Verified Carbon Standard

VCS Methodology

VM0004

METHODOLOGY FOR AVOIDED PLANNED LAND USE CONVERSION IN PEAT SWAMP FORESTS

Version 2.0

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Sectoral Scope 14

CONTENTS

1 SOURCES

This methodology is based on elements from the following methodologies:

- AR-AM0004 (version 4.0): Reforestation or afforestation of land currently under agricultural use
- AR-AM0007 (version 5.0): Afforestation and Reforestation of Land Currently Under Agricultural or Pastoral Use
- AR-AM0005 (version 4.0): Afforestation and reforestation project activities implemented for industrial and/or commercial uses

The updates to the methodology regarding WRC requirements and accounting were largely dependent on:

- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (hereafter referred to as the *2013 IPCC Wetlands Supplement*)

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

- VCS "Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities"
- CDM Tool "Calculation of the number of sample plots for measurements within A/R CDM project activities."
- VCS Tool for Non-Permanence Risk Analysis and Buffer Determination

The leakage approach outlined in this methodology was adapted from the most current versions of the VM0007 leakage modules:

- VMD0009 – Estimation of emissions from activity shifting for avoiding planned deforestation and planned degradation (LK-ASP)"
- VMD0011 – Estimation of emissions from market-effects (LK-ME)"
- VMD0044 – Estimation of emissions from ecological leakage (LK-ECO)

Other VM0007 modules utilized or referenced as part of the updates to this methodology include:

- VMD0016 - Methods for Stratification of the Project Area (X-STR)
- VMD0042 - Estimation of baseline soil carbon stock changes and greenhouse gas emissions in peatland rewetting and conservation project activities (BL-PEAT)

- VMD0046 - Methods for monitoring of soil carbon stock changes and greenhouse gas emissions and removals in peatland rewetting and conservation project activities (M-PEAT)
- VMD0050 - Estimation of Baseline Carbon Stock Changes and Greenhouse Gas Emissions in Tidal Wetland Restoration and Conservation Project Activities (BL-TW)
- VMD0051 - Methods for Monitoring of Carbon Stock Changes and Greenhouse Gas Emissions and Removals in Tidal Wetland Restoration and Conservation Project Activities (M-TW)

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project Method
Crediting Baseline	Project Method

This methodology outlines transparent and conservative methods to estimate the avoided net greenhouse gas emissions resulting from project activities implemented to stop planned land use conversion in tropical peat forest. It allows for the estimation of changes in carbon stocks in selected aboveground carbon pools and accounts for peat emissions. It conservatively used a project method for determining the baseline scenario from amongst the plausible scenarios and presents methods to transparently estimate the GHG emissions expected from the most likely land use(s) prior to the start of the project activity.

The methodology adopts a baseline approach that accounts for “*changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project starts*”, taking into account national, sectoral, and local policies influencing the land use prior to the start of the project activity; the scope of project alternatives relative to the baseline; and barriers to implement the avoided deforestation project activity.

The methodology anticipates several possible baseline scenarios and determines additionality with a project method that uses the latest version of the VCS “Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities”.

Baseline methodology steps

1. The project boundary is defined for all eligible discrete parcels of land to be protected from land use change that are under the control of the project participants at the starting date of the project activity.
2. Stratification of the project area is based on local site classification maps/tables, the most updated land-use/land-cover maps, satellite images, vegetation maps, landform maps as well as supplementary surveys, and the baseline land-use/land-cover is determined separately for each stratum. This methodology also requires stratification by peat depth in order to take into consideration Peat Depletion Time (PDT) in peat emissions calculations in the baseline scenario.
3. The baseline scenario is determined by applying the "*Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities*".
4. The *ex ante* calculation of baseline net GHG emissions is performed by strata. The baseline carbon stock change in aboveground biomass is estimated based on methods developed in IPCC 2003 Good Practice Guidance (GPG) for Land Use, Land-Use Change and Forestry (LULUCF) as well as on methods that utilize high resolution aerial digital imagery. The baseline GHG emissions from peat are estimated based on regional data on CO_2 emissions and emission factors in combination with results of a stratified peat map of the project area.
5. Additionality is demonstrated using the latest version of the "*Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities*".
6. The *ex ante* actual net GHG emissions avoided are estimated for each stratum in the project activity.
7. Leakage emissions, including both carbon stock decreases and peat emissions outside the project boundary, are accounted for by activity displacement, market effects, and ecological leakage calculations.

The methodology also outlines methods to monitor both carbon stock changes in the living biomass and peat emissions of project activities and increases in the GHG emissions that result from the implementation of the project activity. It outlines methods and procedures that complement the provisions of the baseline methodology.

The methodology outlines methods for assessing and accounting for displacement of economic activities attributable to the project activity and for emissions that occur due to market effects.

The methodology recommends the use of remotely sensed data to monitor the project carbon stocks as well as disturbances to biomass and peat carbon stocks within the project boundary. The methodology specifies annual monitoring and supports the recording of disturbances, if any. It recommends the adoption of standard operating procedures for monitoring, data collection and archival in order to maintain the integrity of the data collected in the monitoring process.

Monitoring methodology steps

1. The project implementation is monitored, including the project boundary, the area prevented from land use change and any activities that reduce carbon stocks or result in peat emissions in the project area over the crediting period. If the project boundary is not a functionally discrete hydrological unit, a hydrological buffer zone is also monitored to ensure against drainage activities occurring that could potentially impact peat emissions in the project area, per Applicability Condition K of this methodology.
2. Stratification of the project area is monitored periodically because two different strata may become similar enough in terms of carbon to justify their merging. The *ex post* stratification considers monitoring of the project strata to verify the applicability of the *ex ante* stratification, and variables that influence the strata. The *ex post* stratification procedures facilitate cost-effective, consistent and accurate monitoring of carbon stock changes of the project during the crediting period.
3. Baseline net GHG emissions are not monitored in this methodology. The methodology prescribes validity of the baseline identified *ex ante* at the start of the project activity for the crediting period, thereby avoiding the need for monitoring of the baseline over the crediting period, and achieves savings in the costs associated with baseline monitoring. However, the baseline is re-assessed/revised every 10 years at which time baseline emissions calculations are updated.
4. The calculation of *ex-post* actual net GHG emissions avoided is based on data obtained from sample plots, regional literature values and methods developed in IPCC GPG-LULUCF to estimate carbon stock changes in the carbon pools and peat emissions.
5. Leakage due to activity displacement and market effects is monitored and accounted in order to calculate the net GHG emissions avoided. Ecological leakage is unlikely in many projects, so the project proponent must choose to monitor ecological leakage if it is likely to occur, or justify why ecological leakage is de minimis for the project. This is done at time of validation or at the re-evaluation of the baseline.
6. The QA/QC guidelines proposed as part of the monitoring plan verify the accuracy and consistency of field measurements and ensure the integrity of data collection, management of project databases and the database archival during the crediting period.

