area that is hydrologically connected to the project area in which peat is present shall be presented at validation. This map must contain the extent of the buffer zone as specified in applicability condition 7. The area that is hydrologically connected to the project area shall be determined using a hydrological model using bulk density and peat depth data measured at project site to simulate the water table depth under known hydrological conditions according to the following flow diagram.



An example of a sufficient hydrological model is SimGro[3], which utilizes the Modflow model in the backend; an example of how SimGro is applied for peat swamp forests in Indonesia is provided in Wösten et al. (2008). Project proponents must duly record all procedures used to delineate the area

[3] Available from the Alterra institute at Wageningen University at http://www.alterra.wur.nl/UK/research/Specialisation+water+and+climate/Integrated+Water+Management/SIMGRO/

of hydrological connectivity in the Project Document. The project area boundary must distinguish the areas or strata containing peat soil and not containing peat soil.

Project duration is fixed and must be a minimum of 20 years and a maximum of 100 years and is renewable at most four times with total project crediting period not exceeding 100 years as specified in the latest version of the VCS Program Documents.

Reporting requirements in the PD
1. Evidence that each of the applicability conditions is met. 2. The project location description as required by the VCS Program Documents. 3. A list of specific sources of greenhouse gases that will be considered in the project based on Table 1.

6. PROCEDURE FOR DETERMINING THE BASELINE SCENARIO

The most current version of the VCS "*VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities*" must be used to determine the most likely baseline scenario.

7. PROCEDURE FOR DEMONSTRATING ADDITIONALITY

The most current version of the VCS "*VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities*" must be used to determine additionality.

PD Reporting requirements
1. Demonstration on how the project is additional using the additionality tools from the VCS.

The most current version of the VCS "VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities" must be used to determine the most likely baseline scenario. The procedures described in VCS tool VT0001 must be followed to identify and analyze the alternative baselines. The most plausible baseline must be selected from the list of available alternative baselines using the step-wise approach below. The selected baseline shall be planned conversion to a non-forest land use. The areas or strata where the most plausible baseline scenario is not the planned conversion of forest to non-forest land-use shall be excluded from the project area. The following steps must be repeated for each of the strata of the project area to justify the selected baseline scenario:

1. Demonstrate that the project area is suitable for selected alternative non-forest land-use. Suitability of conversion to non-forest land-use must be described by providing a detailed account of accessibility to relevant markets for the goods and services derived from project area, and suitability of soils, topography and climate for intended conversion. Exclude any areas that were found to be unsuitable for non-forest land-uses from the project.
2. For all the areas that were found to be suitable for conversion to non-forest land-use, enumerate and describe all the possible agents of planned forest deforestation in the

region. An agent of the planned deforestation can be either the land-owner, or the right holder.

a. If a specific agent of deforestation can be identified, it must be demonstrated that this specific agents of planned deforestation is likely to proceed with conversion within the project credit period in absence of AFOLU project. The likelihood of deforestation by the specific agent of deforestation must be demonstrated by providing documentary evidence that demonstrates legally approved conversion by the identified agent of deforestation. The evidence used may be one or more of the following:
    - Valid forest conversion license owned by agent of deforestation.
    - Documentation that a request for approval for forest conversion has been filed with the tenure holder and relevant government department, if applicable.
    - Documentation that provides evidence of landowner investment to establish suitability of project lands to proposed post-deforestation land use.
    - Record of planned deforestation activities of agents in the past 10 years in the country.
    - Purchase offer of the project area by an entity to convert the land to non-forest land-use
    - Bid for conversion announced by the land-owner.

b. If no specific agent of deforestation can be identified, the likelihood of deforestation must be demonstrated through the existence of three conversion permits on other areas within the union of a 250-km buffer around the project area and the jurisdiction with decision-making authority on concession permitting.

3. The justification of selection of a baseline scenario is strong when more than one of the criteria mentioned above holds true or when more than three conversion permits are presented. When multiple deforestation agents are identified, the most plausible agents for that spatial unit must be selected.
4. Provide a description of the planned conversion activities of the most plausible agent of planned deforestation in areas similar to the project area. If the most likely agent can be specifically identified but has never converted areas similar to project area, then project proponents must demonstrate that it is indeed likely that such conversion may take place in absence of the project activity. The propensity of conversion can be demonstrated by providing a verifiable description of conversions taking place within the jurisdictions such as province, state or region within the past 10 years. The descriptions could be augmented with relevant documents, images and maps, if available. Verifiable historic account of such conversion may come from several sources including scientific publications based on primary data using social assessment, government records, remote sensing assessments and management plans.

8. QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

8.1.1 Select Spatial and Temporal Boundaries

This step includes the demarcation the project area and the reference region.

8.1.1.1 *Describe Spatial Boundaries of the Discrete Project Area Parcels*

Project proponents shall provide digital (vector-based) files of the discrete project area parcels Keyhole Markup Language (KML) file format as required by VCS. A clear description must accompany each file, and the metadata must contain all necessary projection reference data. In addition, the PD must include a table containing the **name** of each discrete project area parcel, the **centroid coordinate** (latitude and longitude using a WGS1984 datum), the **total land area** in ha, **details of tenure/ ownership/zoning** and the relevant **administrative unit** belongs to (county, province, municipality, prefecture, etc.).

8.1.1.2 *Stratify Each Unique Project Parcel According to Potential Conversion Scenario*

Stratify each unique project parcel according to the most likely land conversion that will take place on the land. For each of the legal zoning categories present on the land, identify the most likely conversions based on (a) previous official applications of concessions in the project area, or (b) previous active concessions in the project area that are not active anymore, or (c) common practice.

Identify the most relevant conversion scenarios that may be present on the land while taking into account any legal limits and requirements for the conversion.

Table 3. Steps to identify conversion strata and examples

Sub-step	Example
1. Identify the different legal zoning categories of the project area.	In Indonesia, forest land can be sanctioned in many ways. Production forest land can be sanctioned as HP ("Hutan Produksi") or HPK ("Hutan Produksi Konversi") according to Indonesian law.
2. For each of the legal zoning categories, identify the most likely conversions based on (1) previous official applications of concessions, or (2) previous active concessions on the forest land, or (3) common practice in the area 250 km around the project area	HP land is gradually degraded and converted into HPK HPK land is converted into oil palm plantation
3. Identify potential legal constraints of the conversions	Conversion of palm oil may only be done on areas that are not riparian and that have less than 3 m of peat. Land clearance through burning for plantation establishment is illegal in Indonesia.
4. Demonstrate that the land conversions identified are truly possible according to biophysical constraints or legal constraints.	Conversion of palm oil cannot be done on sloping terrain or on high-clay soils.

Combine the four sub-steps of Table 3 into discrete "conversion strata" such as:

- Conversion to oil palm plantations on HPK land
- Degradation of peat land immediately adjacent to oil palm plantations
- Logging of merchantable timber

Provide a map of the project area with each of the conversion strata clearly identified.

8.1.1.3 *Specify Temporal Boundaries of the Project*

Project proponents must fix the following temporal boundaries

- The **historical reference period** with exact start date. The end of the historical reference period must coincide with the project start date. The duration of the historical reference period must be between 6 and 10 years.
- The **project crediting period** with exact start date and project end date. The start of the crediting period is equal to the start of project date and is the date when the first project activity for which NERs are claimed is implemented. The duration of the crediting period must be between 20 and 100 years.
- Project proponents must seek third-party verification at least every five years. The **frequency of verification** may change during the crediting period (e.g., every two years during the first ten years of the crediting period, and every five years thereafter). The frequency and years of verification must be fixed for the duration the baseline is valid and must be included in the PD or in a monitoring report if the baseline is updated.

Baselines must be updated at year five, ten and every ten years thereafter. Under specific circumstances, the baseline must be updated more frequently. These circumstances are outlined in the monitoring section.

Reporting Requirements in the PD
1. Maps for all project areas with the LULC classes and forest stratification. 2. Shape files of the discrete project area parcels and the reference region[4]. All necessary meta-data to correctly display the files must be included. 3. Table of all the discrete project area parcels with their ID, name, coordinate centroid (latitude and longitude using a WGS1984 datum), total land area in ha, details of tenure/ownership, and the relevant administrative unit. 4. Overview map of the whole reference region with the location of the discrete project area parcels clearly indicated.

8.1.2 Determine Baseline Conversion Rates

As specified in the applicability criteria, three options exist to determine the baseline rate of conversion of the project area. The conversion rate must be estimated separately for each of the project conversion strata. Note that subsequent options may only be used if prior options are invalid or not applicable. Different conversion strata within one project may use different options to determine the baseline conversion rate.

8.1.2.1 *Option (a) - Legally Approved Conversion Rate*

If the project proponent can produce documentary evidence that demonstrates a legally approved conversion rate for the project area by an identified agent of deforestation, this rate must be used in the carbon accounting for the project. Examples of such evidence include legally approved management plans, management maps, etc. The documents provided as evidence used must have all necessary legal approvals and permits. However, the permits may not be valid any longer due to the existence of the REDD project.

[4] Note that separate digital boundaries are also necessary for all individual forest strata per discrete project parcel where ANR activities are implemented, and must remain available for the duration of the project's crediting period. This is detailed in section 8.2.4.2.3.

8.1.2.2 *Option (b) – Historical Conversion Analysis in a Reference Region*

In case no legally recognized forest conversion rate is available, the rate of deforestation and forest degradation in the project area under the baseline scenario may be calculated from the reference region which is used as a proxy for the baseline calculations within the project area. Following criteria must be met for a valid reference region:

- Lies within 250 km distance from the project boundary and is located within the jurisdiction of the project area.
- The deforestation agents or group of agents in the reference region are similar to the deforestation agents or groups of agents in the project area.
- Forest in the reference region is similar to the project area. For example the presence of species or species group must be similar or the both areas must have similar dominant forest types or species group
- The slope at the 85% quantile of the distribution of slopes of the project area must be smaller than the maximal slope of the reference region.
- The ecological factors and micro-climate in the reference region must be suitable to support the land use that is expected to be the post-conversion land use in the project area. For example, if the baseline is conversion to oil palm plantation then the reference region must be suitable for oil palm plantations. The suitability may be demonstrated by evidence of historical conversion leading to oil palm plantation.
- The reference region must be comparable with respect to rainfall, length of rainy season, distribution of rainfall over different months and mean annual temperature.
- The land zoning or sanctioning status must be same as that of the project area.

The reference region consists of at least three areas that have a similar land conversion stratum as the ones identified in the project area, but on which the conversion has already occurred in the reference region. The quantification of the conversion rate shall only be based on the land that is legally allowed to be converted using current legal restrictions, even if such restrictions were not into force at the time the historical conversion occurred. Land that has been converted but is not allowed to be converted according to current legal restrictions shall be excluded from the conversion rate calculation.

To determine the conversion rate on the three areas, at least two maps of forest cover are required: at least one image from 0-5 years before project start, and (b) at least one image from 5-15 years before project start. There must be at least 5 years difference between the two maps of forest cover. If no forest cover maps are available, a remote sensing-based forest cover map must be developed. The spatial resolution of the remote sensing data used to create these maps must be at least 30m. The LULC classes used during classification must contain *at least* the six IPCC LULC classes (Forest Land, Crop Land, Grass Land, Wetlands, Settlements, and Other Land) in the LULC class definitions. The definition of these classes must be consistent with Chapter 2 of the IPCC GPG-LULUCF 2003. In cases where the country has defined more specific LULC classes than the IPCC classes, these definitions must be used if they are accurate enough for project-specific classification. All steps involved in pre-processing (e.g., orthorectification, cloud masking, haze removal, radiometric corrections), classification (e.g., (sub-) pixel based or segment-based), and post-processing (e.g., spatial and temporal filtering) must be duly noted in the PD. In addition, an independent accuracy analysis must be included. The accuracy assessment of the LULC classification and forest stratification process must follow the best practices for remote sensing (e.g., Congalton 1991). The LULC classes or forest strata for these reference locations must be identified using field observations, in-situ maps, remote sensing data, and other ground-truthing data. At least 50 reference locations per LULC class or forest stratum must be used. More specifically, the classification accuracy must be assessed by comparing the classes of the points from the validation dataset with the classes of the same locations on the classification products. A confusion matrix or error matrix will be produced together with different statistical measures of overall accuracy, producer's accuracy, user's accuracy and kappa statistics for each classified image. Similarly, classification within the classes must be conducted to account for degradation i.e. multiple classless within the strata within a land cover classes for each classified image. Every individual image shall meet the accuracy threshold of 70%. In addition, the smallest accuracy across all images shall be used for discounting purposes as described in Table 4.

Table 4. Accuracy discounting factors for LULC classification as a function of the smallest attained accuracy across all images used.

	Discounting factor for emission reductions from avoided deforestation based on the accuracy of LULC classification
Smallest accuracy attained	$u_{classification}$
>85%	1.00
80-85%	0.85
75-80%	0.80
70-75%	0.75
<70%	Project is not eligible

The historical conversion rate, (i.e., proportion of converted forest area divided by the total forest area of the earliest LULC map) must be interpolated for each of the conversion strata in the project area by multiplying the rate with the area of the conversion stratum. Present a table of annual deforested area, as well as the remaining forest cover for each conversion stratum. Obviously, conversion must stop after no more forest is available so that the remaining forest cover remains positive.

8.1.2.3 *Option (c) – Conservative Estimate of a Conversion Rate*

If option (a) or option (b) are not applicable, a conversion rate obtained from the literature may be used on the condition that it can be demonstrated that (i) it is conservative, (ii) it is not older than 10 years and (iii) it is from the same country or province as the project area. It is up to the project proponent to demonstrate that the selected rate is valid and conservative. The validator will assess the conservativeness of the selected rate on the following basis:

- Applicable rates must be acquired from literature sources such as peer-reviewed literature, official land use change maps and reports. Project proponents must substantiate why a proposed rate is applicable. At least three different rates from three different and independent sources from within the past 10 years must be presented in the PD so that the auditor can assess the conservative nature of the selected values
- The most conservative rate (i.e., smallest of the available rates) must be used. The Project Design Documents must state available rates and the justification for the used value as most conservative.
- The rates used or proposed by project proponents must be cross-checked for conservativeness in scientific publication archives by the validator. Common scientific archives are ISI Web of Knowledge, Google Scholars, Agricola, PubMed or similar archives that index scientific publications.

However, even if all of the conditions above are met, an auditor has the authority to disapprove validation of a project when doubt remains on the conservative nature of the proposed conversion rate.

The existing peat conversion methodology uses a conversion rate based on legal permits, management plans, or other valid documentation, which is, oftentimes, difficult to access. Even though deforestation is evident from remote sensing data, no documentation may exist to substantiate the deforestation rate. This methodology includes the option to infer the baseline deforestation rate from remote sensing analyses combined with records of land sanctioning, which are usually available. The methodology includes three different approaches to quantify the baseline emissions rate in peat forests. Such flexibility is particularly relevant in countries where management plans do not always contain information on conversion rates.

Reporting Requirements, include in the PD sections 2.3 and 2.4
1. For option (a): list of the documentary evidence used for the legally approved conversion rate (option a). 2. For option (b): description of the maps used for the historical analysis or remote sensing data used, detailed description of the remote sensing procedures, and a report on the accuracy of the remote sensing analysis. 3. For option (c): justification of the used source including rationale on conservative nature and validity of the source. 4. Table of annual deforested area, as well as the remaining forest cover for each conversion stratum.

8.1.3 Determine Plant Emission Factors for All Included Transitions

For each LULC class or forest stratum that could be subject to a transition as identified in section 8.1.3.1, it is necessary to determine the average carbon stock density, based on **permanent sampling plots on forest LULC classes** and **non-permanent sampling plots on non-forest LULC classes**. The number of plots and their location must be determined in a stratified sampling design. The following steps are to be followed:

1. Identify the LULC classes and forest strata for which carbon stocks are to be quantified.
2. Review existing biomass and biomass increment data for comparison with field measurements.
3. Determine the sample size per LULC class or forest stratum.
4. Measure carbon density stocks of each LULC class or forest stratum.
5. Calculate emission factors for each land transition category.

8.1.3.1 *Identify the LULC Classes and Forest Strata for which Carbon Stocks are to be Quantified.*

Present a table of all transitions between LULC classes and forest strata that are likely to occur for every conversion stratum in a table similar to Table 5. The main categories of transitions are deforestation, forest degradation, increased forest cover and regeneration. A list must be prepared of the transitions that are considered by the project proponents by analyzing a matrix combining all relevant LULC class and forest strata subject to deforestation, forest degradation, and increase forest cover and regeneration. In addition, a temporal component of every transition must be defined, where relevant. For example, for deforestation, it must be defined what the period of Temporarily Unstocked is. Likewise, for forest degradation, the minimal duration that the smaller carbon stock density has occurred for must be fixed.

The organic matter stock density of each LULC class or forest stratum that is included in a transition must be quantified.

Table 5. Example LULC and forest strata transition table showing all possible transitions.

From Class	To Class	Transition	Period of Temporarily Unstocked
DCD	BAR	Deforestation	3 years
DCD	AGR	Deforestation	3 years
DCD	WTS	Deforestation	3 years
EVG	BAR	Deforestation	3 years
EVG	AGR	Deforestation	3 years
EVG	WTS	Deforestation	3 years
BAR	DCD	Reforestation	Not relevant
AGR	DCD	Reforestation	Not relevant
WTS	DCD	Reforestation	Not relevant
BAR	EVG	Reforestation	Not relevant
AGR	EVG	Reforestation	Not relevant
WTS	EVG	Reforestation	Not relevant

EVG = evergreen forest class, DCD = deciduous forest class, BAR = degraded woodland, AGR = cropland, WTS = wetland

8.1.3.2 *Review Existing Data of Biomass Stock Densities and Biomass Net Annual Increments*

8.1.3.2.1 Review existing data on biomass stock densities

For the purpose of sampling design and quality assurance of the measured values, all existing data on biomass stock densities must be reviewed. Sources that must be consulted include (lower-ranking options may only be used if higher-ranking options are not available): (a) peer-reviewed scientific literature conducted within the reference region, (b) peer-reviewed scientific literature from an area similar to the reference region, (c) non peer-reviewed reports or studies from the reference region or similar areas. Sources that contain a measure of the variation of the values (range, standard deviations, standard errors, or coefficients of variation) are specifically useful, since these can be used for preliminary determination of the number of sampling plots required during field sampling. For every data source used, note the following items:

- Methodology (field inventory, extrapolation from satellite imagery, ecosystem model, or GIS analysis).
- Number of measurement plots used.
- Whether all species are included in the sampling.
- The minimum DBH of measured trees in the biomass inventory.
- Region in which the samples were taken.

8.1.3.2.2 Review existing data on net annual increments of biomass

Whereas the GHG benefits from avoided deforestation and avoided forest degradation are based on observed transitions between LULC classes and forest strata, the GHG benefits from ANR activities are based directly on the empirically observed increases in biomass stock densities. Therefore, a correct accounting of the GHG benefits from ANR activities requires a sound baseline natural regeneration rate. Therefore, for accurate ex-ante estimates, all existing data on net annual increments of biomass carbon stocks must be reviewed. Sources that must be consulted include (lower-ranking options may only be used if higher-ranking options are not available): (1) values measured by the project proponents in the project area using the methods used for forest inventories discussed in this methodology, (2) national or local growth curves and tables that are usually used in national or local forest inventories, (3) values from peer-reviewed literature, report the items above, (4) values from GPG-LULUCF Table 3A.1.5. These values are representative for regeneration in well-managed forests, and will therefore be conservative. These values must be reported for every stratum on which ANR activities are planned. For any values used other than the ones given in GPG-LULUCF Table 3A.1.5, the estimated values must be proportionally discounted if the uncertainty (percentage of mean) exceeds 15%.

8.1.3.3 *Determine the Sampling Design, i.e., Number, Location, and Layout of Biomass Plots*

This section relates to determining the sampling design for biomass plots. The sampling design for peat depth locations is explained in Section 8.1.4.2. The sampling of peat may follow a different sampling design than the sampling of aboveground biomass.

The determination of the sample size (**number of biomass sampling plots**) required per LULC class and forest strata that are identified in 8.1.3.1 is dependent on (1) the required precision of 15% at 95% confidence level and (2) the variance in the specific LULC class and forest strata. A similar sampling design is used to determine the peat depth and water table measurement and wherever applicable, measurements occur together on the same plots. Extra measurement plots must be installed within the ANR areas to reliably estimate the increase in carbon density. Use AR-AM Tool 03 ("Calculation of the number of sample plots for measurements within A/R CDM project activities") to determine the number of biomass inventories required.

Further explanation on how to select the **layout of biomass sampling plots** (form, nesting, etc.) can be found in textbooks such as Hoover (2008). For measuring and monitoring carbon density in the forest strata, a network of permanent forest sampling plots must be established. Due to the significant anthropogenic influence on non-forest land, it is not deemed feasible to install permanent sampling plots. Therefore, the average carbon stock density on non-forest LULC classes shall be assessed using non-permanent sampling plots. Alternatively, conservative defaults gathered from scientific literature may be used to quantify the carbon stock density on non-forest land. The applicability of these default values shall be confirmed by the validator.