3 DEFINITIONS AND ACRONYMS

The following definitions and acronyms apply in the methodology.

3.1 Definitions

Accumulation rate
Rate at which depth of peat accumulates; depth (cm) yr-1

Activity displacement leakage
Leakage as a result of the project activities that represents a shift of pre-project planned

activities to non-forest land that degrades the land and likely leads to GHG emissions outside the project boundary

Aerial imagery method
The use of aerial photography to estimate the GHG emissions from peat and the changes in carbon stocks in aboveground biomass of peat swamp forests. It is preferable when carbon stocks must be estimated over large and/or inaccessible areas of forest.

Allometric Imagery Method (AIM)
An empirical expression of distribution to estimate the GHG emissions from peat and the changes in carbon stocks in aboveground biomass of peat swamp forests that would occur in the absence of project activities.

Biomass expansion factor (BEF)
The factor by which the conversion of biomass from merchantable volume to aboveground biomass is assessed.

Buffer zone
A zone established to ensure that potential negative impacts to the hydrology, such as a drop in the water table, outside the project area are monitored. The buffer zone may be inside or outside the geographic boundary of the project area. Where it is outside of the project area, the buffer zone must be adjacent to the project area and binding water management agreements with land holders in the buffer zone must be in place by the time of the first verification.

Dissolved organic carbon (DOC)
Reactive carbon in peat soil that is converted to CO2 after reacting with water in aquatic ecosystems following a disturbance or soil erosion event. This carbon is not transferred from one location to another, but instead emitted to the atmosphere as a GHG emission.

Drainage depth
Depth of water table (typically measured in cm) relative to the soil surface.

Ground truthing
On-site measurements of GHG emissions, peat subsidence, ground water level, soil moisture, vegetation cover and diversity, that are used to calibrate and validate remote-sensing results.

Logging damage factor (LDF)
A representation of the quantity of emissions (tCO_2e) that will ultimately arise per unit of extracted timber (m3). These emissions arise from the non-commercial portion of the felled tree (the branches and stump) and trees incidentally killed during tree felling.

Oxidation
The process by which peat is exposed to and reacts with oxygen, resulting in conversion of stored carbon in peat to GHG emissions released into the atmosphere. Emissions from peat oxidation may occur if there is a peat supply available to undergo oxidation.

Peat Depletion Time (PDT)
The estimated number of years for all peat to be depleted from an area following a disturbance event, typically due to fire and/or oxidation.

Peat dome
A peat landform that is typically thicker than surrounding peatlands with greater capacity for storing water.

Root to shoot ratio
A measurement of the proportion of plant tissues with supportive functions (roots) compared to the amount of plant tissue with growth function (shoots).

Stratification
The categorization of the project region into relatively homogeneous units, primarily based on land use and land cover (LULC) and peat depth within this methodology. Stratification may reduce variance within homogenous units, reducing transaction costs and uncertainty.

Subsidence
The recession of the peat surface over time. This may be impacted by drainage depth, historic land use and current land cover, peat bulk density, carbon content, and more.

3.2 Acronyms

Acronym	Description
BD	Bulk density
CDM	Clean Development Mechanism
CF	Carbon fraction
CH_4	Methane
DBH	Diameter at breast height
d.m.	Dry matter
DEM	Digital Elevation Model
GHG	Greenhouse gas
GIS	Geographic Information System
GPG for LULUCF	Good Practice Guidance for Land Use, Land-use Change and Forestry
GPG2000	Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
GWP	Global Warming Potential
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous Oxide
NTFP	Non-timber forest product
PD	Project Description
POC	Particulate organic carbon

QA/QC	Quality Assurance/Quality Control
SOC	Soil organic carbon
tCO_2e	Metric Tons of Carbon Dioxide Equivalents

4 APPLICABILITY CONDITIONS

This methodology includes project activities implemented to avoid planned land use conversion in peat swamp forests.

This methodology is applicable under the following conditions:

1) Project activities only include avoided planned land use conversion on undrained tropical peat swamp forests Previously drained peatlands are not eligible. Forest must be defined according to the host country's forest definition as agreed upon under UNFCCC participation or FAO definitions that includes minimum thresholds for area, height and crown cover. Peatland must be similarly defined according to national definitions and include thresholds for carbon content and the thickness of the carbon rich layer.

2) Project activities must be located in southeast Asia.

3) The application of the procedure for determining the baseline scenario in Section 6 leads to the conclusion that the most appropriate baseline scenario is complete conversion of forest to another land use.

4) Project activities must avoid complete conversion of peat swamp forests to another known land use; avoided forest degradation is not eligible. It is assumed that land preparation during the conversion of peat forest would have removed all existing aboveground biomass stocks through logging and burning.

5) Only discrete parcel(s) of peatland are eligible. Deforestation trends that follow a "frontier" approach are not eligible. The land use conversion avoided must be in areas officially and legally designated for and under direct threat of such conversion, and the area and specific geographic location of all planned land use conversions in the baseline must be known and come from written documentation including land use conversion permits, government records, concession maps, etc. Planned deforestation must be projected to occur within ten years of the project start date.

6) Only Lland use changes that would be caused by corporate or governmental entities (plantation companies, national or provincial forestry departments, etc.) are included. Land use changes from community groups, community-based organizations, individuals or households are excluded.

7) Peat drainage emissions in the baseline scenario must be calculated using a common practice peat drainage depth appropriate for project area by completing measurements

within an appropriate proxy area. In cases where data on local common practice is difficult to acquire, peat drainage emissions in the baseline scenario must be calculated using conservative peer-reviewed literature or IPCC default values.

8) Carbon stocks in dead wood and litter may be expected to further decrease (or increase less) in the absence of the project activity during the time frame that coincides with the crediting period of the project activity and may be conservatively excluded.

9) The parcel(s) of peat swamp forest to be converted to another land use must not contain human settlements (towns, villages, etc.) or human activities that lead directly to deforestation, such as clearing for agriculture or grazing land. Activities that involve the utilization of natural resources within the project boundary that do not lead to deforestation are permitted (e.g., selective logging, collection of NTFPs, fuelwood collection, etc.) as this degradation is accounted for in the monitoring methodology.

10) The biomass of vegetation within the project boundary at the start of the project is at steady-state, or is increasing due to recovery from past disturbance, and so monitoring project GHG removals by vegetation may be conservatively excluded i.

11) The volume of trees extracted as timber per hectare prior to land conversion in the baseline is conservatively assumed to be equivalent to the total volume (or biomass) of all trees of commercial value above the minimum size class sold in the local timber market.

12) There must be no ecological leakage due to project activities. Project proponents must demonstrate:

    a. There is no hydrological connectivity to adjacent (non-project) areas; or

    b. Ecological leakage due to hydrological connectivity is avoided by project design and site selection; or

    c. Where projects are hydrologically connected to adjacent areas and the project proponent is unable to establish that project design and site selection do not nullify the risk of ecological leakage, a monitored buffer zone must be established (see Sections 5.2.1 and 8.3.3) to ensure there is no ecological leakage.

13) Where a project activity to mitigate impacts from hydrological connectivity causes an increase in GHG emissions in the project area or buffer zone, such emissions must be included in GHG accounting where above de minimis. The total land area allocated to the deforestation agent for planned deforestation must be shown not to have increased solely for the purpose of eliciting REDD credits.

14) In order to demonstrate permanence of the peat carbon stock, the maximum quantity of GHG emissions reductions may not exceed the difference between baseline and project scenarios soil carbon stocks 100 years after the project start date. No GHG emission reductions may be claimed for a given area of peatland once the project year exceeds PDT. The procedure for determining the PDT must conservatively consider peat depth

and subsidence rate within the project boundary and may be estimated based on the relationship between subsidence and peat depth in the project area.

15) Projects seeking to implement rewetting activities are not applicable under this methodology.

5 PROJECT BOUNDARY

5.1 Carbon Pools

Table 1 lists the carbon pools and GHGs included within the project boundary along with a brief explanation as to why they are included or excluded. No carbon pools are optional for inclusion.

Table 1: Applicable carbon pools

Source		Gas	Selected	Justification/Explanation of choice
Baseline	Aboveground tree biomass	CO_2	Yes	Major carbon pool subject to the project activity.
		CH_4	Yes	Methane emissions from the burning of aboveground biomass are considered for all fire events per latest IPCC Guidelines.
		N_2O	Yes	Nitrous oxide emissions from the burning of aboveground biomass are included for all fire events per latest IPCC Guidelines.
	Aboveground non-tree biomass	CO_2	Yes	Major carbon pool subject to the project activity.
		CH_4	Yes	Methane emissions from the burning of aboveground biomass are considered for all fire events per latest IPCC Guidelines.
		N_2O	Yes	Nitrous oxide emissions from the burning of aboveground biomass are included for all fire events per latest IPCC Guidelines.
	Belowground biomass	CO_2	No	It is assumed that belowground biomass (BGB) is included in the peat component. Additionally, root to shoot

				ratios for peat swamp forests are highly uncertain; root biomass may be estimated using a model based on aboveground biomass estimates, but many existing models are only applicable to upland forests and these ratios are likely not appropriate for peat swamp forests[1].
		CH_4	No	It is assumed that belowground biomass (BGB) is included in the peat component.
		N_2O	No	It is assumed that belowground biomass (BGB) is included in the peat component.
	Dead wood	CO_2	No	Conservatively excluded per the applicability conditions.
		CH_4	No	Conservatively excluded per the applicability conditions.
		N_2O	No	Conservatively excluded per the applicability conditions.
	Litter	CO_2	No	Conservatively excluded per the applicability conditions[2].
		CH_4	No	Conservatively excluded per the applicability conditions.
		N_2O	No	Conservatively excluded per the applicability conditions.

[1] Cairns, M.A., S. Brown, E.H. Helmer, G.A. Baumgardner. 1997. Root biomass allocations in the world's upland forests. Oecologia 111:1-11.

[2] According to field measurements conducted by the project proponent in 57 plots using standard operating procedures as outlined in AR-AM0007, the litter pool represents approximately 0.01% of the total aboveground carbon stocks in peat swamp forests (0.009 ± 0.0017 t C ha^{-1}); therefore a decrease in this carbon pool does not result in a significant GHG emission. Sulistiyanto (2004) also showed that litter makes up 2.4% of the above and belowground tree biomass in both mixed swamp and low pole peat forests in Central Kalimantan. If the REDD project were an A/R project, the litter pool would be deemed an insignificant emission (<5% of total emissions) using the CDM approved tool titled "Tool for testing significance of GHG emissions in A/R CDM project activities".

	Peat	CO_2	Yes	Major carbon pool subject to the project activity.
		CH_4	Yes	Major carbon pool subject to the project activity, especially with regards to peat burning and peat drainage.
		N_2O	Yes	Literature has found that drained organic soils may be a significant source of GHG emissions from N_2O. Nitrous oxide emissions from peat burning are conservatively excluded as peat burning in the baseline scenario will exceed the project scenario.
	Soil organic carbon	CO_2	No	The soil component is included in the peat component.
		CH_4	No	The soil component is included in the peat component.
		N_2O	No	The soil component is included in the peat component.
	Wood Products	CO_2	Yes	Removal of timber is associated with deforestation in the baseline, and significant quantities of carbon may be stored in long-term wood products rather than being emitted into the atmosphere. Thus the quantity of live biomass going into long-term timber products in the baseline scenario is included.
		CH_4	No	Not a relevant pool as wood products are not burned.
		N_2O	No	Not a relevant pool as wood products are not burned.
Project	Aboveground tree biomass	CO_2	Yes	Major carbon pool subject to the project activity.
		CH_4	Yes	Methane emissions from the burning of aboveground biomass are

				considered for all fire events per latest IPCC Guidelines.
		N_2O	Yes	Nitrous oxide emissions from the burning of aboveground biomass are included for all fire events per latest IPCC Guidelines.
	Aboveground non-tree biomass	CO_2	Yes	Major carbon pool subject to the project activity.
		CH_4	Yes	Methane emissions from the burning of aboveground biomass are considered for all fire events per latest IPCC Guidelines.
		N_2O	Yes	Nitrous oxide emissions from the burning of aboveground biomass are included for all fire events per latest IPCC Guidelines.
	Belowground biomass	CO_2	No	It is assumed that belowground biomass (BGB) is included in the peat component. Additionally, root to shoot ratios for peat swamp forests are highly uncertain; root biomass may be estimated using a model based on aboveground biomass estimates, but many existing models are only applicable to upland forests and these ratios may not be appropriate for peat swamp forests[3].
		CH_4	No	It is assumed that belowground biomass (BGB) is included in the peat component.
		N_2O	No	It is assumed that belowground biomass (BGB) is included in the peat component.
	Dead wood	CO_2	No	Conservatively excluded per the applicability conditions.