Within a LULC class or forest stratum, the **location of biomass sampling plots** must be selected either systematically with a random start (see 2003 IPCC GPG-LULUCF) randomly within a cell of a systematic grid (see Thompson, 2002), or using a systematic grid. The randomization must be done *ex-ante* by a computer program. This is required to avoid subjective choice of plot locations. For each sample plot, record the observed LULC class, forest type, and estimated forest canopy closure.

Summarize the sampling framework following the guidance of section 4.3.3.4 of GPG LULUCF in the PD and provide a map and the coordinates of all sampling locations.

8.1.3.4 *Measure Carbon Stock Densities*

The plot-wise plant carbon stock density from a sampling plot shall be kept separate for aboveground live, aboveground dead and belowground tree carbon stock density. The above ground dead plant carbon stock density can be calculated by summing the biomass carbon stock density in the lying deadwood and standing deadwood components. Likewise, the aboveground live plant carbon stock density can be calculated by summing the biomass carbon stock density in the aboveground tree and aboveground non-tree components.

$$OM_{AGD}(i,p) = OM_{LDW}(i,p) + OM_{SDW}(i,p) \quad \text{[EQ1]}$$

$$OM_{AGL}(i,p) = OM_{AGT}(i,p) + OM_{AGNT}(i,p) \quad \text{[EQ2]}$$

Where,

$OM_{LDW}(i,p)$ = Lying deadwood organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]

$OM_{SDW}(i,p)$ = Standing deadwood organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]

$OM_{AGD}(i,p)$	=	Aboveground dead tree organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]
$OM_{AGL}(i,p)$	=	Aboveground live organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]
$OM_{AGT}(i,p)$	=	Aboveground live tree organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]
$OM_{AGNT}(i,p)$	=	Aboveground live non-tree organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]

In addition, the following symbol is used in subsequent equations, calculations as well as monitoring tables:

$OM_{BG}(i,p)$	=	Belowground tree organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]
$OM_{SOM}(i,p)$	=	Soil organic matter contained in mineral substrate (i.e. not in peat soil) of plot p within LULC class or forest stratum . [Mg DM ha^{-1}]. Measure this pool only in areas that do not contain peat soil. Consider $OM_{SOM}(i,p)$ is equal to "0" for all the areas that contain peat soil.

For the aboveground live (AGL), aboveground dead (AGD), belowground (BG), and non-peat soil organic matter (SOM) pools, the average stock densities of stratum $\boldsymbol{i}$ and associated statistics are calculated using the equations below. The "o" subscript indicates the AGL, AGD, BG, or SOM carbon pool.

$$OM_o(i) = average\left(OM_o(i,p)\right) \quad \text{[EQ3]}$$

$$stdev\left(OM_o(i)\right) = stdev\left(OM_o(i,p)\right) \quad \text{[EQ4]}$$

$$stderr\left(OM_o(i)\right) = \frac{stdev\left(OM_o(i)\right)}{\sqrt{n_i}} \quad \text{[EQ5]}$$

$$HCWI\left(OM_o(i)\right) = t_{0.95,n-1} \cdot stderr\left(OM_o(i)\right) \quad \text{[EQ6]}$$

$$CE_{inventory}(i) = \frac{\sqrt{\sum_o HWCI\left(OM_o(i)\right)^2}}{\sum_o OM_o(i)} \quad \text{[EQ7]}$$

$$u_{inventory}(i) = \begin{cases} 1 & \text{if } CE(i) \leq 0.15, \\ 1 - CE(i) & \text{if } 0.15 < CE_{inventory}(i) < 1, \\ 0 & \text{if } CE(i) \geq 1 \end{cases} \quad \text{[EQ8]}$$

Where,

$OM_o(i)$	=	Average plant organic matter density of LULC class or forest stratum i in pool o. [Mg DM ha^{-1}]
$OM_{o,plot\text{-}wise}(i,p)$	=	Total biomass stock density of plot p within LULC class or forest stratum i in pool o. [Mg DM ha^{-1}]
$stdev\left(OM_o(i)\right)$	=	Standard deviation of the total plant-derived organic matter density of LULC class or forest stratum i in pool o. [Mg DM ha^{-1}]

$stderr(OM_o(i))$	=	Standard error of the average of the total plant-derived organic matter density of LULC class or forest stratum i in pool o. [Mg DM ha^{-1}]
n_i	=	Number of sampling plots of LULC class or forest stratum i in pool o. [-]
$HCWI(OM_o(i))$	=	Half-width of the confidence interval around the average of the total plant-derived organic matter density of LULC class or forest stratum i in pool o. [Mg DM ha^{-1}]
$t_{0.95,n-1}$	=	Value of t-statistics (i.e., from *t*-table) at 95% confidence interval and n-1 degree of freedom [-]
o	=	Carbon pool, either aboveground live (AGL), aboveground dead (AGD) and belowground (BG).
$CE_{inventory}(i)$	=	Combined error in estimate of average biomass stock density of LULC class or forest stratum i. $[-]$
$u_{inventory}(i)$	=	Uncertainty of biomass stock density in stratum i. $[-]$

[EQ7] and [EQ8] are used in estimating the combined error, $\boldsymbol{CE_{inventory}(i)}$, and the uncertainty, of the biomass stock density, $\boldsymbol{u_{inventory}(i)}$, respectively. Note that procedures to calculate the uncertainty of the *difference* of two biomass stock densities due to a land transition are included in section 8.1.3.5. Estimation of combined error of the inventory, $\boldsymbol{CE_{inventory}(i)}$ is prerequisite to estimation of uncertainty, $\boldsymbol{u_{inventory}(i)}$. These two equations must be treated as generic and can be applied in estimating uncertainty from some specific project when needed. For example, when uncertainty in estimated carbon stock density in harvest areas are needed, then inventory data from areas under harvest alone must be used in these two equations to estimate inventory uncertainty in harvest areas i.e., $\boldsymbol{u_{inventory,harvest}(i)}$.

Stratum specific average organic matter can be estimated by summing organic matter in different carbon pools. Subsequently, the average total carbon stock is calculated by multiplication with the carbon fraction.

$$OM(i) = \sum_{o} OM_o(i) \quad \text{[EQ9]}$$

$$C_o(i) = CF \cdot OM_o(i) \quad \text{[EQ10]}$$

$$C(i) = \sum_{o} C_o(i) \quad \text{[EQ11]}$$

Where,

$OM(i)$	=	Average plant-derived organic matter of LULC class or forest stratum i. [MG DM ha-1]
$OM_o(i)$	=	Plant-derived organic matter of LULC class or forest stratum i in pool o. [Mg DM ha^{-1}]
$C_o(i)$	=	Average carbon stock density of LULC class or forest stratum i in pool o. [MT C ha^{-1}]
CF	=	Carbon fraction of dry matter in wood (default = 0.5). [Mg C (Mg DM)$^{-1}$]
$C(i)$	=	Average carbon stock density of LULC class or forest stratum i. [MT C ha^{-1}]

The exact measurement of above-ground and below-ground tree carbon must follow international standards and follow IPCC GPG LULUCF 2003. These measurements are explained in detail in CDM approved methodology AR-AM0002 “Restoration of degraded lands through afforestation/reforestation”. A step-by-step Standard Operations Procedure for field measurements must be prepared ex-ante and contain a detailed, step-by-step explanation of all of the required field-work for both ex-ante and ex-post measurements. This document will ensure consistency during the crediting period by standardizing sampling procedures from year to year.

- **Aboveground tree biomass**,$\boldsymbol{OM_{AGT}(i,p)}$. The aboveground tree biomass must be calculating by measuring the DBH of all trees with a DBH > 5 cm within the sampling plot. The applicability of the allometric equation $\boldsymbol{f_{allometric}}$ used must be specifically verified according to the procedures of this methodology described in Section 10.4. The allometric equation(s) must remain fixed during a baseline validation period. During verification, project proponents may propose to replace previously used allometric equations, and BEF values by more accurate ones, if these would become available. The use of different allometric equations and BEF values is subject to the explicit approval of the validator.
- **Aboveground non tree biomass**, $\boldsymbol{OM_{AGNT}(i,p)}$. The above ground non-tree vegetation must be measured by destructive harvesting techniques.
- **Belowground biomass**, $\boldsymbol{OM_{BG}(i,p)}$. The below-ground biomass pool must be estimated from the above-ground biomass using a relationship $\boldsymbol{f_{belowground}}$ between aboveground and belowground biomass, such as a root-to-shoot ratio. The assumptions for using a root-to-shoot ratio are verified in the applicability criteria. Similar as to the constants for the aboveground biomass, $\boldsymbol{f_{belowground}}$ must be fixed during a baseline validation period. During baseline validation, project proponents may replace a previously used $\boldsymbol{f_{belowground}}$ by a more accurate one, if this would become available.
- **Lying dead-wood**, $\boldsymbol{OM_{LDW}(i,p)}$. Lying deadwood must be sampled with the line intersect method (Harmon and Sexton, 1996) using the equation by Warren and Olsen(1964) as modified by Van Wagener (1968).
- **Standing dead-wood**, $\boldsymbol{OM_{SDW}(i,p)}$. Standing dead trees shall be measured using the same procedures used for measuring live trees with the addition of a decomposition class.
- **Soil organic matter**, $\boldsymbol{OM_{SOM}(i,p)}$. Soil organic carbon pool must be estimated using soil samples taken at different soil horizons only from areas that do not contain peat soils. The depth to which the soil samples are taken and analyzed must be at least 30 cm as per the recommendation of the IPCC GPG-LULUCF (2003). In these samples, depth, bulk density and concentration of organic dry matter shall be recorded.

8.1.3.5 *Calculate Emission Factors*

Emission factors only include the carbon pool-related sources due to changes in biomass between the LULC classes and forest strata. Since N_2O and CH_4 emissions from forest fires increase emissions, they can be conservatively omitted for baseline calculations[5]. Once the carbon stock densities are calculated, biomass carbon emission factors and their uncertainties for each LULC class or forest stratum transition are calculated as:

$$EF_{AGL}(CS1 \rightarrow CS2) = \frac{44}{12} \cdot \left(C_{AGL}(CS2) - C_{AGL}(CS1)\right) \quad \text{[EQ12]}$$

$EF_{AGL}(CS1 \rightarrow CS2)$	=	Emission factor for change in aboveground live plant organic matter from an LULC class or forest stratum 1 to 2. [$tCO_2e\ ha^{-1}$]
$CS1 \rightarrow CS2$	=	Land transition from LULC class or forest stratum 1 to 2.

[5] Note that under the project scenario, N_2O emissions from controlled burning must be included in the carbon accounting.

$C_{AGL}(i)$	=	Carbon density of aboveground plant organic matter of classes or forest stratum i. [MT C ha^{-1}]

The biomass emission factor for aboveground deadwood must be spread over time by a temporal component. Project proponents may propose their own temporal component (e.g., an exponential equation) if the conservative nature of the temporal component can be demonstrated using peer-reviewed literature or field measurements. If no temporal component is proposed by the project proponents, the default temporal component from the VCS shall be used using the following formula:

For $t \leq 10$:

$$EF_{AGD}(CS1 \rightarrow CS2, t) = \frac{44}{12} \cdot \frac{\left(C_{AGD}(CS2) - C_{AGD}(CS1)\right)}{10}$$

For $t > 10$:

$$EF_{AGD,plant}(CS1 \rightarrow CS2, t) = 0$$

$EF_{AGD}(CS1 \rightarrow CS2, t)$	=	Emission factor from change in above ground dead wood from an LULC Class or forest Stratum (CS) 1 to 2 at t years after transition. [tCO_2e ha^{-1}]
$CS1 \rightarrow CS2$	=	Land transition from LULC class or forest stratum 1 to 2.
$C_{AGD}(i)$	=	Carbon density of aboveground dead plant organic matter of classes or forest stratum i. [MT C ha^{-1}]

Similarly, the total belowground biomass emission factor must be spread over time by a temporal component. Project proponents may propose their own temporal component (e.g., an exponential equation) if the conservative nature of the temporal component can be demonstrated using peer-reviewed literature or measurements conducted by the project proponents. If no temporal component is proposed by the project proponents, the default temporal component from the VCS shall be used using the following formula:

For $t \leq 10$:

$$EF_{BG}(CS1 \rightarrow CS2, t) = \frac{44}{12} \cdot \frac{\left(C_{BG}(CS2) - C_{BG}(CS1)\right)}{10}$$

For $t > 10$:

$$EF_{BG}(CS1 \rightarrow CS2, t) = 0$$

Where,

$EF_{BG}(CS1 \rightarrow CS2, t)$	=	Emission factor for change in belowground plant organic matter from an LULC Class or forest Stratum (CS) 1 to 2 at t years after transition. [tCO_2e ha^{-1}]
$CS1 \rightarrow CS2$	=	Land transition from LULC class or forest stratum 1 to 2.
$C_{BG}(i)$	=	Carbon density of belowground plant organic matter of classes or forest stratum i. [MT C ha^{-1}]

The total soil emission factor is only applicable for from mineral substrate soil (not from peat soil) must be gradually spread over time. Project proponents may propose their own temporal component (e.g., an exponential equation) if the conservative nature of the temporal component can be demonstrated using peer-reviewed literature or measurements conducted by the project proponents. If no temporal component is proposed by the project proponents, the temporal component from the IPCC GPG-LULUCF 2003 and used in following formula for the soil emission factor must be used:

For $t \leq 20$:

$$EF_{SOM}(CS1 \rightarrow CS2, t) = \frac{44}{12} \cdot \frac{\left(C_{SOM}(CS2) - C_{SOM}(CS1)\right)}{20} \quad \text{[EQ13]}$$

For $t > 20$:

$$EF_{BG}(CS1 \rightarrow CS2, t) = 0 \quad \text{[EQ14]}$$

where:

$EF_{SOM}(CS1 \rightarrow CS2, t)$	=	Emission factor for change in soil organic matter from LULC Class or forest Stratum (CS) 1 to 2 at t years after transition. [$tCO_2e\ ha^{-1}$]
$cs1 \rightarrow cs2$	=	Land transition from LULC class or forest stratum 1 to 2.
$C_{SOM}(i)$	=	Carbon density of soil organic matter plant of LULC class or forest stratum i. [$MT\ C\ ha^{-1}$]

Soil emission factor, $EF_{SOM}(CS1 \rightarrow CS2, t)$ is "0" for areas that contain peat.

For aboveground live, aboveground dead, belowground or soil organic matter from mineral soil emission factor, the combined error in estimated biomass stock densities for a transition from one stratum to another is measured as:

$$CE_{transition}(CS1 \rightarrow CS2) = \frac{\sqrt{\sum_o \left(HWCI\left(OM_o(CS1)\right)^2 + HWCI\left(OM_o(CS2)\right)^2\right)}}{\left|\sum_o OM_o(CS2) - \sum_o OM_o(CS1)\right|} \quad \text{[EQ15]}$$

The uncertainty discounting for estimated emissions factors for a transition from one stratum to another is estimated using [EQ16].

$$u_{transition}(CS1 \rightarrow CS2) = \begin{cases} 1 & \text{if } CE_{transition}(CS1 \rightarrow CS2) \leq 0.15 \\ 1 - CE_{transition}(CS1 \rightarrow CS2) & \text{if } 0.15 < CE_{transition}(CS1 \rightarrow CS2) < 1 \\ 0 & \text{if } CE_{transition}(CS1 \rightarrow CS2) \geq 1 \end{cases} \quad \text{[EQ16]}$$

Where:

$u_{transition}(CS1 \rightarrow CS2)$	=	Discounting factor for the emission factor for the transition from LULC class or forest stratum 1 to class 2 according to the uncertainty of the biomass inventory. [-]

$HWCI(OM_o(CS1))$ and $HWCI(OM_o(CS2))$	=	Half-width of the 95% confidence interval around the mean plant organic matter density of LULC classes or forest strata 1 and 2 in pool o. [$tCO_2e\ ha^{-1}$]
$CE_{transition}(CS1 \rightarrow CS2)$	=	Combined error in estimated biomass stock density change for a transition from one stratum to another. [-]

Note that a positive sign of EF_o indicates a net sequestration of carbon, or an increase in the carbon stock, and a negative sign indications emission. List the estimated emission factors, the associated uncertainties, and the lower confidence limit per LULC class and forest strata category in a table in the PD. The inventory must be iteratively expanded until for every transition, $u_{transition}(CS1 \rightarrow CS2)$ is greater than 0.75. This threshold serves to ensure a minimal accuracy of biomass inventories.

Finally, it must be checked that all forest stratum transitions are compatible with the definition of degradation. More specifically, it must be checked that the carbon stock densities in two different strata differ at least by 10% of the carbon stock of strata with lower level of carbon stock. For example, if strata "A" has 50 Mg C ha-1, then strata "B" must have at least 55.1 Mg C ha-1.

PD Reporting requirements
1. Rationale on which LULC classes and forest strata are selected for quantification. 2. Table with existing data in carbon stock density measurements in the literature, including the methodology, number of sampling plots, whether all species were included, minimum DBH used, and region in which the samples were taken. 3. Table with baseline net annual increments due to natural regeneration rates. Report the same information on the data sources as for the previous PD requirement 4. Sample framework for collecting field data, including size, layout, and location. 5. Spreadsheet containing the calculations of carbon stock densities. 6. Statistical distributions (histograms) of all carbon stock measurements per LULC class and forest type. 7. Table with descriptive statistics on carbon stock densities per predicted LULC class or forest stratum i for different carbon pools o, including: • Average, $OM_o(i)$ • Standard deviation, $stdev(OM_o(i))$ • Number of observations, n_i • Standard error around the mean, $stderr(OM_o(i))$ • Half-width of the 95%-confidence interval around the mean, $HCWI(OM_o(i))$. 8. Look-up table with emission factors per LULC class and forest type

8.1.4 Determine Peat Activity Data and Emissions

The accounting framework of this methodology is based on discrete "conversion strata", which represent typical conversion scenarios for different parts of the project area (e.g., peat lands converted first to production forest with logging, followed by full conversion to oil palm plantation, or peat lands that are directly converted to oil palm plantation). If the part of the project area do not contain peat, this procedure must be skipped entirely. Emissions from peat will be dependent on:

1. **Conversion rate for each conversion stratum**
2. **Rate at which the peat disappears after conversion**, which may depend on the type of conversion and whether oxidation or burning are the main causes of the peat subsidence
3. **The peat depth at every location in the project area**. The peat depth is important to calculate the "Peat Depletion Time" (PDT)[6] for every location in the project area, as prescribed by the AFOLU PRC Requirements.

The conversion rate for each conversion stratum (component 1) is determined or quantified using the procedure described in section 8.1.2. This section focuses on providing procedures to determine the rate at which the peat disappears (component 2) in Section 8.1.4.1, and the peat depth at every location (component 3) in Section 0. Finally, Section 8.1.4.3 explains how to bring all components together and calculate the Peat Depletion Time and annual emissions from peat.

8.1.4.1 *Define Water table Drainage Depth and Maximal Subsidence Rate for Every Conversion Stratum*

Using literature or water-table monitoring points, identify the drainage level for every potential conversion stratum. Smaller values are more conservative. The drainage level can be demonstrated by evidence such as photographs and images of locations that are identical to the project area, or scientific literature. In addition, the drainage level can also be substantiated by investigating the intended purpose of the land, or the common practice within the jurisdiction, or past activities of the identified agents of deforestation. If drainage levels from the literature are used, it shall be justified that the conditions of the project area are such that the value from the literature is applicable. More specifically, it shall be justified that the drainage infrastructure of the cited literature can be effectively implemented in the project area. Some transitions will not be associated with any drainage. For example, forest degradation due to logging may not be associated with drainage, unless access canals are created. True conversion to other land uses, such as natural forest to oil palm plantations, or natural forest to pulp-wood systems, will be almost certainly associated with drainage. Values of water table drainage are stored in the $drainage(j,t)$ variable.

$drainage(j,t)$	=	Drainage level of conversion type j at time t [cm]

In addition, for every conversion stratum, a "maximal peat subsidence scenario" must be developed. The maximal peat subsidence scenario details how much peat can maximally be lost due to peat oxidation and burning (in cm yr^{-1}) for every year after the conversion. This rate is maximal in the sense that the peat layer never gets depleted beyond this. Separate the maximal peat subsidence rate into the maximal subsidence rate from oxidation and the maximal subsidence rate from burning. The rate of subsidence from oxidation for a specific stratum must be justified given the corresponding drainage level for that stratum. For every conversion stratum that is identified in the baseline scenario and for which subsidence from fire is included, project proponents shall demonstrate that the fire threat is real and anthropogenic. The threat of fire must be demonstrated with fire maps and historical databases on fires on areas within the reference region that are undergoing the specific conversion. The approximate annual rate of peat subsidence from oxidation and burning must be set in the PD and justified using (1) measurements by project proponents, or (2) literature values such as the ones found in Couwenberg et al. (2010). Whenever a value from literature is used for subsidence from burning or oxidation, the selected value must be reduced

[6] The PDT is the time during which GHG emissions would occur in the baseline until the peat has disappeared due to gradual oxidation or other losses, within the project boundary based on peat depth maps, water levels, and associated CO_2 emissions and subsidence rates.

proportionally to the uncertainty if the uncertainty exceeds 15%[7]. The relevance of the use of any value from literature shall be justified by taking into account climate, peat type, and other relevant factors.