[3] Cairns, M.A., S. Brown, E.H. Helmer, G.A. Baumgardner. 1997. Root biomass allocations in the world's upland forests. Oecologia 111:1-11.

		CH_4	No	Conservatively excluded per the applicability conditions.
		N_2O	No	Conservatively excluded per the applicability conditions.
	Litter	CO_2	No	Conservatively excluded per the applicability conditions[4].
		CH_4	No	Conservatively excluded per the applicability conditions.
		N_2O	No	Conservatively excluded per the applicability conditions.
	Peat	CO_2	Yes	Major carbon pool subject to the project activity.
		CH_4	Yes	Major carbon pool subject to the project activity, especially with regards to peat burning and peat drainage.
		N_2O	Yes	Literature has found that drained organic soils may be a significant source of GHG emissions from N_2O (IPCC, 2019). Nitrous oxide emissions from peat burning are conservatively excluded as peat burning in the baseline scenario will exceed the project scenario.
	Soil organic carbon	CO_2	No	The soil component is included in the peat component.
		CH_4	No	The soil component is included in the peat component.
		N_2O	No	The soil component is included in the peat component.
	Wood Products	CO_2	No	As any logging in the project scenario is likely illegal logging and it is uncertain what happens to timber

[4] According to field measurements conducted by the project proponent in 57 plots using standard operating procedures as outlined in AR-AM0007, the litter pool represents approximately 0.01% of the total aboveground carbon stocks in peat swamp forests (0.009 ± 0.0017 t C ha^{-1}); therefore a decrease in this carbon pool does not result in a significant GHG emission. Sulistiyanto (2004) also showed that litter makes up 2.4% of the above and belowground tree biomass in both mixed swamp and low pole peat forests in Central Kalimantan. If the REDD project were an A/R project, the litter pool would be deemed an insignificant emission (<5% of total emissions) using the CDM approved tool titled “Tool for testing significance of GHG emissions in A/R CDM project activities”.

				after removal from the project area, it is conservatively assumed that there are no long-lived wood products in the project scenario and that emissions occur immediately upon removal.
		CH_4	No	Not a relevant pool as wood products are not burned.
		N_2O	No	Not a relevant pool as wood products are not burned.

5.2 Geographical Location

Project participants must define the "project boundary" at the beginning of a proposed project activity and must provide the geographical coordinates of lands to be included, so as to allow clear identification for the purpose of verification. The remotely sensed data[5] with adequate spatial resolution, officially certified topographic maps, land administration and tenure records, and/or other official documentation that facilitates the clear delineation of the project boundary may be used. The data must be geo-referenced and provided in digital KML shapefile data format in accordance with VCS guidelines.

The project boundary includes emissions sources and gases as listed in Table 1.

The original project boundary is fixed over the project life. Even if unforeseen circumstances arise within the project boundary such as deforestation, degradation, fire, or other land use change, the project boundary may not be shifted. The project boundary as well as areas of change must be monitored as part of the project's monitoring activities and GHG emissions associated with these changes must be calculated. Any emissions that occur within the project boundary in a given year after the start of the project must be subtracted from the carbon benefits estimated for that year.

5.2.1 Buffer Zone

Where a project area is hydrologically connected to areas outside the project, a buffer zone must be established to ensure that potential negative impacts to the hydrology, such as a drop in the water table, outside the project area are monitored. The buffer zone may be inside or outside the geographic boundary of the project area. Where it is outside of the project area, the buffer zone must be adjacent to the project area and binding water management agreements with land holders in the buffer zone must be in place by the time of the first verification. The size and shape of the buffer zone must be sufficient to monitor negative impacts both inside and outside

[5] Remotely sensed data includes data acquired from earth observation satellites or aerial photographs.

the project area, which may be demonstrated through peer reviewed literature, expert judgment, and/or monitoring following the requirements of the module VMD0044.

5.3 Stratification

5.3.1 Land Use and Land Cover

In this methodology, land use and land cover stratification is achieved in four steps:

Step 1: Stratification according to pre-existing conditions and baseline projections:

a) Define the factors influencing carbon stock changes in carbon pools.

b) Collect local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified above.

c) Do a preliminary stratification based on the collected information.

d) Carry out supplementary sampling for site specifications for each stratum, including as appropriate:

- Existing aboveground carbon stocks or vegetation types
- Present and past land tenure and land use;
- Baseline land use in the absence of project activity:

e) Do the final stratification of the baseline scenario based on supplementary information collected from d) above. Distinct strata may differ significantly in terms of their baseline net greenhouse gas emissions.

f) For highly variable landscapes the option exists to carry out a systematic unbiased sampling to determine the percentage of the project area occupied by each stratum. At each plot, based on the site specifications found, the plot must be assigned to one of the strata identified in paragraph e. The proportions defined will be applied across the project area to define baseline condition. Subsequent sampling for determination of baseline carbon must take place in each of the defined strata.

Step 2: Stratification according to the project activity:

a) Define the project activities

Distinct strata may differ significantly from each other in terms of their actual net greenhouse gas avoided emissions.

Step 3: Final *ex ante* stratification:

b) Verifiably delineate the boundary of each stratum as defined in step 2 using GPS, analysis of geo- referenced spatial data, or other appropriate techniques. Check the consistency with the overall project boundary. Coordinates may be obtained from GPS field surveys or analysis of geo-referenced spatial data, including remotely sensed images, using a Geographical Information System (GIS).

c) Project participants may build geo-referenced spatial databases in a GIS platform for each parameter used for stratification of the project area under the baseline and the project scenario. This will facilitate consistency with the project boundary, precise overlay of baseline and project scenario strata, transparent monitoring and ex post stratification.

Step 4: Leakage stratification: similar to Step 1 above, except areas analyzed are those to which activities are expected to be displaced (*ex ante*) or have been displaced (*ex post*) rather than the project boundary.

a) Define the factors influencing carbon stock changes in carbon pools.

b) Collect local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified above.

c) Stratify based on the information collected in (b) above.

m_{BL} is the number of *ex ante* defined baseline strata as determined with step 1. m_{BL} remains fixed for the entire crediting period.

m_{PS} is the number of strata in the project scenario as determined *ex ante* with step 2.

m_{LK} is the number of strata in the leakage scenario as determined with step 4.

The methodology may include one or more categories of proposed land use conversions and land cover types, all designated as different strata (*i*) in the baseline scenario. If more than one land use conversion is anticipated in the baseline scenario (e.g., part of the land within the baseline scenario is expected to undergo one type of conversion whereas other parts of the land are expected to convert to another type), the project participants must stratify the lands under the baseline according to the likely land use/land cover or combinations of land use/land cover types in the baseline.

The sampling framework, including sample size, plot size, plot shape and plot location must be specified in the PD. When estimating existing carbon stocks within baseline strata for an avoided emissions project, permanent sampling plots are not necessary because these carbon stocks do not need to be tracked over time. Therefore, temporary sampling plots may be used. However, if project proponents choose to monitor increases in carbon stocks in the vegetation over the life of the project, permanent sampling plots must be installed. The number of sample plots is estimated based on accuracy and costs.

The number, size and location of sampling plots must be determined using the current version of the CDM Tool "*Calculation of the number of sample plot for measurements within A/R CDM project activities*".[6]

If baseline carbon stocks are to be estimated remotely using high resolution aerial imagery, plots must be established on the imagery using the same methods as for establishing plots on the ground. The number, size and location of sample plots to be established and measured may be calculated as for ground plots above using imagery-derived information such as the area of each stratum (A_i), the total project area (A), sample plot size (AP), standard deviation for each stratum (st_i), desired precision (DLP) and average value of the estimated quantity (Q).

5.3.2 Peat Depth

In order to accurately estimate PDT for the project area, this methodology requires a separate stratification of the peat layer based on the PDT. Emissions from peat may occur only as long as there is a peat supply available to undergo oxidation. Over time, the peat surface subsides and the depth of the aerobic peat layer is reduced. Published information on peat subsidence rates from south-east Asian peatlands is limited, but initial subsidence rates of up to several dozen centimeters per year have been reported, followed by a lower linear rate[7]. Oxidation continues at this lower rate until the peat depth or drainage depth reaches a threshold at which no further oxidation occurs. The point in time at which the peat is no longer oxidized is the PDT, as this is the point at which there are no additional GHG emissions from oxidation of peat within an area.

5.3.2.1 Peat depth map at project start date

The project proponent may select a peat thickness mapping approach that is the most appropriate for the project circumstances. The peat depth map must have a minimum spatial resolution of 30m x 30m. To ensure accuracy, all remote sensing based peat mapping approaches must check accuracy with some form of ground-truthing[8]. Some examples of potential approaches include:

- A field sampling approach, with measurements using soil augers or soil corers taken at points within the project area. These points must be distributed either along transects oriented perpendicularly to rivers in valley systems or perpendicular to the peat dome for rounded peat dome systems or evenly distributed in a grid across the project area. Interpolation within a GIS must be used to produce the final peat thickness map.
  - Examples of this approach may be found in VM0007 modules VMD0046 (M-PEAT) and VMD0016 (X-STR), as well as in literature (e.g. Ramsar Convention Secretariat, 2018).
  - There are a wide range of geostatistical interpolation methods available, such as inverse-distance weighting, kriging, natural neighbor, spline functions, with a range of implementations available, from ArcGIS to ENVI to QGIS to statistical software such

[6] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.1.0.pdf

[7] Wosten, JHM, AB Ismail, and ALM van Wijk. 1997. Peat subsidence and its practical implications: a case study in Malaysia. Geoderma 78: 25-36.

[8] . FAO Peatland mapping and monitoring - Recommendations and technical overview. Pg 9. http://www.fao.org/3/CA8200EN/CA8200EN.pdf

as R or STATA. The project proponent must detail the interpolation method chosen, the implementation used, and the exact parameters used. The project proponent must also detail why the chosen interpolation method and implementation are appropriate to the project.

- A mixed field sampling and remote sensing approach, using field sampling with either soil augur or soil core measurements or GPR (ground penetrating radar) measurements combined with DEMs (Digital Elevation Models) such as the NASA Shuttle Radar Topography Mission (SRTM) DEMs or LiDAR-based DEMs (see Vernimmen, 2020).
- A remote sensing approach, with image classification of either remotely sensed medium to high-resolution optical imagery such as Sentinel 2 or Landsat 8 alongside radar satellite imagery such as ALOS-PALSAR2 or SAR (Synthetic Aperture Radar) and supplemented by DEMs such as the NASA SRTM DEMs (e.g. Rudiyanto, Minasny, Setiawan, Saptomo, & McBratney, 2018).

A peat depth map must be produced that is applicable to the project area as of the project start date. If the peat depth map is produced using data from prior to the project start date, the project proponent must demonstrate that the map has been corrected for any disturbances or subsidence that occurred since data collection. It is conservative to not correct for any accumulation of peat that may have occurred following measurements. Using data collected after the project start date does not require corrections for subsidence or disturbance but corrections must be made for potential peat accumulation. If a disturbed area is measured after the project start date, it will have a lower peat depth than it would have in the baseline scenario at the project start date, and thus lower the potential for baseline emissions in the disturbed area. However, undisturbed areas must be conservatively corrected by subtracting from total measured peat depth any potential accumulation that occurred in the time between the project start date and time of measurements. Accumulation rates for peat may be selected from literature if no site-specific data is available (e.g. Table 3 of Hope, Chokkalingam, & Anwar, 2005).

Once a peat depth map for the entirety of the project area as of the project start date has been produced, it must be stratified based on peat depth into intermediate strata *k* that will be used to calculate the depth of peat burned in the baseline scenario as well as the PDT stratum *j.* This stratified peat depth map will also be used for monitoring project emissions within peat areas (Section 8.2.4). The range of each stratum may be selected by the project developer, but the first stratum must range from 0 cm of peat depth to the minimum peat depth threshold. If a definition of peat is available in a country's REDD Forest Reference Emission Level submission to the UNFCCC, a project must use that minimum threshold. If a national definition of peat is not available, a default minimum depth of 50 cm may be applied. This first stratum (k=0) will not be eligible for baseline or project GHG emissions from peat as these areas do not meet the definition of peatlands.

Peat depth increments for additional strata must begin at the minimum threshold of peat depth. The project developer must justify the depth increments of each stratum within the Project Design Document.