Note that this maximal burn depth must not take into account restrictions related to the dry depth of the peat layer or the peat layer depth itself. The dry depth of the peat layer is taken into account in Section 8.1.4.3. The symbols for subsidence from burning and oxidation in the rest of the methodology are:

$subsidence_{oxidation}(j,t)$	=	Annual maximal subsidence due to oxidation for stratum j at time t [cm]
$subsidence_{burning}(j,t)$	=	Annual maximal subsidence due to burning for stratum j at time t [cm]

Table 6 demonstrates examples of estimating subsidence from oxidation and burning for three different conversion scenarios. Drainage activities have been assumed in all of these scenarios. In the first scenario, it is assumed those existing biomasses are burnt by inducing fire. In the second scenario, no fire was assumed. In the third scenario, repeated fire is assumed at alternative years. It was assumed that the fire causes depletion of peat by 34 cm annually (an average loss in tropical peat fire). In Table 6, the subsidence of peat was assumed to take place at the rate of 4.5 cm per year.

Table 6. Example of peat subsidence rates during the project crediting period.

	Peat subsidence rate* [cm yr^{-1}]					
	Scenario 1: Conversion to oil palm by burning existing biomass		Scenario 2: Conversion to oil palm by removing existing biomass without burning		Scenario 3: Clear-cutting followed by drainage and severe degradation	
year	Oxidation	Burning	Oxidation	Burning	Oxidation	Burning
1	4.5[8]	34[9]	4.5	0	4.5	34
2	4.5	0	4.5	0	4.5	0
3	4.5	0	4.5	0	4.5	34
4	4.5	0	4.5	0	4.5	0
5	4.5	0	4.5	0	4.5	34
> 5	4.5	0	4.5	0	4.5	0

* This table serves as an example of subsidence rates for 3 hypothetical conversion scenarios in which, for example, fire is used to convert forest to oil palm plantation (case 1), or the fire recurrence period is every two years after severe degradation (case 3).

[7] For example, if the average subsistence rate from the literature is 30 cm year^{-1} with a reported uncertainty of 20%, project proponents shall use 30*(1-20%) or 24 cm year^{-1}. On the other hand, if the uncertainty reported is <15%, then 30 cm year^{-1} shall be used.

[8] Note that 4.5 cm per year is only an example and represents a subsidence rate when the drainage level is at least 50 cm (Couwenburg et al., 2010).

[9] Likewise, the 34 cm per year is only an example and is cited by Couwenburg et al. (2010).

8.1.4.2 *Delineate Peat Depth*

No GHG emissions reductions may be claimed for a given area of peatland for longer than the time it would have taken for the peat to be completely lost under baseline conditions. As a consequence, it is of great importance to know the peat depth at every location of the project area. Project proponents shall delineate the peat depth and create peat depth maps in a conservative fashion. The amount of credits than can be generated is proportional to the depth of the peat layer in the project area. As a consequence, peat layer maps that follow the principle of conservativeness shall not overestimate the depth of the peat layer. In practice, peat depth maps must indicate the *minimal* peat depth with 95% confidence. No other deduction for uncertainty originating from delineating the peat depth is necessary if project proponents can demonstrate the peat depth maps indicate the minimal peat depth with 95% confidence.

- **Procedures to determine peat depth**. A peat depth map shall be created by empirically measuring peat depth at various locations throughout the project area. Soil samples must be collected and analyzed for the entire peat profile, i.e., from the surface of the peat layer to the top to the mineral soil level or at least to the maximum subsidence over the project life. The value of maximum subsidence for the project life must be calculated from the annual subsidence rates as determined in section 8.1.4.1. Peat samples must be taken throughout the peat profile and analyzed for bulk density and carbon content. It is allowed to use literature values for bulk density and carbon content if it can be demonstrated that their use is conservative. Project proponents must either (1) demonstrate that the uncertainty for bulk density measurements is within 15% relative to the mean, in which the uncertainty is defined as the half-width of the confidence interval (HWCI) at a confidence level of 95% or (2) apply an uncertainty deduction that is proportional to the actual uncertainty, if the uncertainty is greater than 15%. In other words, if the uncertainty is 15%, no deduction is necessary, however, if the uncertainty is 16%, a deduction of 16% is needed. The exact procedures used to measure peat depth and analyze peat samples must be duly recorded in a Standard Operations Procedure (SOP) that must be made available to an auditor at validation of the Project Document.
- **Required number of peat depth sampling locations**. It is impossible to measure peat depth at every location of the project area. Therefore, it is sufficient to measure peat depth at key locations within the project area and interpolate the peat depth in between the measured locations using an interpolating technique such as kriging (see "Interpolating measurements of peat depth"). Similar as to the sampling design for biomass stock densities, the determination of the sample size (number of peat depth sampling locations) required is dependent on (1) the required precision of 15% at 95% confidence level and (2) the variability of the peat depth across the project area. Since peat depth is a continuous variable across the project area, the precision is quantified using the estimation standard deviation, divided by the mean peat depth:

$$\hat{p} = \frac{1}{\overline{Y_{measured}}} \cdot \sqrt{\frac{\sum_{i=1}^{n}\left(Y_{measured}(i) - Y_{modeled}(i)\right)^2}{n}} \qquad \text{[EQ17]}$$

  $Y_{modeled}(i)$ must be estimated using leave-one-out cross-validation, as is described further in this section ("Cross-validation of peat depth measurements").

  While the exact number and locations of peat depth sampling is not prescribed within this methodology, project proponents must demonstrate that the resulting peat map is conservative. Unfortunately, there is no closed-form and analytical solution available to determine the correct number of samples n for a given precision and confidence level, as there is for biomass plots. Instead, project proponents shall sample peat depths in multiple phases and iteratively increase the number of sampling locations until the precision is reasonably close to 15%. Note that it is not required to have the precision exactly 15% since the peat depth map that is used for crediting is discounted for uncertainty and indicates the minimal peat depth with 95% confidence. The number of sampling locations and the geographic coordinates of the sampling locations shall be included in the SOP. It is allowed to gradually expand the number of locations where peat depth was sampled during the project crediting period so that costs can be spread over time.

- **Locations of peat depth sampling.** It is most optimal to measure peat depth in locations where the uncertainty around the expected depth of the peat layer is greatest, such as in areas where the depth of a peat dome changes rapidly or where dendritic peat is present. If project proponents are using an adaptive sampling approach, the standard error of an interpolated (e.g., kriged) surface can be used to determine where the uncertainty around the expected peat depth is greatest. If no other information is available, a random location of peat sampling depth will be statistically most valid. However, a complete random location of peat sampling is often practically challenging due to the time it may take to reach a specific location within a dense peat swamp forest. Therefore, it is recommended to use a combination of transects and random locations to select peat depth measuring locations. In addition, peat depth samples must be taken to cover both elevated (anticline) areas and depressed (syncline) areas within a dome. A transect across the peat dome is recommended. Additionally, great care must be taken so that sampling intensity is high where sudden changes in peat depth are expected. Therefore, it is recommended that the sampling locations of peat depth are taken perpendicular to natural boundaries such as rivers as well as the most likely shape of the peat dome.
- **Interpolating measurements of peat depth**. Although project proponents are allowed to use any technique to interpolate peat depth in between empirical measurements if it can be demonstrated that the technique is conservative, kriging is a robust technique Kriging refers to a set of special interpolating techniques from geostatistics. Kriging techniques analyze the variance of the difference between measurements, and its relationship to the distance between the sampling locations. The approximation of this relationship by a model curve provides the variogram, which allows the estimation of the three components for all of the points around the measurements: (1) the general trend in the data, (2) the spatially correlated variation and (3) the spatially uncorrelated noise. The predicted surface produced by kriging remains an estimate, for which a standard error can be calculated. Even though ordinary kriging has shown the best results for interpolating peat depth surfaces, project proponents may use block kriging or co-kriging with ancillary data such as elevation, biomass, inundation, distance to streams, etc. if so desired.
- **Cross-validation of peat depth measurements**. One particular feature of some interpolating techniques, including kriging, is that at the locations where empirical measurements are available, the modeled value is the same as the empirical value. Therefore, to calculate a truly unbiased estimation variance and calculate the difference $\left(Y_{measured}(i) - Y_{modeled}(i)\right)$, one must use leave-one-out cross-validation (LOOCV). Leave-one-out cross-validation involves using a single observation from the original sample as the validation data, and the remaining observations as the training data. This is repeated such that each observation in the sample is used once as the validation data. In other words, one has to conduct a separate interpolating analysis for every sampling location, but always with the value of that particular sampling location left out of the input dataset. The resulting interpolated value is then truly unbiased and can be compared to the empirical measurement by taking the difference $\left(Y_{measured}(i) - Y_{modeled}(i)\right)$.

Project proponents shall duly record all steps conducted during the kriging analysis and present the variogram and variogram model in the Project Document. In addition, project proponents shall provide a map of (1) the average peat depth, (2) the standard error around each peat depth, and (3) the minimal peat depth with 95% confidence to the auditor. Further in this methodology, values of peat depth at the start of the crediting period are referred to with the following notation:

$PeatDepth(i, 0)$ = Peat depth for location i at the start of the crediting period [cm]

Finally, project proponents shall create a table showing the amount of land present in 10-cm intervals of minimum peat depth with 95% confidence for every peat conversion stratum (see Table 7). The goal of this table is to provide an overview of how much peat is present in the project area.

Water table measurements must be conducted at the same locations as peat depth measurements. However, it is allowed to have less water table measurement locations than peat depth locations.

Table 7. Example table showing the distribution of area according to peat depth for different conversion strata.

	Size of area with specified range in peat depth for different conversion strata [ha]		
Specified range in peat depth [cm]	Conversion to oil palm by burning existing biomass	Conversion to oil palm by removing existing biomass without burning	Clear-cutting followed by drainage and severe degradation
0-50	2500	2300	2600
50-60	400	300	450
60-70	300	400	400
70-80	200	200	300
80-90	200	200	300
….			

8.1.4.3 *Calculate Emissions Related to Peat under the Baseline Conditions*

Calculate the emissions related to peat under the baseline conditions using the algorithm described below. This algorithm must be used separately for each of the conversion strata identified. Note that, to remain conservative, the land that is converted every year is allocated first in the peat strata with lower peat depth.

Create a data-structure in which all the grid cells developed during kriging have the following data elements:

- $PeatDepth(i, t)$ = remaining peat depth for grid cell i
- $conversion(t)$ = year during the crediting period that the grid cell is converted. Set to 0 at the beginning of the project period.

Sort the grid cells from smallest (or no) peat depth to greatest peat depth, and set t_{model}, the current year of the peat emission model to 1.

Cycle through the following steps for each year of a 100-year period following the project start date:

1. Mark a number of cells for conversion during year t_{model} so that (1) the total sum of the area of the cells marked for conversion equals the annual conversion rate, (2) the cells are marked from smallest peat depth to greater peat depths, (3) the cells have not been converted yet. Mark cells for conversion by setting $conversion(t)$ to t_{model}, the current year of the crediting period.

2. For each of the cells that were converted in the current time step or before, calculate the annual subsidence from burning, $\Delta PeatDepth_{\text{burning}}(i, t_{model})$, as following:.

   $\Delta PeatDepth_{\text{burning}}(i, t_{model})$ shall be set to the smallest of the following three values:

   (1) $subsidence_{burning}(j, t_{model} - conversion(t) + 1)$

   (2) $PeatDepth(i, t_{model})$

   (3) $drainage\big(j, t_{model} - conversion(t)\big) - 40$

   If the drainage level is less than 40 cm, $\Delta PeatDepth_{\text{burning}}(i, t_{model})$ must be set to 0.

   [EQ18]

   Per (1), the subsidence cannot be greater than the typical subsidence from burning for a given time after conversion as specified in section 8.1.4.1. Per (2), the subsidence cannot be greater than the depth of the remaining peat. Per (3) the actual burn depth is restricted by the depth of the peat layer that is at least 40 cm above the water table. The latter is necessary since it must be considered that only dry peat can burn[10]. As a consequence, if the drainage level is less than 40 cm, no burning can occur and $\Delta PeatDepth_{\text{burning}}(i, t_{model})$ must be set to 0.

3. Once the annual subsidence from burning is calculated, the subsidence from oxidation is calculated next. For each of the cells that were converted in the current time step or before, calculate the annual subsidence from oxidation, $\Delta PeatDepth_{\text{oxidation}}(i, t_{model})$, as following:

   $\Delta PeatDepth_{\text{oxidation}}(i, t_{model})$ shall be set to the smallest of the following two values

   (1) $subsidence_{oxidation}(j, t_{model} - conversion(t) + 1)$

   (2) $PeatDepth(i, t_{model}) - \Delta PeatDepth_{\text{burning}}(i, t_{model})$

   [EQ19]

   Per (1), the subsidence cannot be greater than the typical subsidence from oxidation for a given time after conversion as specified in section 8.1.4.1. Per (2), the subsidence cannot be greater than the depth of the remaining peat after the subsidence from burning was factored in.

   As a consequence, peat subsidence will follow the common pattern after conversion as specified in section 8.1.4.1, and no peat subsidence can happen after the end of the peat depletion time, as required by the VCS AFOLU Requirements.

[10] This requirement is analogous to the approved VCS methodology VM0004. The rationale is that the layer of peat 40 cm directly above the lowered water table is too wet to burn due to capillary rise of water in the pore spaces of the peat. Research from temperate peat soils indicates that peat layers remain sufficiently moist up to 40cm above the watertable for averagely decomposed peat material (Gnatowski et al., 2002)

4. Calculate the new peat depths for the following time period as:

$$PeatDepth(i, t_{model} + 1) = PeatDepth(i, t_{model}) \pm \Delta PeatDepth_{\text{oxidation}}(i, t_{model}) \pm \Delta PeatDepth_{\text{burning}}(i, t_{model}) \quad \text{[EQ20]}$$

5. Calculate the emissions from peat oxidation and burning as:

$$E_{peat}(i, t_{model}) = E_{peat,oxidation}(i, t) + E_{peat,burning}(i, t) \quad \text{[EQ21]}$$

$$E_{peat,oxidation}(i, t_{model}) = \frac{44}{12} \cdot \Delta depth_{\text{oxidation}}(i, t_{model}) \cdot BD(i) \cdot CellSize.\frac{CF}{100} \quad \text{[EQ22]}$$

$$E_{peat,burning}(i, t_{model}) = \left(\frac{44}{28} \cdot \frac{GWP_{N_2O}.ER_{N_2O}.}{r_p} + \frac{16}{12} \cdot GWP_{CH_4}.ER_{CH_4}\right) \cdot \Delta PeatDepth_{\text{burning}}(i, t_{model}) \cdot BD(i) \cdot CellSize.\frac{CF}{100} \quad \text{[EQ23]}$$

Note that for non-plantation landscapes, the peat emission factor will be very specific to the landscape in question and may be based on past logging history, land use and water management practices, existing drainage infrastructure, and the existence of drainage canals. If it is determined that these factors will significantly impact the peat emission factor, project proponents shall re-stratify the area according to these factors so that the emission factor can be assumed to be homogeneous within one stratum.

6. Increase t_{model} by one and repeat the previous steps until t_{model} equals the end of the 100-year modeling period.

Calculate the total emissions from peat for year t of the crediting period as:

$$E_{peat}(t) = \sum_{i=1}^{nrGridCells} E_{peat}(i, t) \quad \text{[EQ24]}$$

Where:

$nrPeatStrata$	=	Number of peat strata [-]
$nrConversions$	=	Number of conversion types [-]
$drainage(j, t)$	=	Drainage level of conversion type j at time t [cm]
$depth(i, t)$	=	Minimal depth of peat for peat stratum i [cm]
$BD(i)$	=	Adjusted mean bulk density of peat stratum i at 95% confidence level The uncertainty in bulk density must be calculated and discounted using the HWCI, see equations [EQ2] through [EQ5] for guidance on how to calculate a HWCI. If the HWCI is less than 15% of the average bulk

		density in the stratum, no adjustment is necessary. If the HWCI is greater than 15%, the value must be reduced proportionally to the HWCI. [Mg m^{-3}].
$CellSize$	=	Size of square shaped cell [m^2]
CF	=	Carbon fraction in peat mass
r_p	=	Carbon-to-nitrogen (C:N) ratio in peat [-]
GWP_{N_2O}	=	Global warming potential of N_2O [-]
ER_{N_2O}	=	Emission ratio of N_2O [-]
GWP_{CH_4}	=	Global warming potential of CH_4 [-]
ER_{CH_4}	=	Emission ratio of CH_4 [-]
$E_{peat}(i,t)$	=	Emission from peat from peat stratum i at time t [$tCO_2e\ yr^{-1}$]
$E_{peat}(t)$	=	Emission from peat at time t [tCO_2e]

8.2 Project Emissions

8.2.1 Put in Place Agreements to Avoid Conversion

Avoiding legally allowed conversion of the project area requires putting a legally binding agreement in place between the participating communities, landowners, project developers and the relevant government administrative units. These legal agreements are particularly important when the project proponents do not legally own the forest land, and the land-tenure status is unclear or obscured by a complex administrative hierarchy. The project proponents must put in place legally binding agreements with communities and the relevant administration units to avoid the forest conversion through purchasing or securing long-term conservation easements, or the revision of spatial plans and zoning laws. The establishment of these agreements will require funds, which are covered by the benefits from carbon trading. In addition, strengthening and clarifying the land-tenure status is essential to ensure that the extraction of forest goods remains sustainable. Obviously, a legal protection of the land is not sufficient for a sound protection of the forest land. It must be complemented with an effective protection, social fencing, or patrolling system.

8.2.2 Identify Project Activities that Prevent Loss of Biomass

Under the project applicability criteria, it is assumed that the biomass in the project area will not decrease under the project scenario. Since local communities may be using the land, some activities must be introduced that focus on increasing the livelihood options of local communities or prevention of leakage through e.g. increasing the land use intensity of already deforested land. Note that ex-post, credits are calculated on all empirically observed changes in stocks. All emissions related to losses of biomass under the project scenario must be discounted from credits.

8.2.2.1 *Development of sustainable forest and land use management plans.*

Forest and land use management plans must be established in a participatory and democratic way. These plans can include the volumes of timber, fuel-wood or NTFP each community can sustainably harvest, the areas of livestock grazing, or the area of forest land that can be converted into settlements or cropland, and where the conversion must take place. The management plans must be based on current and future need for forest products and land. Such plans will increase the efficiency of the current land use and avoid the random conversion of forest patches which can accelerate forest degradation. The plans must be integrated and compatible with the land tenure and use rights. The plans must be long-term or permanent (where possible) in nature.

The management plan is only binding for participating communities and will not affect the drivers of deforestation for which the agents are not participating in the project.

8.2.2.2 *Demarcation and Protection of Boundaries*

The installation of fences, gates, boundary poles, and signage provides local communities a transparent, recognizable and fixed boundary of the project area. Because legal protection alone may be insufficient to prevent deforestation; often a physical boundary or signage is required to avoid deforestation, and support social fencing and patrolling. The boundaries of the discrete project area parcels must be clearly demarcated to be recognized by potential trespassers of the forest (hunters, loggers, or other encroachers).

The boundaries of the forest must be protected and patrolled. Often, there is a lack of official law enforcers to do this task, while communities are committed to defend their land-tenure and land use rights. Communities can be engaged in the regular patrolling of the forest area. It must be clarified with the local administration which actions can be taken in case of illegal trespassing (e.g., confiscating chainsaws, alerting local law enforcers, etc.). Improve synergies among local communities, law enforcement and other relevant agencies to support boundary protection. Other project actions include the creation of logistical plans to protect boundaries, social fencing, and the acquisition of equipment (e.g., small motorized vehicles) for patrolling and enforcement.

8.2.2.3 *Fire prevention*

If forest fires are threatening the project's forest, specific fire prevention measures could be taken. These include (1) installation of fire breaks, (2) cleaning of the forest from dead wood that can act as fuel for fires, especially around regenerating and young secondary forests, and (3) discouraging or eliminating (if possible) fire-based hunting techniques. Saplings and small trees are particularly vulnerable to forest fires. If this requires cutting down trees, or removing dead wood, the loss of carbon must be accounted for.

8.2.2.4 *Providing alternative livelihoods to the agents of deforestation.*

If deforestation agents can engage in alternative livelihoods that are not based on deforestation, they can secure their income without the need to further clear forests.

- As many as possible, planned project activities must be **carried out by the local communities.** Engaging communities in forest patrolling, biomass inventory, fire prevention activities, installation of fences and boundary poles, and assisted natural regeneration activities. These activities will provide employment and a greater financial return flowing to the communities. In addition, the active involvement of the local communities will strengthen the project goals and decrease the risks of project failure.
- Part of the forest can be made accessible for sustainable **eco-tourism**, which will create jobs and increase revenue.
- The sustainable extraction of **non-timber forest products** can be further developed and commercialized. This includes the harvesting of honey, medicinal plants, fungi, and the extraction of resins. Clear harvesting plans need to be developed to ensure the sustainable extraction of these commodities.

8.2.2.5 *Decrease the consumption of fuel-wood.*

The collection of fuel-wood only leads to forest degradation if it is collected from live trees. A low-intensity collection of fuel-wood from downed dead wood may in fact have a positive effect on forest regeneration by decreasing the potential for forest fires. In cases where the collection of fuel-wood leads to forest degradation, the introduction of fuel-efficient wood-stoves stoves will decrease the need for local consumption fuel-wood (Top et al., 2004). Adoption rates of these alternatives need to be monitored, together with the potential sale of fuel-wood on local markets, which can potentially annul the GHG benefits generated by the alternative stoves. Only fuel-wood gathering for domestic use is allowed in project areas. No commercial sale of fuel-wood gathered in project areas is allowed.

The success of the implementation and on-going maintenance of these activities is critically dependent on the active involvement of all stakeholders in the planning and execution of these project activities. In particular, the local communities must be actively involved. Therefore, project management, advisory, oversight and consultative structures shall be developed to ensure an active involvement of all stakeholders. Through consultation with stakeholders, a transparent mechanism shall be set-up to ensure the equitable distribution of benefits from carbon benefits from the project.

A holistic approach must be taken towards meeting the various resource needs of local communities. For example, rather than excluding local communities from using any forest resources at all (and therefore necessarily forcing them to acquire these resources outside of the project area or purchase these on local or provincial markets, leading to outsource leakage), a sustainable (agro-)forestry management plan must be put in place that can meet local wood and agricultural needs.

8.2.3 Estimate GHG Emissions from Fire Prevention Activities

The carbon loss occurring from the removal of woody biomass from fire prevention activities such as fire breaks must be accounted for[11]. This includes the emissions from fire breaks cleared by cutting or controlled burning woody biomass. In case controlled burning is used to remove woody biomass, all CH_4 emissions related to the burning must be included. The emissions from fire breaks can be calculated by:

$$E_{fireBreaks} = \frac{44}{12} \cdot \sum_{i=1}^{nrStrata} area_{biomassLoss}(i) \cdot C(i) + \frac{16}{12} \cdot \sum_{i=1}^{nrStrata} area_{fireBiomassLoss}(i) \cdot C(i) \cdot GWP_{CH4} \cdot ER_{CH4} \quad \text{[EQ25]}$$

where:

$E_{fireBreaks}$	=	Annual GHG emissions from implementation of fire-preventing actions as REDD project activities. [tCO_2-eq yr^{-1}]
$area_{biomassLoss}(i)$	=	Total annual area of forest stratum i that was cleared. [ha yr^{-1}]
$C(i)$	=	Carbon stock density in forest stratum i. It is conservatively assumed that all biomass is removed. [Mg C ha^{-1} yr^{-1}].
$area_{fireBiomassLoss}(i)$	=	Annual area of forest stratum i that was cleared by controlled burning. [ha yr^{-1}]
GWP_{CH4}	=	Global Warming Potential for CH_4 (IPCC default value = 21 for the first commitment period). [-]
ER_{CH4}	=	Emission ratio for CH_4 (IPCC default value = 0.012). See Table 3A.1.15 in IPCC GPG-LULUCF (2003). [-]
$nrStrata$	=	Number of forest strata. [-]

[11] Emissions from clearing herbaceous vegetation are insignificant.

8.2.4 Changes in Sinks from Assisted Natural Regeneration Activities

8.2.4.1 *Scope and Applicability*

This methodology allows specific measures aimed at restoring degraded forest. These ANR activities serve a triple goal: (1) increase the project area's overall GHG sink strength, (2) reduce activity-shifting, and (3) provide alternative livelihoods to local communities by employing local communities for executing the work. Implementing ANR activities is optional, but shall only be done if all of the following applicability criteria are met.

- ANR activities occur on degraded forest land within the project area. The conversion of non-forest land into forest land is not allowed under this methodology.
- Assisted natural regeneration activities must take place on degraded land on which no prior ANR activities have taken place.
- Assisted natural regeneration activities may consist of thinning, removal of invasive species, enrichment planting, and coppicing.
- The total size of the areas on which ANR activities are planned must be fixed in the Project Document and the exact location of the ANR activities must be identified before or at the first verification.
- Based on the location of ANR activities, total areas planned on peat containing soil and non-peat containing soils must be available at the time of verification.

Assisted Natural Regeneration shall only be done by implementing one or more of the following measures:

- Removal of invasive understory species such as ferns or herbs to promote the growth of tree seedlings
- Thinning of over-stocked and stagnated forest stands to promote radial growth
- Removal of exotic and/or invasive tree species to promote the growth of native species
- Stem removal on trees with multiple shoots to promote the growth of a single stem
- Enrichment planting with trees of biodiversity or social value

A detailed ANR management plan with a detailed description of all activities including their location, must be included in the PD. An update to the management plan may be submitted at the first verification. However, after first verification, the management plan must be fixed.

8.2.4.2 *General Quantification*

The calculation of the GHG removals by sinks due to assisted natural regeneration activities is based on the CDM methodology AR-ACM0001 version 3. Wherever possible in this section, notation from AR-ACM0001 version 3 was retained. Combining and annualizing equations (33), (12), (13), and (14) from AR-ACM0001 version 3 yields:

$$C_{ANR}(t) = \Delta C_{ANR}(t) - E_{ANR,biomassLoss}(t) - \Delta C_{ANR,BSL}(t) - LK_{ANR}(t) - GHG_{E,ANR}(t) \quad \text{[EQ26]}$$

Where:

$C_{ANR}(t)$	=	Net anthropogenic greenhouse gas removals due to biomass increase in assisted natural regeneration. [tCO_2e]
$\Delta C_{ANR}(t)$	=	Annual change in carbon stocks in all selected carbon pools due to ANR for year t. [$tCO_2e\ yr^{-1}$]

$E_{ANR,biomassLoss}(t)$	=	Increase in CO_2 emissions from loss of existing woody biomass due to site-preparation (including burning), and/or to competition from forest (or other vegetation) planted as part of the ANR activities. [tCO_2e]
$GHG_{E,ANR}(t)$	=	Increase in GHG emissions as a result of the implementation of the proposed ANR activities during year t. [tCO_2e]
$\Delta C_{ANR,BSL}(t)$	=	Baseline greenhouse gas emissions or sources for year t. [tCO2e yr^{-1}]
$LK_{ANR}(t)$	=	Total GHG emissions due to leakage for year t. [tCO2e yr^{-1}]

- The procedure for calculating $\Delta C_{ANR}(t)$ is explained in section 8.2.4.2.1.
- The procedure for calculating $\Delta C_{BSL}(t)$ is explained in section 8.2.4.2.2.
- The activity-shifting leakage from ANR activities is included in the total project's leakage, as explained.
- The procedure for calculating $E_{ANR,biomassLoss}$ and $GHG_{ANR,E}(t)$ is explained in section 8.2.4.2.3.

8.2.4.2.1 Estimate Carbon Stock Increase from Biomass

The procedure to calculate the carbon uptake by biomass due to assisted natural regeneration follows the CDM-approved methodology AR-ACM0001 version 3, but adds an explicit uncertainty deduction.

$$\Delta C_{ANR}(t) = \frac{44}{12} \cdot \sum_{i=1}^{nrStrata} \Delta C(t,i) \cdot u_{inventory,ANR}(t,i) \quad \text{[EQ27]}$$

Where:

$\Delta C_{ANR}(t)$	=	Annual change in carbon stocks in all plant carbon pools due to ANR for year t during the crediting period. [$tCO_2e\ yr^{-1}$]
$nrStrata$	=	Number of forest strata. [-]
$\Delta C(t,i)$	=	Carbon stock change for ANR stratum i for year t during the crediting period. [Mg C yr^{-1}]
$u_{inventory,ANR}(t,i)$	=	Discounting factor for the increase in carbon stocks from ANR activities in stratum i during time t [-]

As stated earlier, $\Delta C_{plant}(t,i)$ is the sum of all plant carbon pools. Similarly as in AR-ACM0001 version 3, changes in dead wood under the project scenario must be conservatively omitted for *ex-ante* calculations. The aboveground and belowground tree biomass is calculated using the "allometric method" following Equation (22) in AR-ACM0001 version 3:

$$\Delta C(t,i) = area_{projectAreaWithANR,projectScenario}(t,i) \cdot \frac{C(t_2,i) - C(t_1,i)}{t_2 - t_1} \quad \text{[EQ28]}$$

Where:

$area_{projectAreaWithANR,baselineScenario}(t,i)$	=	Amount of land on which ANR activities are planned under the baseline scenario for year t and in stratum i. [ha]
$C(t_2,i)$ and $C(t_1,i)$	=	Aboveground plant carbon stock density during years t_2 and t_1 respectively and in stratum i. [Mg C ha^{-1}]
$t_2 - t_1$	=	Duration between times 1 and 2. [year]

The larger of the two combined errors of the carbon stock density at time t_1 and t_2 must be used for uncertainty assessment in ANR areas.

$$CE_{inventory,ANR}(i) = max\left(CE_{inventory,ANR}(t_2,i), CE_{inventory,ANR}(t_1,i)\right) \quad \text{[EQ29]}$$

The discounting factor for uncertainty around biomass stock densities in the ANR area is estimated as:

Where:

$CE_{inventory,ANR}(t,i)$	=	Combined error in estimated biomass stock density at time period t (i.e., time t_1 or time t_2) within stratum i. [-]
$CE_{inventory,ANR}(i)$	=	Combined error in estimated biomass stock density within stratum i. [-]
$HWCI(C(t_1,i))$ and $HWCI(C(t_2,i))$	=	Half-width of the 95% confidence interval around the mean carbon stock density of LULC classes of forest stratum i respectively at time t_1 and t_2. [tCO_2e ha^{-1}]
$u_{inventory,ANR}(i)$	=	Uncertainty discounting factor around biomass stock densities in transition stratum i within ANR areas during time t. [–]
$max\left(CE_{inventory,ANR}(t_2,i), CE_{inventory,ANR}(t_1,i)\right)$	=	Maximum of combined error in inventories that were carried out at time t_2 and t_1 in LULC class or forest stratum i.[-]

Ex-ante, values for biomass densities in ANR areas must be based on pilot projects or data on biomass increases in regenerating forests from the literature. *Ex-post*, this quantity must to be monitored for actual biomass according to a network of permanent sampling plots. Select a sampling design that can yield a level of precision of ±15% of estimated mean at 95% confidence level. See section 8.1.3.3 for instructions on determining sampling size.

8.2.4.2.2 Calculate Baseline Emissions or Sinks on Land on which Assisted Natural Regeneration Activities are Planned

Baseline emissions from land on which ANR activities are planned are calculated analogously as for land without ANR activities using [EQ30].

$$\Delta C_{ANR,BSL}(t) = \quad \text{[EQ30]}$$

$$- \sum_{i=1}^{nrFNFtransitions} \sum_{tt=1}^{t} \begin{pmatrix} u_{classification} \\ \cdot u_{transition}(i) \end{pmatrix} \cdot \begin{pmatrix} \begin{pmatrix} \Delta area_{projectAreaWithANR,baselineScenario}(t,i) \\ \cdot (EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt)) \end{pmatrix} \\ + \begin{pmatrix} \Delta area_{projectAreaWithANRNonPeatSoil,baselineScenario}(t,i) \\ \cdot EF_{SOM}(i,t-tt) \end{pmatrix} \end{pmatrix}$$

where:

$\Delta C_{ANR,BSL}(t)$	=	Baseline GHG emissions or sources for year t. [tCO2e yr^{-1}]
$EF_{AGL}(i)$, $EF_{AGD}(i,t-tt)$, $EF_{BG}(i,t-tt)$, $EF_{SOM}(i,t-tt)$	=	Emission Factor respectively for aboveground live, above ground dead, belowground, and soil organic matter in mineral substrate biomass for transition i at time t after tt years of transition. Section 8.1.3.5. [tCO2e]
$nrANRStrata$	=	Number of strata within the project area on which ANR activities are proposed. [-]
$\Delta area_{projectAreaWithANR,baselineScenario}$	=	Hectares undergoing transition i within the project area within the ANR area, under the baseline scenario for year t. [ha yr-1].
$\Delta area_{projectAreaWithANRNonPeatSoil,basel}$	=	Hectares undergoing transition i within the project area in non-peat soil within the ANR area, under the baseline scenario for year t. [ha yr-1].
$nrFNFtransitions$	=	Number of forest/non-forest transitions among land classes or forest strata, meaning transitions in which either the “from” or the “to” classes are non-forests. [-]
$u_{classification}$	=	Discounting factor for uncertainty of LULC classification. [-]
$\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$	=	Hectares undergoing transition i within the ANR area under the baseline scenario for year t. [ha yr^{-1}]
$u_{transition}(i)$	=	Discounting factor for all emission reductions, based on the uncertainty of biomass inventory related to transition i.
$EF(i)$	=	Emission factor for transition i. [tCO_2e ha^{-1}]

8.2.4.2.3 Calculate Emission Sources from Assisted Natural Regeneration

Under this methodology, all emissions from the proposed ANR project activities are combined in $E_{sources,ANR}$:

$$E_{sources,ANR}(t) = E_{biomassLoss,ANR}(t) + E_{fire,ANR}(t) + E_{fertilization,ANR}(t) \quad \text{[EQ31]}$$

where:

$E_{sources,ANR}(t)$	=	Emissions of sources from methane, nitrous oxide, fuel-CO_2 and biomass removal from ANR activities during year t. [tCO_2e]
$E_{biomassLoss,ANR}(t)$	=	Increase in CO_2 emissions from loss of existing woody biomass due to site preparation, and/or competition from forest (or other vegetation) planted as part of the ANR

		project activity. [tCO_2e]
$E_{fire,ANR}(t)$	=	CH_4 and N_2O emissions of controlled burning of existing woody biomass for land preparation of assisted natural regeneration activities during year t. [tCO_2eyr^{-1}]
$E_{fertilization,ANR}(t)$	=	GHG emission from fertilization for land preparation of assisted natural regeneration activities (e.g., to accelerate growth in the early development stages of the seedling) during year t. [$tCO_2e\ yr^{-1}$]

- The **CO_2 emissions from loss of existing woody biomass** for land preparation, $E_{biomassLoss,ANR}(t)$, are calculated as following

$$E_{biomassLoss,ANR}(t) = \frac{44}{12} \cdot \sum_{i=1}^{nrANRstrata} area_{biomassLoss,ANR}(t,i) \cdot \Delta C(i) \quad \text{[EQ32]}$$

Where:

$E_{biomassLoss,ANR}(t)$	=	Increase in CO_2 emissions from loss of existing woody biomass due to site preparation, and/or competition from forest (or other vegetation) planted as part of the ANR project activity. [tCO_2e]
$nrANRstrata$	=	Number of strata within the project area on which ANR activities are proposed. [-]
$area_{biomassLoss,ANR}(t,i)$	=	Area of biomass removed within ANR stratum i during year t. [ha]
$\Delta C(i)$	=	Removed carbon content in ANR stratum i. [$Mg\ C\ ha^{-1}\ yr^{-1}$]

- The CH_4 and N_2O emissions of burning of existing woody biomass for land preparation, $E_{fire,ANR}$, are calculated as following:

$$E_{fire,ANR} = \sum_{i=1}^{nrANRStrata} area_{fireBiomassLoss,ANR}(t,i) \cdot \Delta C(i) \cdot \left(\frac{44}{28} \cdot \frac{GWP_{N_2O}.ER_{N_2O}}{r_p} + \frac{16}{12} \cdot GWP_{CH4} \cdot ER_{CH4}\right) \quad \text{[EQ33]}$$

where:

$E_{fire,ANR}$	=	Annual GHG emissions from implementation of fire-preventing actions as REDD project activities. [$tCO_2e\ yr^{-1}$]
$nrANRStrata$	=	Number of strata within the project area on which ANR activities are proposed. [-]
$area_{fireBiomassLoss,ANR}(t,i)$	=	Area of biomass removed within ANR stratum i during year using controlled burning t. [ha]
$\Delta C(i)$	=	Burnt carbon content in ANR stratum i. [$Mg\ C\ ha^{-1}\ yr^{-1}$]
r_b	=	Carbon-to-nitrogen (C:N) ratio in biomass [-]
GWP_{N_2O}	=	Global warming potential of N_2O [-]

ER_{N_2O}	=	Emission ratio of N_2O [-]
GWP_{CH4}	=	Global Warming Potential for CH_4 . [-]
ER_{CH4}	=	Emission ratio for CH_4 (IPCC default value = 0.012). [-]

- The N_2O from the use of fertilizer must be quantified using CDM tool "Estimation of direct nitrous oxide emission from nitrogen fertilization". The variable $N_2O_{direct-N,t}$ within this tool is equivalent to $E_{fertilization,ANR}(t)$ within this methodology.

Reporting Requirements in the PD
1. Shape files of every individual stratum where ANR activities are planned, separately for every discrete project parcel. All necessary meta-data to correctly display the files must be included. The shape files must remain available for the duration of the project's crediting period. 2. Estimates of biomass increases due to assisted natural regeneration activities based on literature data. Include the source, the methodology used, whether all species were included, the minimal DBH of measured trees, and the region in which the biomass increases were measured. This quantity may be reported separately for the different forest strata where relevant. 3. Summary table of $\Delta C_{ANR}(t)$, the GHG benefits from assisted natural regeneration activities, $\Delta C_{ANR,BSL}(t)$, the baseline GHG changes on the land on which assisted natural regeneration activities are proposed. 4. Summary of the difference $\left(\Delta C_{ANR}(t) - \Delta C_{ANR,BSL}(t)\right)$, the net GHG benefits from ANR without taking emission sources into account for every year t of the crediting period. 5. List of the assumptions, data sources, and other information relevant to the calculation of the emissions for every source related to assisted natural regeneration. 6. Summary table of $E_{biomassLoss,ANR}(t)$, $E_{fire,ANR}(t)$, $E_{fertilization,ANR}(t)$ for every year t of the crediting period. 7. Summary of $E_{sources,ANR}(t)$, the sum of the GHG emissions sources related to assisted natural regeneration for every year t of the crediting period in the appropriate column of the summary table.

8.2.5 Estimate GHG Emissions from Harvesting

This methodology allows (limited) harvesting of timber from the project area. Allowing harvesting activities undoubtedly (1) increases the attractiveness of a REDD project to participating communities by providing employment and/or controlled access to forest resources, (2) reduces activity-shifting and market leakage, and (3) ensures that harvesting occurs legally, controlled and in a sustainable fashion. An integrated forest management plan or a harvest plan must be developed and all harvesting activities must be carried out according to this plan. The plan must include boundary of areas within a REDD project where harvest activities take place, as well as details of the forest inventory, projected forest growth, projected removal and harvest schedules, harvest methods, and location of harvest activities. The areas within the harvest areas that are located on peat soil must be clearly demarcated. In addition, forest management as well as silvicultural activities that aim at enhancing the growth and vigor of the forests inside the harvested areas shall be described in the plan. The integrated forest management plan must be submitted at validation or during a verification event and may be updated at a verification event. If the REDD project is also generating credits from ANR activities, then ANR areas cannot overlap with harvest areas.

The project proponents must adhere to the following requirements for planning and implementing forest harvest activities in the project area:

- The harvest plan and harvest activities must follow any Best Management Practice (BMP) guidance of the country or jurisdiction – if such BMP guidance exists.
- The potential impact of the harvesting activities must be included in the Environmental Impact Assessment section of the project design document. The assessment must demonstrate that harvesting activities do not threaten biodiversity or the environment.
- The harvest plan must describe the biophysical sustainability of the forest harvest. At minimum, the biophysical sustainability must be demonstrated by ensuring that the net removal of biomass from harvesting is less than the net increment of the biomass in the forest. It is recommended that project proponents use criteria and indicators (C & I) to assess the sustainability developed for the country or jurisdiction or use internally applicable C & I such as those from International Tropical Timber Organization (ITTO). In addition, it is recommended to obtain sustainability certification from third parties such as Forest Stewardship Council or Sustainable Forestry Initiative or similar institutions.