Once stratification is complete, the average peat depth for each stratum *k* at the project start date is calculated as follows:

$$D_{Peat,k,t=0} = \frac{\sum_{PD_{D,min,k}}^{PD_{D,max,k}} (A_{PD_D,k,t=0} * PD_D)}{A_k} \quad (1)$$

where:

$D_{peat,k,t}$	= Average peat depth in stratum *k* at the project start date; cm
$A_{PDD,k,t=0}$	= Area in stratum *k* at a peat depth of *D* at the beginning of the baseline crediting period; hectares
PD_D	= Peat depth of area at depth *D*; cm
$PD_{D,min,k}$	= Minimum bound of peat depth *D* within stratum *k;* cm
$PD_{D,max,k}$	= Maximum bound of peat depth *D* within stratum *k*; cm
A_k	= Total area of stratum *k;* hectares
k	= 1, 2, 3, …*k** peat depth stratum

5.3.2.2 Stratified peat depth map for baseline scenario

The following steps will be used to stratify the project area based on the PDT in the baseline scenario:

1) Produce a stratified peat depth map for the project area following land clearing burns in the baseline scenario by subtracting the depth of peat burn for each stratum (*k)* that would be susceptible to burning. The following equation must be used to calculate the depth of peat following burning:

$$D_{Peat,B,pb,k} = D_{Peat,k,t=0} - D_{peatburn,B,k} \quad (2)$$

where:

$D_{Peat,B,pb,k}$	= Average depth of peat following the burning of biomass and peat in the baseline scenario for strata *k*; cm (equivalent to *l* in step 2 below)
$D_{,Peat,k,t=0}$	= Average peat depth in stratum *k* at the project start date; cm
$D_{,eatburn,B,k}$	= Depth of peat burned in the baseline scenario for stratum *k*; cm (may not exceed the maximum peat depth burned as determined below)

a. Single fire events in human-induced fires in southeast Asian peatlands have resulted in losses up to well over one meter of peat (Page, Rieley, Boehm, Siegert, & Muhamad, 2000; Page, et al., 2002; Limin, et al., 2004). In the baseline, it is assumed that peat would be burned along with remaining vegetation after drainage in order to clear the land for the new land use.

The peat fire depth in the baseline scenario ($D_{peatburn,B,k}$) is determined similar to the guidelines of Section 5.6.8 of the VM0007 Module VMD0046. The selected value may be based on surface height measurements, field measurements, remote sensing (e.g. following methods described in Ballhorn, Siegert, Mason, & Limin, 2009), expert judgement, literature values (e.g. Couwenberg, Dommain, & Joosten, 2010), and/or datasets of historic burn depths from the project area or justifiably similar areas. The value for burn depths must be justified for each stratum *k*.

The result of this step is a stratified peat depth map for the project area following burning for land clearing in the baseline scenario. Strata for this intermediate peat depth map are represented by the parameter *l.* This stratified peat depth map must be used in the following steps calculating peat burn depth during a specific project year and PDT. This methodology conservatively assumes that following the initial burning event no further fires occur in the baseline scenario.

2) Produce a stratified peat map based on the depth of the burn and combine it with the baseline scenario land clearing data. The end result will be a spatially explicit map stratified by the depth of peat burning in project year *t*. Each stratum in this map will be represented by the parameter *b.*

    a. The stratified post-burn depth of peat map (*l*) produced in Step 1 may be subtracted from the peat depth map at the project start to produce a map of the depth of peat burned across the project area. Each strata will represent the depth of peat burned (cm) in the baseline scenario.

    b. This map stratified by the depth of peat burn may be combined with data on the year in which an area would be cleared and burned (see $t_{cleared}$ in Step 4 below). It is up to the discretion of the project developer as to how best implement this procedure, but the result must be a stratified map representing the total area burned to each depth found in the baseline scenario at project year *t*.

        i. One possible option would be to use a raster calculator in a GIS to multiply *t* by 100 and then add the depth of peat burned map. For example, an area in which 30 cm of peat were burned in year 1 would be represented by a value of 130. A benefit to this approach is that the value will provide information on both the year the peat was burned and the depth to which it was burned.

    c. The result of this step will be a map stratified by the depth of peat burned in project year *t*. This map will be an important product for peat burning emissions calculations in Section 8.1.2.2.

3) Calculate PDT for each stratum *l* of the map produced in Step 1 by using a conservative subsidence rate to calculate the number of years it would take for peat to be depleted.

$$PDT_{y,l} = \frac{l}{S_{y,l}} \tag{3}$$

where:

$PDT_{y,l}$	= Years after land-clearing/burning in stratum *l* in which peat oxidation ceases (PDT); years (y)
$S_{y,l}$	= Subsidence rate in stratum *l* at *y* years; cm yr^{-1}

l = Average depth of peat following the burning of biomass and peat in the baseline scenario for strata k; cm

a. Surveys must be conducted in proxy areas of land use change in the vicinity of the project area to determine common drainage practices including common drainage depth used for water management. Results from the survey must be reported in the PD and used in calculations. However, this data may not be available to project developers due to potential unwillingness of land managers of proxy areas to share specific practices and/or data. In these cases, project developers may use available literature data or default data provided below. In all cases, the same subsidence rate must be used both for calculating PDT and for calculating drainage emissions (Section 8.1.2.1).

b. Hooijer, Silvius, Wosten, & Page, (2006) report estimates of minimum and maximum values of drainage depths for the establishment of both large-scale plantations and mixed cropland/small-scale agriculture (Table 1). These estimates are considered conservative: e.g., average drainage depths well over 1 meter (up to 3 meters in some cases) are reported for many oil palm and pulpwood (Acacia) plantations. Therefore, in areas where peat depth exceeds 1.5 meters, projects with no data must apply a conservative drainage depth of 0.8 m (80 cm) when the baseline scenario is conversion to large-scale plantations and 0.4 m when the baseline scenario is conversion to small-scale agriculture. In cases where total peat depth is between 0.5 and 1.0 meters, default drainage depth must be conservatively assumed to be maintained at 50% of the total peat depth for conversion to large-scale plantations and 25% when the baseline scenario is to small-scale agriculture.

Table 2: Minimum, likely, and maximum drainage depths within baseline land use classes (Hooijer, Silvius, Wosten, & Page, 2006)

Land Use	Minimum (m)	Likely (m)	Maximum (m)
Large croplands, including plantations	0.80	0.95	1.10
Small-scale agriculture	0.40	0.60	0.80

c. The project proponent must use historical or local common practice information or expert judgment to determine an accurate peat drainage rate based on peat depth. Literature figures suggest peat drainage/subsidence rates for areas with peat depth >= 50cm is 4.5cm yr^{-1}. Recent literature has demonstrated that peat subsidence and oxidation immediately following the initial land clearing and land burning is significantly higher than the lower linear rate observed in later years (Hooijer, et al., 2012). A project developer may choose to use a variable subsidence rate in year *y* by providing evidence that this is the case for the project area. The appropriate subsidence rate and emissions factors must (Section 8.1.2.1.1) be used for both the production of the PDT stratified map and emissions calculations. To simplify calculations and more evenly spread out baseline emissions over the project lifetime, linear subsidence rates and emissions factors appropriate for the project crediting period may instead be used.

d. The result of this step is a stratified map representing the number of years (y) after an area is cleared and burned at which time peat drainage emissions will no longer occur in the baseline scenario. The following step combines this stratified map with the baseline scenario data on the year an area is cleared to calculate the PDT. The PDT in this map will be represented by the number of years after the project start date (*t*) that peat drainage emissions cease. This will be calculated for the entirety of peat areas within the project area.

4) Once Step 3 is completed, this data is combined with baseline scenario data on the year in which an area is cleared to calculate PDT relative to the project start date. The following formula may be used:

$$z = PDT_{y,l} + t_{cleared} \quad \textbf{(4)}$$

where:

z	= Number of years *t* after the project start date at which peat is depleted and/or peat oxidation no longer continues in the baseline scenario; years
$t_{cleared}$	= Number of years after the project start date in which area is cleared; years
$PDT_{y,l}$	= Years after land-clearing/burning in stratum l in which peat oxidation ceases (PDT); years (y)

a. The parameter $t_{cleared}$ will be calculated as part of the baseline scenario in Section 6 through the use of documentation demonstrating the time an area would be cleared. This parameter represents the year in which an area would have been cleared in the baseline scenario relative to the project start date.

b. As $PDT_{y,l}$ and $t_{cleared}$ are both spatially explicit, a GIS raster calculator may be used to add them together.

c. The result of this step will be a spatially explicit raster at the resolution of the initial peat depth made prior to Step 1. As the value *z* represents the number of years until peat is depleted in the baseline scenario, these values may be used to stratify by PDT into a stratum *j.* This stratified map will be used in the GHG emissions calculations explained in Section 8.1.2. The strata *j* starts from 0 which includes all the areas that are non-peat at the project start. The next stratum is indicated by 1 which includes all the area where peat is depleted within year 1 of the project crediting period under the baseline scenario. Similarly, the strata values will increment until the end of the project crediting period. Finally, all the areas where peat oxidation will continue beyond the project lifetime may be combined into one single stratum. This is because the PDT in these areas exceeds the remainder of the project crediting period and peat oxidation will continue across the project lifetime in the baseline scenario in these areas.

6 BASELINE SCENARIO

The current version of the VCS "*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 plausible baseline scenario.

All project activities eligible for this methodology must be APWD (Avoiding Planned Wetland Degradation) activities. When establishing the baseline scenario, the project proponent must present verifiable evidence to demonstrate that the project area was intended to be drained or otherwise converted to a different land use or land cover class. As evidence, the project proponent may present documents such as:

1. Government plans (for publicly owned and managed wetland),
2. Community plans (for publicly owned and community-managed wetland),
3. Concession plans (for publicly owned and concession holder managed),
4. Landowner plans (for privately owned wetland).

The baseline scenario assumes that the entirety of the project area will be logged and the remaining biomass burned before conversion to a different land use or land cover class. The project proponent must demonstrate that this is common practice for the region.

The project proponent must identify and account for any land-use activities that would occur in the baseline project scenario and affect hydrological processes resulting in increased carbon burial and GHG reductions within the project area. Some activities include those that would change the landscape form, such as constructing levees or dams to constrain water flows or hold water. Activities that would change the land surface and affect runoff into hydrological systems must also be considered, such as clearing forests, creating ditches, or paving surfaces.

The project proponent must identify and account for any land-use activities that would occur in the baseline project scenario and affect hydrological processes resulting in decreased sediment supply to the project area. Some activities include the construction of upstream dams, or stabilizing eroding areas along the coast. Since the supply of sediment varies over time, in considering these activities, the time-averaged delivery of sediment to the project area must be considered.

7 ADDITIONALITY

The current version of the VCS "*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.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

Greenhouse gas emissions reductions and removals are calculated using the equations outlined in this section. This methodology includes the quantification of emissions reductions and removals for the gases defined in Table **1** above, as deemed appropriate by WRC Requirements listed in the *VCS Standard* and project area conditions.

8.1 Baseline Emissions

This methodology outlines methods to estimate the GHG emissions from peat and the changes in carbon stocks in aboveground biomass of peat swamp forests that would occur in the absence of project activities.

Baseline net GHG emissions are represented as follows:

$$C_{BSL,t} = \sum_{i=1}^{m_{BL}} \Delta C_{B,AG,it} + E_{B,p,t} \quad \textbf{(5)}$$

where:

$C_{BSL,t}$	= sum of changes in aboveground carbon stocks and peat emissions in year *t* of the baseline scenario; t CO_2-e.
$\Delta C_{B,AG,it}$	= sum of carbon stock changes in aboveground biomass under the baseline scenario for stratum *i* at time *t*; t CO_2-e (Equation 6)
$E_{B,p,t}$	= total baseline GHG emissions from drained peat under the baseline scenario at time t; tCO2-e (Equation 59)
i	= 1, 2, 3, …m_{BL} baseline land use/landcover strata
t	= 1, 2, 3, …t^* years elapsed since the start of the project activity

In this methodology Equation 5 is used to estimate baseline net greenhouse gas emissions for the period of time elapsed between project start (*t*=0) and the year *t*=*t**, *t** being the year for which baseline net greenhouse gas emissions are estimated.

8.1.1 Estimation of Carbon Stock Changes in Aboveground Biomass ($\Delta C_{B,AG,it}$)

For all strata, carbon stock changes in aboveground biomass may be estimated as the sum of carbon stock changes resulting from initial land clearing and from future land-use activities:

$$\Delta C_{B,AG,it} = E_{timber,it} + E_{B,BiomassBurn,it} - R_{B,growth,it} + E_{harvest,it} \quad (6)$$

where:

$\Delta C_{B,AG,it}$ = sum of carbon stock changes in aboveground biomass under the baseline scenario in stratum i at time t; t CO_2-e

$E_{timber,it}$ = sum of carbon stock changes in aboveground biomass due to timber extraction prior to land clearing in stratum i at time t; t CO_2-e

$E_{B,BiomassBurn,it}$ = sum of carbon stock changes in aboveground biomass due to biomass burning for stratum i at time t under the baseline scenario; t CO_2-e