The harvest plan/description in PD must include the following information:

- Description of harvest areas in terms of location, size, forest inventory and topography.
- A description of all silvicultural activities that will be applied in the areas where harvesting will be carried out. This description must include number of trees removed and number of trees retained, in case of individual tree selection cut methods. For clear-cut methods or group selection cut methods, maximum opening size must also be described.
- The harvesting methods, i.e. mechanized vs. manual, as well as all processes such as felling, bunching, skidding/ forwarding, loading, and unloading. All machinery and equipment must be described.
- The harvest frequency (years between harvests) and volume of harvest at each time period.
- Regeneration assumptions and description of site indexes for dominant species in the strata. The harvest plan must include the expected tree density that will be maintained in the project area. Additionally, growth estimates for harvest areas in terms of total biomass as well as biomass stock density per unit area must be described and all assumptions and validity of any growth estimates must be justified. If any software based models have been used, proper justification of the suitability of such models used must also be described in the harvest plan.
- Activities that are practiced to protect soil, water, site and residual trees in the harvest area.
- Documentation on presence/absence of any threatened or endangered species and/or habitat on site, potential impacts on species and mitigation measures, presence/absence of natural heritage areas, and potential impacts on natural heritage areas and mitigation measures.
- A map of the harvest site including the following:
    - Plot locations
    - Harvest area boundary within the project area boundary
    - Slope classes
    - Streams/rivers/roads (if present)
    - Wetlands (if present)
    - Stream side management zones or river buffer (if applicable)
    - Planned skid trails (if applicable)
    - Landing sites/areas (if applicable)

8.2.5.1 *Determining Long-term Average Carbon Stock*

The long-term average carbon stock represents the maximum carbon stock that can be attained in harvest areas. GHG benefits shall be calculated using a carbon stock that never exceeds the long-term average carbon stock in the areas where harvest activities take place. The long-term average shall be quantified based on an appropriate minimal time period which must include at least one full harvest/cutting cycle. The minimal time period must be established as following:

a. If the harvest plan concentrates harvest activities in smaller blocks and continuously moves harvesting activities from one block to the next throughout the forest until all the areas are harvested within one harvesting cycle (as practiced in clear-cut or group-selection cut methods), the minimal time period shall end at the first year after the end of the crediting period during which all forest blocks have undergone a similar number of harvesting cycles. For example, if the crediting period is 30 years and the duration for all blocks to be harvested once is 12 years, the minimal time period shall be 36 years even though project crediting period is only 30 years.
b. If the harvest plan intends to target individual trees for harvest throughout the crediting period and the harvest can take place anywhere in a specified area within the forest (as practiced in individual tree selection cut methods), then the established time period over which the long-term average is calculated must be the length of the project crediting period. For example, if the crediting period is 30 years and harvesting of individual trees are carried out throughout the forest during the project crediting period, then the long-term average must be estimated based on the project crediting period.

After determining the time period for estimating the long-term average, the long-term average carbon stock density must be calculated using [EQ34].

$$LTAC_{harvest} = \frac{\sum_{t=0}^{T} \sum_{i=1}^{nrStrata} C_{harvest}(t,i) \cdot u_{inventory,harvest}(i)}{T} \quad \text{[EQ34]}$$

where:

$LTAC_{harvest}$	=	Long-term average Carbon stock density contained in harvested areas. [Mg C ha-1]
$nrStrata$	=	Number of forest strata. [-]
$C_{harvest}(t,i)$	=	Biomass carbon stock density at time t in stratum i in harvested areas. [Mg C ha^{-1}]
$u_{inventory,harvest}(i)$	=	Discounting factor for the uncertainty in biomass estimation in harvested areas in stratum i in harvest areas. The most recent $u_{inventory,harvest}(t,i)$ value must for used for discounting the estimate for future years. [tCO2 ha-1]
T	=	Minimal time period for estimating long term average. [yr].

The ex-ante estimation of $LTAC_{harvest}$ shall use biomass carbon stock density $C_{harvest}(t,i)$ values that are estimated using a projection model such as a computer simulation model or a growth table. All projection models shall be properly calibrated using field measurements and must estimate the removal of biomass from the harvest areas using the harvest management plan. After the start of the project, the projection model shall be re-calibrated using actual harvesting and biomass growth data and $LTAC_{harvest}$ shall be re-calculated at verification. Any projection model used must have the following characteristics:

- The used models have been prescribed or recommended by the forest department or related agencies in the country/jurisdiction. For example, growth models or yield project tables listed in forest act/regulations can be used. Alternatively, models that have been found in peer reviewed literature and are from the same region as of the project area can be used. However, such models must be parameterized for the specific conditions of the project area.
- The used models must be clearly documented with respect to the scope of the model, assumptions, known limitations, embedded hypotheses, assessment of uncertainties, and sources for equations, data sets, factors or parameters.
- Simulation software must be based on local data or calibrated for use in the project area. CO2FIX is an example of a simple ready-to-use model that can be easily applied globally. In contrast, FVS, a different simulation model, has more functionality but requires calibration for use outside of the US (and Canada).
- When no individual simulation model is available, a simple spreadsheet model using IPCC biomass growth estimates or growth estimates from expert opinion corroborated by local studies and historical practices for the project area can be used. The IPCC biomass tables provide estimates of annual growth and total biomass as a function of different forest types, age-group, and time. When biomass removal is tracked along with the annual growth, the biomass remaining in forest can be estimated.

8.2.5.2 *Quantification of Emissions from Harvesting*

Some harvesting of timber may occur under the project scenario if the applicability conditions for harvesting are met (see Section 4). This section contains procedures to account for the emissions created by harvesting. The calculation of emissions must be specific to a given harvest stratum. The delineation of harvest strata must be derived from a harvesting plan.

$$E_{sources,harvest}(t) = E_{harvest,timber}(t) + E_{harvest,fossil-fuel}(t) \quad \text{[EQ35]}$$

$$E_{harvest,timber}(t) = \frac{44}{12} \cdot CF \cdot \sum_{i=1}^{nrHarvestStrata} area_{harvest}(t,i) \cdot OM_{AGT}(i) \cdot \left(f_{harvest}(t,i) + f_{damage}(t,i)\right) \quad \text{[EQ36]}$$

If machinery is used for harvesting, emissions from fossil fuel combustion, $E_{harvest,fossil-fuel}(t)$, must be accounted for as well using Approved VCS Module VMD0014 “Estimation of emissions from fossil fuel combustion (E-FFC)”.

where:

$E_{sources,harvest}(t)$	=	GHG emissions from timber harvesting during year t. [$tCO_2e\ yr^{-1}$]
$E_{harvest,timber}(t)$	=	GHG emissions from timber harvesting during year t of the crediting period [$tCO_2e\ yr^{-1}$]
CF	=	Carbon fraction in timber. Use IPCC defaults [-]
$nrHarvestStrata$	=	Number of harvest strata [-]
$area_{harvest}(t,i)$	=	Area of forest land in harvest stratum i that is harvested at time t of the crediting period [ha]
$OM_{AGT}(i)$	=	Above ground live tree biomass in harvest stratum i for year t [Mg DM

ha^{-1}]

$f_{harvest}(t,i)$ = The proportion of biomass removed by harvesting for harvest stratum i and year t. Data for this variable should be obtained from harvest schedule information. Values may be constrained by the timber available for commercial harvest. [-]

$f_{damage}(t,i)$ = The proportion of additional biomass removed for road/track and landing construction for harvest stratum i and year t. Data for this variable should be based on regional and local comparative studies and experimental information derived from the local forest industry. [-]

$E_{harvest,fossil-fuel}(t)$ = GHG emissions from fossil fuel during timber harvesting during year t of the crediting period [$tCO_2e\ yr^{-1}$]

8.2.6 Estimate Emission sources from Community Development Activities

It is good practice to support community development activities as part of the REDD project to minimize any displacement of activities due to the conservation of the forest area. Under this methodology, a number of potential community development activities are allowed (see further for a detailed specification). Note that the implementation of potential community development activities is optional. However, if community development activities are implemented, they must follow the specification and applicability criteria detailed in this section.

Any significant increase in GHG emissions due to the implementation of community development activities ($E_{sources,leakagePrevention}(t)$) must be subtracted from the project's overall GHG emission benefits according to the procedures included within this section. The following sources of GHG emissions are included in this methodology:

$$E_{sources,leakagePrevention}(t) = \Delta E_{fertilization}(t) + \Delta E_{flooded\ rice}(t) + \Delta E_{livestock}(t) \quad \text{[EQ37]}$$

Where:

$E_{sources,leakagePrevention}(t)$ = Emission sources from community development activities for year t of the crediting period. [tCO_2e]

$\Delta E_{fertilization}(t)$ = Annual difference in GHG emissions due to increased use of N fertilizer as an agricultural intensification measure for year t of the crediting period. [tCO_2e]

$\Delta E_{flooded\ rice}(t)$ = Annual difference in GHG emissions due to increased use of flooded rice production systems as agricultural intensification measures for year t of the crediting period. [tCO_2e]

$\Delta E_{livestock}(t)$ = Annual difference in GHG emissions by enteric fermentation and manure management from increased animal stocking rates as an agricultural intensification measure for year t of the crediting period. [tCO_2e]

8.2.6.1 *Check Conditions and Quantify Emissions from Intensification of Annual Cropping Systems*

Scope and Applicability

Intensification of annual crop production systems as a community development activity is optional, but shall only be introduced if all of the following conditions are demonstrated:

- The agricultural intensification measures are implemented only on land on which annual crop production systems are implemented.
- The agricultural intensification measures are implemented on land that is already under annual crop production systems at the time of validation.

- The agricultural intensification measures shall not be implemented on organic soils.

Intensification of annual crop production systems shall only be done by implementing one or more of the following measures:

- increasing synthetic or organic N inputs
- the use of fallow crops or shrubs
- replacing subsistence crops by cash crops
- replacing low-yielding crop varieties by higher-yielding, or less pest-sensitive crop varieties
- introduction of irrigation systems
- introduction of inundated rice production systems

Quantification and Monitoring of N2O Emissions

Use CDM tool "Estimation of direct nitrous oxide emission from nitrogen fertilization"[12] *to quantify emissions.* The variable $N_2O_{direct-N,t}$ within this tool is equivalent to $\Delta E_{fertilization}(t)$ within this methodology. Add annual values of $\Delta E_{fertilization}(t)$ to the summary table of all GHG emissions due to project activities.

All variables that are required to be reported ex-ante by the CDM tool must be included within the PD. All variables that are required to be monitored by the CDM tool must be included within the monitoring plan. For the purpose of this methodology, the following variables are specified in more depth than the specification provided within the CDM tool.

$M_{SFi,t}$ = Mass of synthetic fertilizer type i applied in year t. $M_{SFi,t}$ is the difference between the synthetic fertilizer applied during the project in year t and the synthetic fertilizer applied during the baseline. The amount of synthetic fertilizer used per cropping system and per project parcel in the baseline must be quantified and monitored.

$M_{OFj,t}$ = Mass of organic fertilizer type *j* applied in year t. $M_{OFj,t}$ is the difference between the organic fertilizer applied during the project in year t and the organic fertilizer applied during the baseline. The amount of organic fertilizer used per cropping system and per project parcel in the baseline must be quantified and monitored.

Quantification and Monitoring of CH4 Emissions from Flooded Rice Production

Use GPG 2006 AFOLU Section 5.5 "Methane Emissions From Rice Cultivation" to quantify the methane emissions from flooded rice using the described Tier 1 default emissions factors and scaling factors. The variable $CH_{4,rice}$ within this tool is equivalent to $\Delta E_{flooded\ rice}(t)$ within this methodology. Add annual values of $\Delta E_{flooded\ rice}(t)$ to the summary table of all GHG emissions due to project activities.

All variables that are required to be monitored by the CDM tool must be included within the monitoring plan. For the purpose of this methodology, the following variables are specified in more depth than the specification provided within the CDM tool.

Rice production systems must be divided into different sub-units according to the water regime and the number of rice harvests per year, as explained in GPG 2006 AFOLU Section 5.5.1. The following variables from the GPG AFOLU must be quantified ex-ante and monitored for every subunit i (notation follows GPG AFOLU section 5.5)

A_{ijk} = Annual difference in harvested area of rice for the sub-unit, as defined by conditions$i$,

[12] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-07-v1.pdf

j, and k, between project and baseline scenario [ha yr^{-1}]. The area of rice cultivation for each condition i, j, and k and for each individual project parcel in the baseline must be quantified using Participatory Rural Appraisals, and re-evaluated regularly.

8.2.6.2 *Estimate GHG Emissions from Increased Livestock Stocking Rates,* $\Delta E_{livestock}$

Scope and Applicability

Increasing livestock stocking rates as a community development activity is optional, but shall only be introduced if all of the following conditions are demonstrated:

- If the proposed activity produces forage to feed livestock, all forage shall have a similar nutritional value and digestibility, and will support only a single livestock group with a single manure management system, cfr. AR-AM0006 applicability criterion (k).
- If the stocking rate is increase for animals that are already in a zero-grazing system or are moved to a zero-grazing system then the grazing activity that is monitored is the production of fodder, cfr. Displacement of Grazing CDM tool Point 5.
- Increased stocking rates shall only occur on Identified Forest land, Identified Cropland, Identified Grassland, and Unidentified land, cfr. Displacement of Grazing CDM tool Point 6.
- Increased stocking rates shall not occur on Settlements, Wetlands, or Other lands – as defined by the GPG LULUCF (i.e. bare soil, rock, ice, and all unmanaged land areas that do not fall into category of forest land, cropland, grassland, settlements or wetlands), cfr. Displacement of Grazing CDM tool Point 5.

Livestock stocking rates shall be increased through either or both of the following measures:

- Increasing the stocking density of livestock on existing grazing land.
- Moving of cattle to a zero-grazing system, defined as a system of feeding cattle or other livestock in which forage is brought to animals that are permanently housed instead of being allowed to graze.

Quantification and Monitoring of Emissions from Increased Stocking rates

Use the most recent version of approved CDM methodology AR-AM0006[13], section 8, "Leakage" to determine the CH4 and N2O emissions from livestock, as well as the CDM AR tool "Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity"[14]. The sum of variable $LK_{FFL,t}$ within AR-AM0006 and $LK_{Displacement,t}$ within the CDM tool is equivalent to $\Delta E_{livestock}(t)$ within this methodology.

Use the variables list of default parameters and parameters to be monitored from AR-AM0006 and the CDM tool for displacement of grazing activities. Livestock population increases must be quantified using Participatory Rural Appraisals or peer-reviewed literature, and re-evaluated regularly.

[13] http://cdm.unfccc.int/UserManagement/FileStorage/T05CO1LWYIJ7EHD9GBVAKZPUSQ2N8X

[14] This tool can be found on http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-09-v2.pdf. This tool has been approved for A/R CDM projects, but is applicable to REDD projects. All references to "A/R CDM" within this tool should be interpreted as "REDD".

PD Reporting requirements
1. Table with $GHG_{otherLeakageSources}(t)$ for every year t of the crediting period. 2. List of the assumptions, data sources, and other information relevant to the calculation of the emissions for sources $\Delta E_{rice}(t)$, $\Delta E_{fertilization}(t)$, and $\Delta E_{livestock}(t)$ from community development activities. 3. A report of $\Delta E_{rice}(t)$, $\Delta E_{fertilization}(t)$, and $\Delta E_{livestock}(t)$ for every year t of the crediting period.

8.3 Leakage

Leakage has been cited as being a major obstacle for the development of avoided deforestation projects (e.g., Schlamadinger et al., 2005; Miles and Kapos, 2008). However, the mere potential for leakage does not necessarily negate the environmental integrity of an avoided deforestation project. Only in cases where potential leakage cannot be identified and quantified does leakage pose an insurmountable barrier. It is good practice to incorporate measures to minimize leakage (see section 8.2.1). The leakage emissions that cannot be avoided must be subtracted from the emission reductions. Under this methodology, leakage is estimated *ex-ante*, but actual NERs are based on actual leakage calculated with project monitoring data. Leakage does not only occur on forest land outside of the project area, but also on non-forest land, such as woodlands or grassland.

8.3.1 Leakage as a result of the displacement of planned conversion activities

An avoided planned deforestation project may shift deforesting activities from the project area to an area outside the project area, causing leakage. Because the quantification of activity shifting leakage is dependent upon the identification of deforestation agents, two different scenarios are discussed for quantification of activity shifting leakage.

- When the **deforestation agents can be identified**, it must be demonstrated that the management plans and/or land-use designations of the deforestation agents' other lands (which shall be identified by location) have not materially changed as a result of the project (e.g., the deforestation agent has not designated new lands as timber concessions). If the deforestation agents were found to have acquired new lands for planned conversion, the area of the new lands shall be used as the basis for calculating leakage. Unless project proponents can demonstrate that newly acquired lands have no peat or lower peat lands, by default, the leakage must be considered to be happening on areas containing peat at the same proportion as that of the project area. Project proponents can simply calculate emissions from leakage by multiplying the gross emission reductions from the project per unit area for a given year with the area of conversion occurring in the newly acquired lands.

- When the specific **deforestation agent cannot be identified**, and only the "most likely" deforestation agent is identified, the areas allotted for land conversion within the administrative level that has jurisdiction over land sanctioning or within the ownership/usage right of the same deforestation agent must be monitored. If the sum of this area increases during the crediting period, compared to historical values, project proponents must deduct the emissions related to this increase from the NERs. More specifically, the following steps must be followed:

  (1) Determine which administration has jurisdiction over the land sanctioning for the identified conversion scenarios in the area in which the project is located.

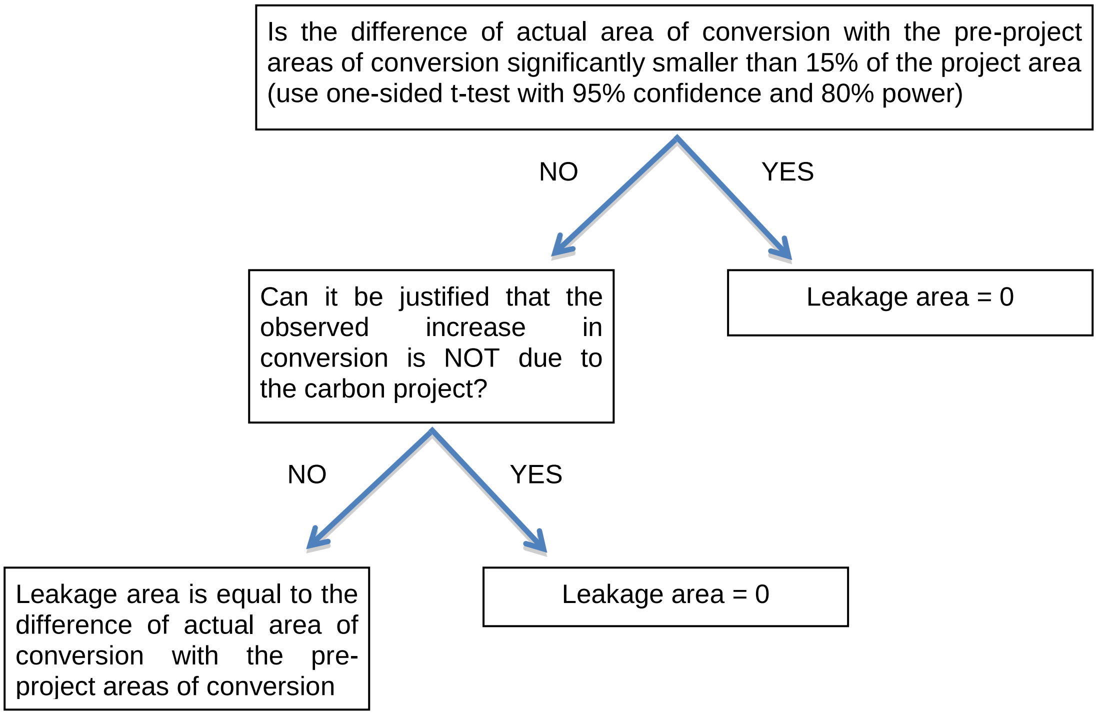
  (2) Acquire all available data on historical areas of conversion for land sanctioned for conversion for each of the conversion strata found in the project area representing for a

period of 10 years before the start of the crediting period. All available data shall be used. The source of the data shall be made available to the auditor so that it can be verified that all of the available data is effectively included. Note that it is acceptable to have gaps in the available data.

(3) Calculate the average annual amount of area allotted for the specific conversion using all of the available data collected in the previous step.

(4) During monitoring, the size of the area that has been sanctioned for the identified conversion scenario(s) by the relevant administrative jurisdiction must be acquired. Calculate the average and standard deviation of the difference of the conversion area with each conversion rate before the project. Using a one-sided t-test, determine whether the actual area allotted for land conversion is not more than 15% of the project area with 95% confidence. Verify that the power of the t-test is at least 80%.
   a. If the statistical power is at least 0.80 and the result of the t-test shows that the increase in the area allotted for conversion is smaller than 15% of the project area, leakage is assumed to be insignificant.
   b. If the statistical power is inadequate or the t-test indicates that the increase in the area allotted for conversion is greater than 15% of the project area, the leakage area is equal to the average difference between the monitored conversion and the pre-project conversion unless it can be justified that the observed increase in conversion is unrelated to the project. Justification can be provided by
      i. Increases in conversion of similar native forest systems far away from the project area and reference region or even globally.
      ii. Analysis of the actual driver of the increase in conversion.
      iii. Peer-reviewed literature and independent sources indicating the causes of the increase in deforestation.

When the leakage area, determined using the procedures is greater than the size of the project area, it should be capped to the size of the project area.



Calculation Example 1

(1) Only data on conversion for 5 out of the 10 years preceding the start of the crediting period are available. The areas are: 40620, 41200, 41025, 40200, and 40650 in ha.
(2) The project area is 5000 ha
(3) The area that was converted after the start of the project is 41050

The average increase in deforestation rate is 311 ha, and the standard deviation is 390 ha. A 15% of the project area equals 750. The zero hypothesis of the t-test is: the true increase in deforestation (estimated as 311 ha) is greater or equal than 15% of the project area (i.e., 750 ha). The alternative hypothesis is: the true increase in deforestation is less than 15% of the project area. The p-value of this t-test is 3%, indicating that the alternative hypothesis is true and that leakage is potentially insignificant. However, a test of the power of the test indicates that the power is only 67%. Therefore, the t-test has insufficient power to conclude anything and leakage has to be assumed to be 311 ha.

Calculation Example 2

(1) Data on conversion for 7 out of the 10 years preceding the start of the crediting period are available. The areas are: 40620, 41200, 41025, 40200, 40650, 40700, and 41050 in ha.
(2) Same project area as in case 1: 5000 ha
(3) Same area that was converted after the start of the project as in case 1: 41050

Now the p-value of the same t-test is 0.005, and the power is 95%. As a consequence, the alternative hypothesis ("the true increase in deforestation is less than 15% of the project area") can be adopted and leakage can be considered insignificant.

8.3.2 Leakage as a result of the displacement of forest products

In addition to the threat of large-scale conversion, the project area may also be at risk of small-scale deforestation and/or degradation activities carried out by the local communities. Small-scale deforestation or degradation activities are carried out either to meet the demand for land, i.e. to create settlements or to convert forests into small-scale agriculture, or to extract timber and non-timber forest products.

Obviously, once the project area is converted to non-forest under the baseline scenario, the threat from small-scale deforestation and/or degradation becomes obsolete. Likewise, once the project area is protected by REDD project activities under the project scenario, the communities' access to the project area is likely severely restricted. As a consequence, the displacement of deforestation activities caused by the communities' demand for land is equal under the baseline and project scenarios, and no net activity-shifting leakage will occur. However, the displacement of deforestation and degradation activities carried out to meet the demand for forest products such as timber and fuelwood may induce activity-shifting leakage when the baseline conversion rate is slower than the rate of protection under the project scenario. This occurs when the project area is only converted gradually under the baseline scenario but protected immediately under the project scenario.

As explained above, once the project area is converted to a non-forest use under the baseline scenario, communities will no longer have access to the forest resources. In other words, activity-shifting leakage will occur from the start of the project and until the time when the project area is completely devoid of the forest cover under the baseline scenario.

As a consequence, if 100% of the planned conversion has taken place by the second year of the project under the baseline scenario, no net emissions from activity-shifting leakage will occur because the communities would have shifted their activities even in absence of the REDD project. If the conversion rate varies over among the conversion strata, a strata-specific leakage must be estimated.

The following steps must be followed to estimate activity-shifting leakage:

a. Identify the communities that are dependent on the project area for forest products or land. There may be more than one community relying on various forest patches/strata of the project area. The PD must provide details of communities that depend (wholly or partially) on the project area for different products. Note that if the surrounding communities do not rely on the forest products from the project area, then there is no activity shifting leakage from these communities. The identification of communities that are dependent on the project area can be done using local experts, focus group discussions, etc.
b. Estimate the annual demand from communities for different forest products ($D_{c,p,t}$ in [EQ38]) and the proportion of the demand that is met by the project area ($P_{c,p,t}$ in [EQ38]) under the baseline scenario. Social survey instruments such as participatory rural appraisal, household surveys or regularly published statistical records from government sources can be used to estimate the historical demand and the proportion of the demand that is met by the project area. The demand for forest products in the future is to be set to the historical demand. The proportion of the demand that is met by the project area is to be set to the historical proportion multiplied with the remaining forest cover under the baseline scenario at time t.

c. Estimate the annual quantity of different forest products that are supplied through project activities and that are agreed in an integrated management plan ($S_{i,p,t}$ in [EQ38]) under the project scenario. This value is "0" if no such plan exists or if the supply of products is not mentioned in PD.
d. Estimate annual quantity of different forest products or alternative goods that can substitute the demand for forest products that are expected to be produced and supplied as part of leakage prevention measures and/or community support under a REDD project ($LP_{l,p,t}$ in [EQ38]). If no leakage prevention measures are in effect or if leakage prevention measures are not supplying any of the products, then this value must be set to "0".
e. Estimate total number of years that would be required to complete the conversion of project area under the baseline. GHG emissions from activity shifting leakages from communities must be estimated for all the years while the planned conversion is progressing in the baseline scenario. If the planned conversion activity completes within the first two years, then leakage from activity shifting can be considered "0".
f. Finally, use the [EQ38] to estimate leakage.

If the total forest area within the project boundary in baseline is > 0, then:

$$E_{ALK,t} = \sum_{c=1}^{communities} \sum_{p=1}^{PT} D_{c,p,t} \cdot P_{c,p,t} - \sum_{i=1}^{strata} \sum_{p=1}^{PT} S_{i,p,t} - \sum_{l=1}^{L} \sum_{p=1}^{PT} LP_{l,p,t}$$

[EQ38]

If this quantity is negative, set the quantity to 0. Note that this quantity becomes 0 when the total forest area within the project boundary under the baseline scenario at point t is 0. If the planned conversion is complete within the first two years then:

$$E_{ALK,t} = 0$$

Where,

$E_{ALK,t}$	=	GHG emissions from activity shifting leakage in year t. [tCO_2e-]
CF	=	Carbon fraction [-].
$D_{c,p,t}$	=	Demand for forest product type p in forest dependent communities c in year t. [Mg DM].
$P_{c,p,t}$	=	Proportion of forest product type p that is fulfilled from the project area in forest dependent communities c in year t under the baseline scenario. The proportion of the demand that is met by the project area is to be set to the historical proportion multiplied with the remaining forest cover proportion under the baseline scenario at time t.[15] [-].
$S_{i,p,t}$	=	Supply of forest product type p from forest strata i in year t as agreed in a forest management plan. [Mg DM].
$LP_{l,p,t}$	=	Supply of forest product type p from leakage prevention activity l in year t. [Mg DM].

[15] For example, if 60% of the demand is met by the project area and at time t only 50% of the project area is converted under the baseline scenario, $P_{c,p,t}$ is 30%.

PD Reporting requirements
1. Description of all applicable agents of conversion. If the agents were not identified in the baseline, then description of most likely agents must be provided with assumptions and justification.
2. Description of all available data on historical area of conversion for each of the conversion strata found in the project area representing for a period of 10 years before the start of the crediting period. The description must indicate the source of that data. The average and standard deviation of the annual amount of area allotted for the specific conversion must also be reported. Additionally, the description of the one-sided t-test as well as the power of the t-test must also be provided. A table with estimated leakage applicable for different conversion strata for the duration of the project crediting periods must be included in the PD. 3. Description and demographic information of the communities that are dependent on the project area must be provided. The communities' demand of different wood products that is met by the project area (wholly or partially) must also be described. If the project activities intend to supply some or all of the wood products' demand, then, the estimated quantity must be reported. If the leakage prevention activities supply some of the forest products then this quantity must be included. If the leakage prevention activities can supply alternative products that can reduce the demand of wood products then such activities must be described. 4. A table with values for $D_{c,p,t}$, $S_{c,p,t}$., $LP_{l,p,t}$ and $E_{ALK,t}$ must be provided.

8.4 Summary of GHG Emission Reduction and/or Removals

8.4.1 Estimate Changes in Carbon in Long-lived Wood Products

When the removed biomass from the project area in the baseline is expected to last for longer than 3 years, then the removed biomass shall not be considered immediately lost. Rather, the loss must be considered as taking place over a period of time. Likewise, if biomass removal takes place in the project scenario and the removed biomass is used for making wood products, and then the emissions from wood products pool must also be considered taking place over a period of time.

First, it must be identified if the harvested wood has short term or long term uses. If the removed biomass is used only for fuelwood or pulp and paper products, then the emissions from harvesting such biomass are considered to be occurring instantly. The drivers of deforestation assessment can be used to estimate the quantity of the harvested wood or biomass from that driver that has short term uses. Drivers such as deforestation for fuelwood collection, deforestation for slash and burn or shifting cultivation and simply burning the woodlands to expand the settlement and agricultural activities will lead to immediate emission of biomass. Biomass removed from non-commercial or pre-commercial thinning or from the non-merchantable timber stock is likely to be put into short term use and thus can be considered emitting greenhouse gases immediately. Note that merchantable limits are specific to the country or jurisdiction where the project area is located. If no country- or jurisdiction-specific merchantable limits are available, a limit of 15 cm for a small-end diameter log is to be used.

For any harvested wood that does not emit carbon immediately - i.e., biomass contained in merchantable volume - the annual change in the carbon stock in these pools is estimated by first allocating the biomass into different wood product categories each with a specific longevity or half-life.[16] Subsequently, the annual loss of carbon from different wood products is quantified using the half-life of the wood product category and a first order decay function. The estimation process is described below:

1. Identify the total volume of harvested wood that is to be considered part of the long-lived wood products pool separate per species. In general, all wood that is harvested for long-term use, i.e. lasting for more than 3 years must be included. In practice, all wood harvested to make logwood, sawn-wood, poles and posts for fencing, or produce furniture and building materials must be considered part of the long lived wood products.[17] Estimate the carbon in long-lived harvested wood as a function of merchantable harvested volume, density, carbon fraction and expected proportion of use in the year of harvest using [EQ39].

$$Cm(t) = \sum_{s=1}^{Species} Vm_s(t) \cdot D_s \cdot CF_s \cdot \frac{44}{12} \qquad \text{[EQ39]}$$

where,

$Cm(t)$	=	Carbon in merchantable harvested volume that was harvested in year t [tCO2e]
s	=	Number of species harvested range from 1 to S [-]
Vm_s	=	Merchantable Volume of harvested wood from species s [m^3]
D_s	=	Density of species [Mg m^{-3}]
CF_s	=	Carbon fraction of species s.[-]

2. Estimate the proportion of the harvested wood identified in the previous step that would be lost during the processing primarily due to mill inefficiency and waste. Proportion of wood lost or put to short term uses from the merchantable volume must be estimated for the country/jurisdiction and for projects. Carbon from waste and mill inefficiency can be considered short-lived and is emitted instantly. Use [EQ40] to estimate this proportion.

$$Ci(t) = Cm(t) \cdot sf \qquad \text{[EQ40]}$$

where,

$Ci(t)$	=	Carbon that is considered immediately emitted because of mill inefficiency and waste from merchantable wood harvested in year t [tCO2e]
sf	=	Short lived wood fraction [-]
$Cm(t)$	=	Carbon in harvested volume that was harvested in year t [tCO2e]

3. Any remaining wood after taking into account the waste and mill inefficiency must be divided into different wood production categories. At a minimum, the wood production categories must include sawnwood, wood based panels, other industrial round wood, and

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[16] A half-life in a first order decay function is the approximate duration of time when 50% of the initial quantity diminishes.

[17] An analysis of the drivers of deforestation and the estimated quantity of carbon loss per drivers or agent of deforestation is the basis for estimating the volume of harvested wood that is to be considered part of the long-lived wood products pool.

paper and paperboard. More wood production categories can be used if information for such categories is available. Carbon in different wood product categories must be estimated using [EQ41].

$$Cm_w(t) = \left(Cm(t) - Ci(t)\right) \cdot P_w \quad \text{[EQ41]}$$

Where,

$Cm_w(t)$	=	Carbon in wood production categories w entering into pool at time t. [tCO2e]
$Cm(t)$	=	Carbon in harvested volume that was harvested in year t [tCO2e]
$Ci(t)$	=	Carbon in harvested volume that was harvested in year t [tCO2e]
P_w	=	Proportion of harvested wood that goes into wood product category w [-]

4. Next, model the decay of carbon in each wood production category using a first-order decay function based on the pre-defined half-life of the wood production category. Specifically, [EQ42] must be used to quantify the loss of biomass from the previous year's quantity in the same wood production category. In addition, the newly wood harvested wood in each wood production category must be added to the carbon remaining in the particular wood production category. Then [EQ43] must be used to obtain the carbon remaining in the long-lived wood products pool at time t.

$$C_w(t) = C_w(t-1) \cdot e^{-\frac{\ln(2)}{h_w}} + Cm_w(t) \quad \text{[EQ42]}$$

$$CW(t) = \sum_{w}^{Categories} C_w(t) \quad \text{[EQ43]}$$

Where,

$CW(t)$	=	Remaining carbon in in the long-lived wood products pool remaining at time t. [tCO2e]
$C_w(t)$	=	Carbon in wood product category w harvested in year t. [tCO2e]
$Cm_w(t)$	=	Carbon in merchantable wood that was harvested and put into wood product category w in year t
$C_w(t-1)$	=	Carbon in wood product w in the previous year i.e. at year $(t-1)$. [tCO2e]
h_W	=	Estimated half-life of wood product category w.[year]

5. Steps 1 through 4 must be followed to quantify the GHG emissions reductions from the harvested wood products for both baseline – $CW_{baseline}(t)$ – and project – $CW_{project}(t)$.

8.4.2 Summarize the projected land use change

- Present a table with the total deforestation and degradation rates under the baseline and project scenarios for the project area and leakage area for every year of the project duration.

- Present tables with the LULC class and forest-strata specific land transitions for the project and leakage area under the baseline and project scenarios.
- Subtract the land transition changes under the baseline scenario from the changes under the project scenario and multiply with the difference of the appropriate emission factor and baseline net annual increment and apply all uncertainty discounting factors.
- Calculate the difference $\left(\frac{44}{12} \cdot \Delta C_{ANR}(t) - \Delta C_{ANR,BSL}(t)\right)$ the net GHG benefits from ANR without taking emission sources into account for every year t of the crediting period.
- Test the significance of increase in GHG emission from project activities using the CDM A/R methodological tool "Tool for testing significance of GHG emissions in A/R CDM project activities" and omit insignificant emissions from NER calculation.

8.4.3 Calculate *Ex-ante* NERs

Use Equation [EQ44] to estimate the *ex-ante* NERs; only use the significant GHG sources as determined in step 2. Prepare a table with all the individual terms of Equation [EQ44]. Calculate the *ex-ante* NERs for every year of the crediting period. After NERs are calculated, use Equation [EQ51] to calculate the VCUs.

Net Emission Reductions (NERs)

= GHG benefits related to avoided deforestation excluding areas subject to harvesting ❶
+ GHG benefits related to avoided peat emissions ❷
+ GHG benefits related to assisted natural regeneration (ANR) in forests ❸
+ GHG benefits related to avoided deforestation in harvest areas subject to long-term average limit on credits ❹
+ GHG emissions from deforestation due to the displacement of planned conversion activities (values are negative) ❺
+ GHG emissions from deforestation due to the displacement of forest good extraction (values are negative) ❻
+ GHG Emissions from methane, nitrous oxide, and fuel due to project activities assisted natural regeneration, and harvesting ❼
+ GHG emissions from changes in carbon stored in long-lived wood products ❽

[EQ44]

Where:

GHG benefits related to avoided deforestation excluding areas subject to harvesting

$$❶ = \sum_{i=1}^{nrFNFTransitions} \sum_{tt=1}^{t} \begin{pmatrix} u_{classification}(i) \\ \cdot u_{transition}(i) \end{pmatrix} \cdot \begin{pmatrix} \begin{pmatrix} \Delta area_{projectAreaWithoutANR,projectScenario}(t,i) \\ +\Delta area_{projectAreaWithoutHarvest,projectScenario}(t,i) \\ -\Delta area_{projectAreaWithoutANR,baselineScenario}(t,i) \\ -\Delta area_{projectAreaWithoutHarvest,baselineScenario}(t,i) \end{pmatrix} \\ \cdot \left(EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt)\right) \\ + \\ \begin{pmatrix} \Delta area_{projectAreaWithoutPeatSoil,projectScenario}(t,i) \\ +\Delta area_{projectAreaWithoutANR,projectScenario}(t,i) \\ +\Delta area_{projectAreaWithoutHarves,projectScenario}(t,i) \\ -\Delta area_{projectAreaWithoutPeatSoil,baselineScenario}(t,i) \\ -\Delta area_{projectAreaWithoutANR,baselineScenario}(t,i) \\ -\Delta area_{projectAreaWithoutHarvest,baselineScenario}(t,i) \end{pmatrix} \\ \cdot EF_{SOM}(i,t-tt) \end{pmatrix} \quad [EQ45]$$

GHG benefits related to avoided peat emissions

$$❷ = E_{peat}(t) \quad \text{[EQ46]}$$

GHG benefits related to assisted natural regeneration (ANR) in forests

$$❸ = \frac{44}{12}\sum_{i=1}^{nrStrata} \Delta C(t,i).u_{inventory,ANR}(t,i) - \sum_{i=1}^{nrFNFtransitions}\sum_{tt=1}^{t}\begin{pmatrix} u_{classification} \\ \cdot u_{transition}(i)\end{pmatrix}\cdot\begin{pmatrix}\begin{pmatrix}\Delta area_{projectAreaWithANR,baselineScenario}(t,i) \\ \cdot (EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt))\end{pmatrix} \\ + \\ \begin{pmatrix}\Delta area_{projectAreaWithANRNonPeatSoil,baselineScenario}(t,i) \\ \cdot EF_{SOM}(i,t-tt)\end{pmatrix}\end{pmatrix} \quad \text{[EQ47]}$$

GHG benefits related to avoided deforestation in harvest areas subject to long-term average limit on credits [EQ48]

In case:

$$\sum_{t=1}^{Crediting\ Period}\left(\frac{44}{12}\sum_{i=1}^{nrStrata} area_{projectAreaWithHarvest,projectScenario}(t,i)\cdot C_{harvest}(t,i)\cdot u_{inventory,harvest}(i)\right) \geq \sum_{t=1}^{Crediting\ Period}\left(\frac{44}{12}\sum_{i=1}^{nrStrata} area_{projectAreaWithHarvest,projectScenario}(t,i)\cdot LTAC_{Harvest}\right)$$

$$❹ = 0$$

In case the inequality above does not hold, (4) shall be:

$$❹ = \begin{pmatrix}\frac{44}{12}\cdot\sum_{i=1}^{nrStrata} area_{projectAreaWithHarvest,projectScenario}(t,i)\cdot C(t,i)\cdot u_{inventory,harvest}(i) \\ - \\ \sum_{i=1}^{nrFNFtransitions}\sum_{tt=1}^{t}\left(\begin{pmatrix} u_{classification} \\ \cdot u_{transition}(i)\end{pmatrix}\cdot\begin{pmatrix}\begin{pmatrix}\Delta area_{projectAreaWithHarvest,baselineScenario}(t,i) \\ \cdot (EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt))\end{pmatrix} \\ + \\ \begin{pmatrix}\Delta area_{projectAreaWithHarvestNonPeatSoil,baselineScenario}(t,i) \\ \cdot EF_{SOM}(i,t-tt)\end{pmatrix}\end{pmatrix}\right)\end{pmatrix} \quad \text{[EQ49]}$$

GHG emissions from deforestation due to the displacement of planned conversion activities (values are negative)

$$❺ = \sum_{i=1}^{nrFNFTransitions}\sum_{tt=1}^{t}\begin{pmatrix} u_{classification}\cdot u_{transition}(i)\cdot\begin{pmatrix} 0 \\ -\Delta area_{leakage,planned}(t,i)\end{pmatrix} \\ \cdot EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt) + EF_{SOM}(i,t-tt)\end{pmatrix} \quad \text{[EQ50]}$$

GHG emissions from deforestation due to the displacement of forest good extraction (values are negative)

$$❻ = E_{ALK,t} \quad \text{[EQ51]}$$

Emissions from methane, nitrous oxide, and fuel due to project activities and assisted natural regeneration

$$❼ = -E_{sources,projectArea}(t) - E_{sources,leakagePrevention}(t) - E_{sources,ANR}(t) - E_{harvest,timber}(t) - E_{harvest,fossil-fuel}(t) \quad \text{[EQ52]}$$

GHG emissions from changes in carbon stored in long-lived wood products

$$❽ = \frac{44}{12} \cdot \left(CW_{project}(\mathrm{t}) - CW_{baseline}(\mathrm{t}) \right) \quad \text{[EQ53]}$$

Variable	Description
$NERs(t)$	Net emission reductions during year t. Section 8.4.3
$nrFNFtransitions$	Number of forest/non-forest transitions among land classes or forest strata, meaning transitions in which either the “from” or the “to” class are non-forests.
$u_{classification}$	Discounting factor for NERs from avoided deforestation, based on the accuracy of classification, i.e. dividing land into broad land use types. Section 8.1.2.2.
$\Delta area_{projectAreaWithoutANR,baselineScenario}(t,i)$	Hectares undergoing transition i within the project area, excluding the ANR area, under the baseline scenario for year t. [ha yr^{-1}].
$\Delta area_{projectAreaWithoutHarvest,baselineScenario}(t,$	Hectares undergoing transition i within the project area, excluding the harvest areas, under the baseline scenario for year t. [ha yr^{-1}].
$u_{transition}(i)$	Discounting factor for all emission reductions, based on the uncertainty of biomass inventory related to transition i.
$EF_{AGL}(i), EF_{AGD}(i, t - tt), EF_{BG}(i, t - tt), EF_{SOM}(i, t - tt)$	Emission Factor respectively for aboveground live, above ground dead, belowground, and soil organic matter in mineral substrate biomass for transition i at time t after tt years of transiion. Section 8.1.3.5. [tCO2e]

$E_{peat}(t)$	Emission from peat at time t.
$nrStrata$	Number of strata within the ANR area.
$\Delta C(t,i)$	Annual change in carbon stock in all selected carbon pools for forest stratum i and year t. Section 8.2.4.2.1
$u_{inventory,ANR}(t,i)$	Discounting factor for the increase in carbon stocks from ANR activities in stratum i during time t [-]
CF	Carbon fraction of wood (use 0.5 by default).
$NAI(i)$	Net annual increment (baseline regeneration rate) on the "from" forest stratum of transition i. Section 8.1.3.2
$\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$	Hectares undergoing transition i within the project area within the ANR area, under the baseline scenario for year t. [ha yr^{-1}].
$\Delta area_{projectAreaWithANRNonPeatSoil,baselineScenario}(t$	Hectares undergoing transition i within the project area in non-peat soil within the ANR area, under the baseline scenario for year t. [ha yr^{-1}].
$area_{projectAreaWithHarvest,projectScenario}(t,i)$	Size of strata i within the project area on which harvest activities are implemented for year t under the project scenario. Section 8.2.4.2.1
$\Delta area_{projectAreaWithHarvest,baselineScenario}(t,i)$	Hectares undergoing transition i within the project area on which harvest activities are implemented under the baseline scenario for year t. [ha yr^{-1}].
$\Delta area_{projectAreaWithHarvestNonPeatSoil,baselineScenari}$	Hectares undergoing transition i within the project area in non-peat soil on which harvest activities are implemented under the baseline scenario for year t. [ha yr^{-1}].
$\Delta area_{leakage,planned}(t,i)$	Hectares undergoing deforestation within the leakage area due to shifting of planned deforestation activities under the project scenario for year t. [ha yr^{-1}].
$E_{ALK,t}$	GHG emissions from activity shifting leakage in year t. [tCO2e]
$E_{sources,projectArea}(t)$	Emissions from sources of methane, nitrous oxide or fuel-CO_2 from activities within the project area for year t.
$E_{sources,communityDevelopment}(t)$	Emissions from sources of methane, nitrous oxide or fuel-CO_2 from community development activities for year t. Emission sources within the leakage area are included in Table 1. Section 8.2.6.
$E_{sources,ANR}(t)$	Emissions of sources of methane, nitrous oxide or fuel-CO_2 from assisted natural regeneration activities for year t. Section 8.2.4.2.3
$E_{harvest,timber}(t)$	GHG emissions from timber harvesting during year t of the crediting period [tCO_2e yr^{-1}]
$E_{harvest,fossil-fuel}(t)$	GHG emissions from fossil fuel during timber harvesting during year t of the crediting period [tCO_2e yr^{-1}]
$CreditingPeriod$	Project crediting period. [year]
$C_{harvest}(t,i)$	Carbon stock density in harvested areas in stratum i at year t.[Mg C ha-1]
$LTAC_{Harvest}$	Long term average carbon stock density in harvest areas. [Mg C ha-1]

VCUs are then calculated by discounting the NERs according to the buffer withholding percentage as determined using the VCS tool for AFOLU non-permanence risk analysis and buffer determination.

$$\text{Voluntary Carbon Units} = \text{NERs} - buffer \cdot (❶ + ❷ + ❸ + ❹ + ❽) \quad \text{[EQ54]}$$

where:

$VCUs(t)$	=	Voluntary Carbon Units. [tCO_2e]
$buffer$	=	the buffer withholding percentage according to the VCS tool for AFOLU non-permanence risk analysis and buffer determination. [-]
$NERs(t)$	=	Net Emission Reductions. [tCO_2e]

Cumulative credits from ANR activities must account for less than 50% of the cumulative credits generated by the project. For every year of the crediting period, divide $C_{ANR}(t)$ from [EQ21] by the total NERS, and confirm that the result is less than 50%. Note that NERs are only validated for a period of ten years after validation, but must be reported for the entire crediting period.

8.4.4 Verify 100-year requirement

Use Equation [EQ44] to estimate the *ex-ante* NERs for a 100-year period following the start of the crediting period. Similar as to section 8.4.3, prepare a table with all the individual terms of Equation [EQ44], for the 100-year period. If any assumptions have to be made in order to extrapolate the estimates to 100 year, they shall be reported in the PD. Verify that:

$$\sum_{t=1}^{projectDuration} NERs(t) \leq \sum_{t=1}^{100} NERs(t) \qquad \text{[EQ55]}$$

PD Reporting requirements
1. GHG benefits from avoided deforestation in the project and leakage area. 2. GHG benefits from avoided forest degradation in the project and leakage area. 3. The difference $\left(\frac{44}{12} \cdot \Delta C_{ANR}(t) - \Delta C_{ANR,BSL}(t)\right)$, the net GHG benefits from ANR without taking emission sources into account for every year t of the crediting. 4. Table with all emissions for every year of the project duration, their relative contribution, and the cut-off value used to determine which emissions were considered insignificant. 5. A list of all the significant emissions from project and ANR. 6. Overview table of the total GHG accounting.

9. MONITORING

9.1 Data and Parameters Not Monitored

Data Unit / Parameter:	CF
Data unit:	Mg C (Mg DM)$^{-1}$
Description:	Carbon fraction of dry matter in biomass
Source of data:	IPCC GPG-LULUCF (2003)
Justification of choice of data or description of measurement methods and procedures applied:	Use default value of 0.5
Any comment:	

Data Unit / Parameter:	$subsidence_{oxidation}(j,t)$
Data unit:	cm
Description:	Annual maximal subsidence due to oxidation for stratum j at time t
Source of data:	Measurement by project proponent or recent literature such as Couwenberg et al. 2010.
Justification of choice of data or description of measurement methods and procedures applied:	The maximal peat subsidence scenario details how much peat can maximally disappear (in cm yr^{-1}) for every year after the conversion. This rate is maximal in the sense that the peat layer never gets depleted beyond this.
Any comment:	

Data Unit / Parameter:	$subsidence_{burning}(j,t)$
Data unit:	cm
Description:	Annual maximal subsidence due to burning for stratum j at time t
Source of data:	Measurement by project proponent or recent literature such as Couwenberg et al. 2010.
Justification of choice of data or description of measurement methods and procedures applied:	The maximal peat subsidence scenario details how much peat can maximally disappear (in cm yr^{-1}) for every year after the conversion. This rate is maximal in the sense that the peat layer never gets depleted beyond this.
Any comment:	

Data Unit / Parameter:	$BurnDepthMax$
Data unit:	cm yr^{-3}
Description:	Maximal peat burn depth
Source of data:	Gnatowski et al., 2002
Justification of choice of data or description of measurement methods and procedures applied:	Use default value of 34 unless empirical values are available.
Any comment:	

Data Unit / Parameter:	r_p
Data unit:	[-]
Description:	Carbon-to-Nitrogen (i.e. C:N) ratio in peat
Source of data:	IPCC GPG-LULUCF (2003), other literature, or laboratory analyses
Justification of choice of data or description of measurement methods and procedures applied:	Use a default value of 60 for undisturbed forest and 70 for logged forest (Satrio et al. 2009), literature values from sampled peat in tropical regions on the condition that it can be demonstrated that the literature value is conservative, or values from laboratory analyses of peat samples
Any comment:	

Data Unit / Parameter:	r_b
Data unit:	[-]
Description:	Carbon-to-Nitrogen (i.e. C:N) ratio in forest biomass
Source of data:	IPCC GPG-LULUCF (2003), other literature, or laboratory analyses
Justification of choice of data or description of measurement methods and procedures applied:	Use a default value of 100 (IPCC GPG-LULUCF 2003) on the condition that it can be demonstrated that the literature value is conservative, or values from laboratory analyses of biomass samples
Any comment:	

Data Unit / Parameter:	GWP_{CH_4}
Data unit:	-
Description:	Global Warming Potential for CH_4
Source of data:	IPCC GPG-LULUCF (2003)
Justification of choice of data or description of measurement methods and procedures applied:	Use default value of 21
Any comment:	

Data Unit / Parameter:	ER_{CH_4}
Data unit:	-
Description:	Emission ratio for CH_4
Source of data:	IPCC GPG-LULUCF (2003)
Justification of choice of data or description of measurement methods and procedures applied:	Use default value of 0.012
Any comment:	

Data Unit / Parameter:	GWP_{N_2O}
Data unit:	-
Description:	Global Warming Potential for N_2O
Source of data:	IPCC GPG-LULUCF (2003)
Justification of choice of data or description of measurement methods and procedures applied:	Use default value of 310
Any comment:	

Data Unit / Parameter:	ER_{N_2O}
Data unit:	-
Description:	Emission ratio for N_2O
Source of data:	IPCC GPG-LULUCF (2003)
Justification of choice of data or description of measurement methods and procedures applied:	Use default value of 0.007
Any comment:	

Data Unit / Parameter:	sf
Data unit:	
Description:	Fraction of carbon in harvested wood products that are emitted immediately because of mill inefficiency for wood product class ty.
Source of data:	Winjum et al. 1998
Justification of choice of data or description of measurement methods and procedures applied:	This can be estimated by multiplying the applicable fraction to the total amount of carbon in different harvested wood product category. The default applicable fraction is 24% and 19% respectively for developing and developed countries.
Any comment:	

Data Unit / Parameter:	p_w
Data unit:	
Description:	Proportion of harvested wood that goes into wood product category w
Source of data:	Winjum et al. (1998), FAO FORESTAT.
Justification of choice of data or description of measurement methods and procedures applied:	Country specific empirical data for a period of time period can be used to estimate the proportion of harvested wood that goes into different wood product categories. Global databases such as FORESTAT of FAO can be used. More granular country specific data can also be used, if available. In case no country specific data is available, the country data from neighboring countries that closely matches the species and ecosystem can be used. When none of these data are available, proportions must be estimated from survey of sawmill productivity within the reference region.
Any comment:	

Table 8. Default proportion of wood in different product categories

Wood products	Developing country	Developed Country
Sawnwood	0.38	0.38
Wood based panels	0.09	0.15
Other industrial round wood	0.32	0.16
Paper and paper products	0.21	0.32

Data Unit / Parameter:	h_w
Data unit:	[year]
Description:	Estimated half-life of wood product category w.
Source of data:	Source: Appendix 3a.1. Table 3a.1.3 of GPG LULUCF. **Table 9. Default half-life values for harvested wood products** **Category** / **Half-life**: Sawn wood: 35 Wood and wood based panels (such as veneer, plywood, structural panels): 30 Non-structural panels (other industrial round woods, poles, posts): 20 Paper and paperboard: 2
Justification of choice of data or description of measurement methods and procedures applied:	Country specified half-life for different wood products, if available, can be used. By default, half-life estimate for different categories of wood products determined by IPCC must be used. Project proponents can use other half-life values as long as they can be justified as valid half-lives applicable in that country if such half-lives are justified.
Any comment:	

Data Unit / Parameter:	ρ
Data unit:	[Mg m^{-3}]
Description:	Wood density of species j
Source of data:	IPCC GPG-LULUCF (2003), or Reyes (1992) Wood Densities of Tropical Tree Species. USDA Forest Service. General Technical Report SO-88
Justification of choice of data or description of measurement methods and procedures applied:	Use value appropriate for wood species in GPG-LULUCF (2003), or Reyes (1992)
Any comment:	

9.2 Data and Parameters Monitored

Data Unit / Parameter:	$nrFNFTransitions$
Data unit:	[-]
Description:	Number of forest/non-forest transitions among land classes or forest strata, meaning transitions in which either the “from” or the “to” class are non-forests.
Source of data:	
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$OM_{plant}(i)$
Data unit:	Mg $DMha^{-1}$
Description:	Total biomass stock of LULC class or forest stratum i.
Source of data:	Biomass inventory.

Description of methods and procedures:	See Section 8.1.3.4.
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	Sample size (or number of plots) must be determined at 95% confidence level within uncertainty of ±15% relative to the mean. If uncertainty exceeds the ±15% threshold and is not conservative, a deduction factor must be applied. The design and layout must be documented in standard operation procedures. See also "QA/QC for field measurements" in section 10.3
Any comment:	

Data Unit / Parameter:	$PeatDepth(i,0)$
Data unit:	cm
Description:	Peat depth for grid cell i at the start of the crediting period.
Source of data:	Field measurement
Description of methods and procedures:	See Section 8.1.4.2
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	Sample size (or number of plots) must be determined at 95% confidence level within uncertainty of ±15% relative to the mean. The design and layout must be documented in standard operation procedures. See "QA/QC for remote field measurements " in section 10.3
Any comment:	

Data Unit / Parameter:	$PeatDepth(i,t)$
Data unit:	cm
Description:	Remaining peat depth for grid cell i at time t in kirgging process.
Source of data:	Model output
Description of methods and procedures:	Use model described in Section 8.1.4.2.
Frequency of monitoring/recording:	Calculate emissions on an annual basis. Re-estimate peat emissions at every verification event.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$BD(i)$
Data unit:	Mg m^{-3}
Description:	Bulk density of peat stratum i.
Source of data:	Measurement by project proponent or recent literature.
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	Precision for bulk density measurements is smaller than 15% at the 95% confidence level or if the precision is greater than 15%, apply an uncertainty deduction that is proportional to the actual precision. See also "QA/QC for remote field measurements " in section 10.3
Any comment:	

Data Unit / Parameter:	$conversion(i,t)$
Data unit:	Year
Description:	Year during the crediting period that the grid cell is converted.

Source of data:	Value is set to 0 at the beginning of the project period and model output is used thereafter.
Description of methods and procedures:	Section 8.1.4.3.
Frequency of monitoring/recording:	Calculate emissions on an annual basis. Re-estimate peat emissions at every verification event.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$LP_{l,p,t}$
Data unit:	[MG DM]
Description:	Supply of forest product type p from leakage prevention activity l in year t.
Source of data:	Field measurements
Description of methods and procedures:	Management plan or field measurement.
Frequency of monitoring/recording:	At least every baseline update
QA/QC procedures to be applied:	
Any comment:	If no leakage prevention measures are in effect or if leakage prevention measures are not supplying any of the products, then this value must be set to 0.

Data Unit / Parameter:	$S_{i,p,t}$
Data unit:	[MG DM]
Description:	Supply of forest product type p from forest strata i in year t from forest management plan.
Source of data:	Field measurements or integrated management plan
Description of methods and procedures:	
Frequency of monitoring/recording:	At least every baseline update
QA/QC procedures to be applied:	
Any comment:	This value must be set to 0 if no such plan exists or supply of products is not mentioned in PD.

Data Unit / Parameter:	$D_{c,p,t}$
Data unit:	[Mg DM]
Description:	Demand for forest product type p in forest dependent communities c in year t
Source of data:	Social survey instruments such as participatory rural appraisal, household surveys or regularly published statistical records from government sources can be used to estimate the demand.
Description of methods and procedures:	
Frequency of monitoring/recording:	Most recent value shall be used in monitoring reports. Value must be updated at least once every baseline update.
QA/QC procedures to be applied:	
Any comment:	The demand for forest products can be adjusted if substitute goods are provided by the project.

Data Unit / Parameter:	$P_{c,p,t}$
Data unit:	[-]
Description:	Proportion of forest product type p that is fulfilled from the project area in forest dependent communities c in year t under the baseline scenario.

Source of data:	
Description of methods and procedures:	Social survey instruments such as participatory rural appraisal, household surveys or regularly published statistical records from government sources can be used to estimate the proportions.
Frequency of monitoring/recording:	Most recent value shall be used in monitoring reports. Value must be updated at least once every baseline update.
QA/QC procedures to be applied:	
Any comment:	Proportion can be adjusted if substitute goods are provided by the project.

Data Unit / Parameter:	$NAI(i)$
Data unit:	Mg C ha^{-1} yr^{-1}
Description:	Net annual increment of biomass for forest stratum i under the baseline scenario.
Source of data:	Estimate within the biomass inventory plots outside of the ANR area
Description of methods and procedures:	Only to be included if ANR activities are implemented (Lower-ranked options may only be used if higher-ranked options are not available). • Values measured by the project proponents in the project area • National or local growth curves and tables • Values from peer-reviewed literature Values from GPG-LULUCF Table 3A.1.5.
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	See “QA/QC for remote field measurements ” in section 10.3
Any comment:	Values from GPG-LULUCF Table 3A.1.5 are representative for regeneration in well-managed forests, and will therefore be conservative

Data Unit / Parameter:	$area_{biomassLoss,ANR}(t,i)$
Data unit:	ha
Description:	Area of biomass removed within ANR stratum i during year t
Source of data:	Log of ANR activities
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	See “QA/QC for data entry, documentation and analyses” in Section 10.3
Any comment:	Must be updated whenever ANR plan changes i.e. during baseline update

Data Unit / Parameter:	$area_{fireBiomassLoss,ANR}(t,i)$
Data unit:	ha
Description:	Area of biomass removed within ANR stratum i during year using controlled burning t.
Source of data:	Log of ANR activities
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	See “QA/QC for data entry, documentation and analyses” in Section 10.3
Any comment:	Must be updated whenever ANR plan changes i.e. during baseline update

Data Unit / Parameter:	$\Delta area_{projectAreaWithoutANR,baselineScenario}(t,i)$
Data unit:	ha yr^{-1}
Description:	Hectares undergoing transition i within the project area, excluding the ANR area, under the baseline scenario for year t

Source of data:	Land-use change modeling
Description of methods and procedures:	Use one of the 3 options described in Section 8.1.2
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	See “QA/QC for land use change modeling” in Section 10.3
Any comment:	

Data Unit / Parameter:	$\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$
Data unit:	ha yr^{-1}
Description:	Hectares undergoing transition i within the ANR area under the project scenario for year t.
Source of data:	Land-use change modeling
Description of methods and procedures:	Use one of the 3 options described in Section 8.1.2
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	See “QA/QC for land use change modeling” in Section 10.3
Any comment:	

Data Unit / Parameter:	$\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$
Data unit:	ha yr^{-1}
Description:	Hectares undergoing transition i within the ANR area under the project scenario for year t.
Source of data:	Land-use change modeling
Description of methods and procedures:	Section 8.2.3
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	See “QA/QC for land use change modeling” in Section 10.3
Any comment:	

Data Unit / Parameter:	$area_{harvest}(t,i)$
Data unit:	[ha]
Description:	Area of forest land in harvest stratum i that is harvested at time t of the crediting period
Source of data:	Log of harvesting activities
Description of methods and procedures:	
Frequency of monitoring/recording:	Every time harvesting occurs
QA/QC procedures to be applied:	See “QA/QC for data entry, documentation and analyses” in Section 10.3
Any comment:	

Data Unit / Parameter:	$f_{harvest}(t,i)$
Data unit:	[-]
Description:	The proportion of biomass removed by harvesting for harvest stratum i and year t.
Source of data:	Log of harvesting activities
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	See “QA/QC for data entry, documentation and analyses” in Section 10.3

Any comment:	Values may be constrained by the timber available for commercial harvest.

Data Unit / Parameter:	$f_{damage}(t,i)$
Data unit:	[-]
Description:	The proportion of additional biomass removed for road/track and landing construction for harvest stratum i and year t.
Source of data:	Regional and local comparative studies and experimental information derived from the local forest industry.
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification. Previous values remain valid if no more recent values are found in the literature.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$E_{harvest,fossil-fuel}(t)$
Data unit:	[tCO_2e yr^{-1}]
Description:	GHG emissions from fossil fuel during timber harvesting during year t of the crediting period
Source of data:	
Description of methods and procedures:	Approved VCS Module VMD0014 “Estimation of emissions from fossil fuel combustion (E-FFC)”.
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$V_{ex,project}(h,j,ty,t)$
Data unit:	m^3 yr^{-1}
Description:	The volume of timber extracted from within the project boundary during harvest h by species j and wood product class ty at time t in the project scenario, respectively [m^3 yr^{-1}].
Source of data:	
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	Standard deviation, standard error, and half-width of confidence interval calculated at 95% confidence (HWCI) must be reported. If the HWCI relative to the mean is greater than 15%, an appropriate uncertainty deduction (u_{V-ex}) must be applied as detailed in section 8.4.1.
Any comment:	

Data Unit / Parameter:	$V_{ex,baseline}(h,j,ty,t)$
Data unit:	[m^3 yr^{-1}]
Description:	The volume of timber extracted from within the project boundary during harvest h by species j and wood product class ty at time t in the baseline scenario, respectively [m^3 yr^{-1}].
Source of data:	
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	Standard deviation, standard error, and half-width of confidence interval calculated at 95% confidence (HWCI) must be reported. If the HWCI relative to the mean is greater than 15%, an appropriate uncertainty

	deduction equal to one minus this proportion must be applied
Any comment:	

Data Unit / Parameter:	$f_{population}(t)$
Data unit:	[-]
Description:	Expected relative increase in the population at year t since the beginning of the crediting period, or the last baseline update (whichever is more recent)
Source of data:	Census data or government reports
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$D_{goods-services,baseline}(i,0)$
Data unit:	
Description:	Demand for forest good or forest service i under the baseline scenario at the beginning of the crediting period or at a baseline update (whichever is more recent). [(measurement unit) household^{-1}]
Source of data:	Household surveys.
Description of methods and procedures:	Household surveys conducted in the “sphere of influence” of the project area, as described in Section 8.3.2.
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$\Delta D_{goods-services,project}(i,t)$
Data unit:	
Description:	Reduction in demand for forest good or forest service i due to project activities. [(measurement unit)]
Source of data:	
Description of methods and procedures:	Calculate based on actual records of activity implementation
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	See “QA/QC for data entry, documentation and analyses” in Section 10.3
Any comment:	

Data Unit / Parameter:	$M_{SFi,t}$
Data unit:	[kg N yr^{-1}]
Description:	Mass of synthetic fertilizer type i applied in year t. $M_{SFi,t}$ is the difference between the synthetic fertilizer applied during the project in year t and the synthetic fertilizer applied during the baseline. The amount of synthetic fertilizer used per cropping system and per project parcel in the baseline must be quantified and monitored.
Source of data:	At least once before every verification
Description of methods and procedures:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	

Any comment:	

Data Unit / Parameter:	$M_{OFj,t}$
Data unit:	[kg N yr^{-1}]
Description:	Mass of organic fertilizer type j applied in year t.
Source of data:	Household surveys.
Description of methods and procedures:	$M_{OFj,t}$ is the difference between the organic fertilizer applied during the project in year t and the organic fertilizer applied during the baseline.
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	A_{ijk}
Data unit:	[ha yr^{-1}]
Description:	Annual difference in harvested area of rice for the sub-unit, as defined by conditions i, j, and k, between project and baseline scenario [ha yr^{-1}]. The area of rice cultivation for each condition i, j, and k and for each individual project parcel in the baseline must be quantified using Participatory Rural Appraisals, and re-evaluated regularly.
Source of data:	Household surveys
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$\Delta E_{livestock}(t)$
Data unit:	[tCO_2e yr^{-1}]
Description:	GHG Emissions from Increased Livestock Stocking Rates
Source of data:	
Description of methods and procedures:	Use the most recent version of approved CDM methodology AR-AM0006[18], section 8, "Leakage" to determine the CH_4 and N_2O emissions from livestock, as well as the CDM AR tool "Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity"[19].
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	
Any comment:	The sum of variable $LK_{FFL,t}$ within AR-AM0006 and $LK_{Displacement,t}$ within the CDM tool is equivalent to $\Delta E_{livestock}(t)$ within this methodology.

Data Unit / Parameter:	$\Delta area_{leakageBelt,projectScenario}(t,i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the leakage area under the project scenario for year t.

[18] http://cdm.unfccc.int/UserManagement/FileStorage/T05CO1LWYIJ7EHD9GBVAKZPUSQ2N8X

[19] This tool can be found on http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-09-v2.pdf. This tool has been approved for A/R CDM projects, but is applicable to REDD projects. All references to "A/R CDM" within this tool should be interpreted as "REDD".

Source of data:	Remote sensing analysis
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every verification
QA/QC procedures to be applied:	See “QA/QC for remote sensing analyses” in section 10.3
Any comment:	

Data Unit / Parameter:	$\Delta area_{leakageBelt,baselineScenario}(t,i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the leakage area under the baseline scenario during year t.
Source of data:	Remote sensing analysis
Description of methods and procedures:	
Frequency of monitoring/recording:	At least once before every baseline update
QA/QC procedures to be applied:	See “QA/QC for remote sensing analyses” in section 10.3
Any comment:	

9.3 Description of the Monitoring Plan

This methodology requires the following monitoring components for calculating actual NERs

- **Monitoring of project and community development activities**. Duly record and justify any deviation from the planned activities as described in the PD. Record any activity that may cause an increase of GHG emissions, which was unforeseen in the PD.
- **Monitoring of deforestation in the project area** using remote-sensing technologies, and validated with ground-truthing data. The deforestation in the project area must be monitored in different conversion and management strata in such a way that the deforestation can be estimated in (a) areas that are subject to harvesting, (b) areas that are not subject to harvesting, (a) areas where ANR activities are implemented, (d) areas where no ANR activities are implemented, (e) areas containing peat, and (f) areas not containing peat soil as used in [EQ45].
- **Monitoring carbon stock densities** in LULC classes. The emission factors used in [EQ44] and related equations must be calculated using the most recent biomass inventories. The number of sampling plots may be gradually expanded after the project start. Since the number of plots included in the emission factor calculation at verification may be different from the number of plots included at validation, $u_{inventory}(i)$, $u_{transition}(i)$ must be re-calculated with the most recent number of sampling plots at verification. However, no biomass inventories older than five years before a verification event may be used for calculating the emission factors.
- **Monitoring carbon in long-lived wood products.** *Ex-post*, $Vm_s(t)$ must be monitored and quantified using forest operation records (i.e., log books kept as part of forest management plan). The uncertainty around the monitored volume of timber must be explicitly reported. *Ex-post* baseline $Vm_s(t)$ must be estimated from literatures and if such data is not available, then it must be set equal to the existing demand for volume of wood products including leakage but excluding community development activities.
- **Monitoring carbon stock increases** in the area on which ANR are performed.
- **Monitoring of the long-term average carbon stock in harvest areas ($LTAC_{Harvest}$).** $LTAC_{Harvest}$ must be performed and must be updated at least once every verification period

and at every baseline update using the most recent forest inventory carried out in the harvest areas. Project proponents must use a log-book to record timber product harvest in the project area. When the actual harvest differs from the estimated harvest by more than 15% then $LTAC_{Harvest}$ must be updated accordingly. The harvest plan/description in the PD must be updated with any changes in the harvest plan.

- **Monitoring of natural disturbances**, if any occurred during the last verification period.
- **Monitoring of leakage from displaced forest conversion**. Project proponents must estimate the size of the annual area that has been sanctioned for the same conversion scenario(s) as the ones identified under the baseline scenario of the project by the relevant administrative jurisdiction that governs over the province, state, or country in which the project area is located. A one-sided t-test must be executed to determine whether the actual area allotted for land conversion is greater than 15% of the average amount of area allotted for the specific conversion with 95% confidence. If it is greater, $\Delta area_{leakage,planned}(t,i)$ in Equation [EQ50] must be set to the difference in area between the actual area for land conversion and the average area predicted based on the data used in the t-test.
- **GHG emissions from deforestation due to the displacement of forest good extraction**. Social assessments must be conducted among the communities that were using the project area to extract goods and services before the start of the project. Using the social assessments, the project proponents must monitor (1) the likely size of the population that is dependent on forest resources of the project area, (2) the communities' demand for wood products and the proportion of the demand that is met from the project area ($D_{c,p,t}$), (3) the supply of wood products from the project area ($S_{i,p,t}$), and (4) the supply of wood products from leakage prevention activities taking into account any activities that may have reduced the demand ($LP_{l,p,t}$). Monitoring of activity shifting leakage is not needed if baseline planned conversion completes within the first two years or when all the forest are converted under the baseline scenario.

A monitoring report is produced which contains all of the information above, and which outlines the calculations for actual NERs generated. This monitoring report is the basis for verification by VCS-accredited verifiers. The actual VCUs are released upon verification and positive evaluation of a monitoring. The VCS requires that verification takes place minimally every five years. Project proponents may choose to seek verification more frequently, especially in the beginning of the crediting period. The PD must contain a fixed time schedule of when verification will be sought during the full duration of the crediting period.

At every verification time, project proponents must check that no other land-based carbon projects registered under the CDM or under any other carbon trading scheme (both voluntary and compliance-oriented) are present in the project area. A formal statement on the lack of any other carbon project in the project area must be included in the monitoring report.

Monitoring plan description requirements in PD

Include the following elements in the monitoring plan:

- Variables to be tracked continuously
  - Authority responsible for tracking.
  - List of variables that will be tracked continuously.
  - Which potential natural disturbances are foreseen?
  - Who will record information on natural disturbances?
  - How will adoption rates and super-acceptance leakage be monitored?
- Variables to be monitored periodically
  - Decision on monitoring frequency and rationale.
  - Decision on the duration of the subsequent monitoring period.
  - Who will monitor the boundaries of the project regions?
  - Field inventory
    - Sample size rationale
    - Sampling plot size and layout rationale
    - Sampling plot location
    - Standard Operations Procedure for field sampling.
  - Information on agents and drivers
    - List of variables to be collected.
    - If a social appraisal needs to be conducted, a list of the variables to be queried.
- Decision and rationale on the period of baseline validation.
- All relevant information on natural disturbances & catastrophes.

10. REFERENCES AND OTHER INFORMATION

10.1 Guidance on Social Assessments

Social assessments must be conducted to collect social information regarding project conditions. For most data items that are to be collected within the methodology, personal interviews with individual households are preferred; these are referred to as “household surveys”. However, for data items that are more challenging to quantify such as forest fires and forest encroachment, semi-structured focus group discussions with representative community members are more appropriate; these are referred to as “participatory rural appraisals”. The sample size for household surveys can be based on a comparatively small proportion of the target population (UN 2008). The required number of household surveys must be selected so that a minimal confidence level of 95% is attained. The exact number of surveys can be determined using the formula in Krejcie and Morgan (1970). In case of semi-structured interviews in participatory rural appraisals; at least 10 focus group discussions must be conducted. Further guidelines for carrying out these appraisals can be found in Cochran (1977), Freudenberger (1994), Kish (1995), Top et al. (2004) and UN (2008). The following steps are to be followed for designing and conducting surveys.

(1) **Assemble all information** that must be collected and determine the goals of the questionnaire. Identify all information that is required by the methodology.

(2) Determine the **target group** of the questionnaire, and sub-divide the group into different strata. Strata must be defined according to one or more of the combination of geography, household size, age, gender, etc. Take proper care to avoid the selection of a biased target group.
(3) Determine the **total sample size** and the number of samples required in each stratum. Identify the population in each of the strata categories defined in the previous step. Set quotas, a minimal number of surveys from each of the sample strata. Surveys must be collected until the quotas have been reached.
(4) **Create your questionnaire.** Transform the required data into neutral, simple and systematic questions. If possible and relevant, generate a set of expected answers. Include partially redundant questions to ensure consistency of data. Include space for some sketch mapping, if relevant. Expected answers could be complemented with graphs, figures, maps and pictures. Allow a “not applicable” or “uncertain” category. Group questions logically according to their contents and leave difficult or sensitive questions until near the end of a survey.
(5) Choose **interviewing methodology** and develop a standard operations procedure for interviewing. Include QA/QC procedures such as re-sampling a randomly selected sub-group by different experts, and the requirement to take geo-tagged pictures. All surveys must contain date, time, location, and name of the expert who conducted the survey. In addition, include a section on how to introduce the purpose of the questionnaires to the interviewees.
(6) **Pre-test the questionnaire** and methodology, and adjust the questionnaire and its methodology, if necessary. More specifically, if questions are multiple choice (discrete), ensure that all potential answers are included.
(7) **Train experts for conducting interviews**. Through instruction, role playing exercises, and test sessions followed by immediate feedback, train experts to conduct interviews. These experts are properly trained in explaining the broader scope of the social assessments.
(8) **Conduct interviews** and enter data. Make sure a copy is made of all surveys is put in a secure archive. Furthermore, all surveys must be scanned and stored electronically to avoid loss of data. Surveys must be immediately evaluated and if systematic problems arise, the survey must be adjusted or experts conducting the interviews are re-trained. Make sure that experts are accompanied by an experienced supervisor for at least 10% of the interviews throughout the surveying campaign, and not only in the beginning of the campaign.
(9) **Analyze the data** - Produce reports.

10.2 Conservative Approach and Uncertainties

This methodology requires key components of the carbon accounting to be estimated within 15% uncertainty, in which the uncertainty is defined as the half-width of the confidence interval (HWCI) at a confidence level of 95%. If the uncertainty exceeds 15%, a deduction proportional to the HWCI shall be applied. Specifically, the following procedures must be followed to account for uncertainty to each applicable parameter.

$$uncertainty = \frac{t_{(0.05,n)} \cdot \frac{s}{\sqrt{n}}}{\bar{x}} \quad [EQ56]$$

Where,

$Uncertainity$ = Uncertainty percentage of estimated mean [-]

$t_{(0.05,n)}$	=	t-value at 95% confidence level for n observations [-]
$\bar{x}$	=	Estimate mean value [unit]
s	=	Estimated standard deviation on mean [unit]

If the uncertainty is less than 0.15, no deduction is required and the estimated value can be used directly. However, if the uncertainty is greater than 0.15, the estimated value must be adjusted (i.e. discounted) proportionally so that the resulting emission reductions remain conservative (i.e., are adjusted downward). Specifically, a parameter that is positively correlated with the net emission reductions shall be adjusted downwardly by multiplying the estimate by $1 - uncertainty$; a parameter that is negatively correlated with the net emission reductions shall be adjusted upwardly by $1 + uncertainty.$

10.2.1 Uncertainty of Key Components of Methodology

The following is a list of the key components of the carbon accounting for which the uncertainty must be estimated and reported, and for which uncertainty deductions must be applied:

- For baseline deforestation rates using remote sensing classification, $u_{classification}$, factors are selected based on the empirically observed accuracy of discerning forest/non-forest classes, and forest biomass classes, respectively, according to the procedures outlined in this methodology.
- Emission factors from tree biomass must be discounted with $u_{transition}$, which equals the half-width of the confidence interval of the mean difference between the two carbon stock densities. Note that the minimum desired level of precision for sampling design of biomass inventory is 15%.
- Biomass stock densities calculated using allometric equations shall be discounted by $u_{inventory}$ if the allometric equation is not accurate within 15% (see Section 10.4).
- ANR growth rates shall be discounted downwardly using the half-width of the confidence interval.
- Subsidence rates shall be discounted downwardly using the half-width of the confidence interval
- For peat depth, the uncertainty deduction is applied indirectly, by limiting the total size of the peat area to the area for which the confidence that the required minimal peat depth is met is at least 95%. Uncertainty deductions can be avoided by increasing the sampling size of peat depth measurements.

10.3 Quality Assurance and Quality Control Procedures

To ensure the precise, verifiable and transparent calculation of net NERs, a quality assurance and quality control (QA/QC) procedure shall be implemented.

QA/QC for **field measurements**

- Persons involved in the field measurement work are trained in the field data collection and data analyses.
- List all names of the field teams and the project leader and the dates of the training sessions.
- Record which teams have measured each sampling plot. Record who was responsible for each task.
- Develop Standard Operating Procedures (SOPs) for each step of the field measurements and adhere to these at all times, both ex-ante and ex-post.

- Put a mechanism in place to correct potential errors or inadequacies in the SOPs by a qualified person.
- Verify that plots have been installed and measured correctly, by having approximately 10% of all plots re-measured by an independent team. If the deviation between measurement and re-measurement is larger than 5%, investigate the source of the error, record and correct.

QA/QC for **data entry, documentation and analyses**

- Review the entry of data into the data analyses spreadsheets by an independent source.
- Archived all original data sheets safely. Electronic data shall be backed up adequately on durable media.
- Ensure that all files are named appropriately. Ensure that all database fields, spreadsheet headings or cells are adequately documented in such a way that it can be verified independently.
- Verify calculations for trivial errors such as unit conversion errors.
- If parameters are common between analyses (e.g., emission factors), ensure that consistent values are used.
- Check for consistency among time series data. Identify outliers as soon after the actual measurement as possible. Investigate the cause of the outlying observation, and correct if needed.
- Compare estimates from field measurements or social appraisals with literature values.
- An SOP for non-biomass monitoring must be developed and adhered to at all times.

QA/QC for **remote sensing analyses**

- Develop Standard Operating Procedures (SOPs) for each step of the remote sensing analyses and adhere to these at all times, both ex-ante and ex-post.
- Use ground-truthing data to validate the LULC classification and forest stratification. Use confusion matrices and accuracy indices to analyze and quantify the accuracy of the classification.
- Use visual interpretation of high-resolution satellite imagery to complement the medium resolution imagery.
- Check for consistency among time series data. If outliers are present (e.g., in deforestation quantities), analyze the cause and correct if errors were made.
- Compare estimates of deforestation and forest degradation rates with relevant estimates from the literature.

QA/QC for **land use change modeling**

- Split the available data in 2/3 for calibration purposes, and 1/3 for validation purposes. Never use the same data for calibration and validation.
- Report a measure for the accuracy of the land use change model.

10.4 Verification Procedure of Allometric Equations

Every time one or more new $f_{allometric}$ equations are proposed, the proposed equation(s) must be verified according to the following criteria:

a) The proposed equation(s) must have an r^2 value of greater than 0.5 (50%) and a p-value that is significant at 95% confidence level as reported in the source publications.
b) The proposed equation(s) was developed from trees where the largest and smallest DBH of the trees fall within the DBH range of the trees within the project areas.
c) If the proposed equation(s) was/were derived from data solely from within the reference region then such equations can be used. If the proposed equation(s) was/were derived outside of the reference region, project proponents must justify the similarity in climatic, edaphic, geographical and species composition between the project area and the location from where the equations were derived. The source publication must include an estimate of the uncertainty or sufficient data to estimate the uncertainty. If this uncertainty is within ±15% of the mean values and is not biased in a non-conservative manner (i.e., the equation(s) do(es) not systematically overestimate the project net anthropogenic removals by sinks), the equation(s) may be used.
d) For any other equations that do not satisfy criteria (d) or if new equations or equations which do not have estimate of uncertainty are to be used, then one of the following two approaches must be carried out:
   - Destructive Sampling
     - Selecting at least 5 trees covering the range of DBH existing in the project area, and felling and weighing the above-ground biomass to determine the total (green) weight of the stem an branch components
     - Extracting and immediately weighing subsamples from each of the green stems and branch component, followed by oven drying at 70°C to determine dry biomass.
     - Determine the total dry weight of each tree from the green weights and the averaged ratios of wet and dry weights of the stem and branch components.
   - Limited Measurements
     - Select at least 10 trees per species distributed across the project area
     - Calculate volume of tree from basal and top diameters and tree height. Multiply by species-specific density to gain biomass of bole. Add an additional 20 percentage of weight to approximately cover the biomass of branches.

   If the biomass of the measured trees is within ±15% of the mean values predicted by the selected default allometric equation, and is not biased – or if biased towards the conservative side (i.e., equation underestimates of the project net anthropogenic removals by sinks), then mean values from the equation may be used. However, if the If the biomass of the measured trees is not within ±15% of the mean values predicted by the selected default allometric equation, estimated biomass must be further discounted with the relative average half-width of the confidence interval of the model.

10.5 Lists of Acronyms and References

AFOLU	Agriculture, Forestry, and Other Land Use
ANR	Assisted Natural Regeneration
ARR	Afforestation, Reforestation, and Revegetation
CDM	Clean Development Mechanism
CP	Conference of the Parties
CV	Coefficient of Variation
DBH	Diameter at Breast Height (1.3 m)
DF	Deforestation

DG	Forest Degradation
DM	Dry Matter
DNA	Designated National Authority
EF	Emission Factor
GHG	Greenhouse Gas
GIS	Geographic Information System
GPG-LULUCF	Good Practice Guide for Land Use, Land Use Change and Forestry
GPS	Global Positioning System
GWP	Global Warming Potential
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
LCL	Lower Confidence Limit
LULC	Land Use and Land Cover
Mg	Mega gram = 1 metric tonne
MMU	Minimum Mapping Unit
MT	Metric Tonne
tCO_2e	Metric Tonne of Carbon Dioxide Equivalents
NER	Net Greenhouse Gas Emission Reduction
PD	Project Document
QA/QC	Quality Assurance / Quality Control
RED	Reduced Emissions from Deforestation
REDD	Reduced Emissions from Deforestation and forest Degradation
SOC	Soil Organic Carbon
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit

10.6 References

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