$R_{B,growth,it}$ = sum of carbon stock changes in aboveground biomass due to biomass growth of living vegetation on the future land-use for stratum i at time t; t CO_2-e

$E_{harvest,it}$ = sum of carbon stock changes in aboveground biomass due to harvest activities at rotation on baseline future land-use for stratum *i* at time *t*; t CO_2-e

8.1.1.1 Estimation of GHG emissions from timber extraction before land clearing ($E_{timber,it}$)

Per applicability condition J of this methodology, in the baseline scenario the project land is assumed to be logged for timber prior to land clearing. Emissions from timber extraction are calculated as:

$$E_{timber,it} = \left(C_{B,it}^{extracted} - C_{B,it}^{woodproducts} \right) \cdot \frac{44}{12} \quad (7)$$

$C_{B,it}^{extracted}$ may be estimated by calculating the biomass of the logs that would be extracted in the baseline case using either allometric equations or a biomass expansion factor to convert from volume to biomass. When estimating the biomass of timber removed (based on a minimum diameter threshold), it is conservative to assume that the biomass of the entire aboveground component (leaves, branches, etc.) of each harvested tree is removed with the logs extracted, leaving no slash behind to burn.

$$C_{B,it}^{extracted} = B_{B,it}^{logged} \cdot CF \cdot A_{B,it}^{logged} \quad (8)$$

$$C_{B,it}^{woodproducts} = C_{B,it}^{extracted} \cdot p \quad (9)$$

where:

$C_{B,it}^{extracted}$ = Carbon stocks from trees extracted under the baseline scenario in stratum *i* at time *t*; t C

$C_{B,it}^{woodproducts}$ = Carbon stocks moving into long-term wood products under the baseline scenario for stratum *i* at time *t*; t C

$B_{B,it}^{logged}$ = Timber biomass logged under the baseline scenario for stratum *i* at time *t*; t d.m. ha^{-1}

CF = Carbon fraction of dry matter (0.5 t C / t biomass); dimensionless

$A_{B,it}^{logged}$ = Area of land logged under the baseline scenario for stratum *i*, in time *t*; ha

p = Percent of harvest industrial roundwood going into long term wood products

Estimation of the area cleared and logged

As per Applicability Condition D in Section 4, the area and specific geographic location of all planned land use conversions in the baseline must be known and come from written documentation including land use conversion permits, government records, concession maps, etc. This threat must be demonstrated by documentary proof at time of validation. As all conversion is required to happen within the first 10 years of the baseline, this evidence does not additional consideration during baseline re-evaluation.

The annual area of forest conversion to the proposed land use type $A_{B,it}^{cleared}$ (and $A_{B,it}^{logged}$ if applicable) must be estimated. A valid verifiable plan by the agent of deforestation must exist for estimating the rate at which deforestation and/or logging is projected to occur, and this rate must be used.

If it is unknown whether the land would be logged prior to conversion, then logging must be assumed because some of the carbon extracted as timber will be stored as long-term wood products; this is a conservative scenario. The area logged must be assumed to be equal to the area cleared unless evidence exists of a different rate.

Estimation of biomass logged

The biomass of timber extracted under the baseline scenario $B_{B,it}^{logged}$ must be estimated in Equation 8. As per Applicability Condition J outlined in Section 4, it is assumed that the size class and species of trees sold in the local timber market would have been extracted in the project area prior to clearing. Species and minimum diameter classes sold in the local timber market may be obtained from government records, timber records of existing logging operations, surveys of illegal logging activities, sawmill surveys, or records of previous land use conversion also meeting the applicability conditions of this methodology.

Alternatively, market surveys may be conducted to determine which species and size classes are sold. It is conservative to assume that all species of a small diameter class threshold would be sold for timber, leaving fewer remaining trees to burn when the land is cleared.

Using plot data collected in Sec. 8.2.1.2.1 and locally-derived volume or biomass equations, estimate the biomass per unit area (t dry matter ha^{-1}) that would be expected to be logged in each stratum *i* at time *t* by following the steps below. If local equations are not available, more generic equations based on forest type may be used, with demonstration of the applicability of the equation outlined in the PD (e.g., through limited destructive harvest measurements collected in the project area).

Step 1: For each plot measured to calculate $MC_{B, AG\_tree,it}$, calculate the biomass of each tree that would have been extracted, defined as all trees within each plot that exceed the minimum diameter threshold. Add the biomass of all trees together and multiply by a plot expansion factor which is proportional to the area of the measurement plot. This is divided by 1,000 to convert from kg to t.

BEF Method:

$$PV_{B,it} = \frac{\left(\sum_{tr=1}^{TR} TV_{B,AG\_tree,tr} \cdot XF\right)}{1000} \quad (10)$$

$$PB_{B,it} = PV_{B,it} \cdot \phi_i \cdot BEF \quad (11)$$

Allometric or Aerial Imagery Method:

$$PB_{B,it} = \frac{\left(\sum_{tr=1}^{TR} TB_{B,tr} \cdot XF\right)}{1000} \quad (12)$$

$$XF = \frac{10,000}{AP} \quad (13)$$

where:

$PV_{B,it}$ = Plot level volume to be extracted under the baseline scenario in stratum i at time t; m^3 ha^{-1}

$PB_{B,it}$ = Plot level biomass to be extracted under the baseline scenario in stratum i at time t; t d.m. ha^{-1}

$TV_{B,tr}$ = Volume per tree tr in trees to be extracted under the baseline scenario; m^3 $tree^{-1}$

$TB_{B,tr}$ = Biomass per tree tr in trees to be extracted under the baseline scenario; t d.m. $tree^{-1}$

XF = Plot expansion factor from per plot values to per hectare values

φ_i = volume-weighted average wood density; t d.m. m^{-3} merchantable volume

BEF = biomass expansion factor for conversion of biomass of merchantable volume to above-ground biomass; dimensionless.

AP = Plot area; m^2

tr = 1, 2, 3, ..., TR trees (TR = total number of trees in the plot expected to be extracted)

Step 2: Calculate the average biomass expected to be extracted within each stratum by averaging across plots within a stratum:

$$B_{B,it}^{logged} = \frac{\sum_{pl=1}^{PL_{it}} PB_{B,it}}{PL_{it}} \quad (14)$$

where:

$B_{B,it}^{logged}$ = timber biomass logged under the baseline scenario for stratum *i* at time *t*; t d.m. ha^{-1}

$PB_{B,it}$ = Plot level biomass to be extracted under the baseline scenario in stratum *i*, time *t*; t d.m. ha^{-1}

pl = Plot number in stratum i; dimensionless

PL_{it} = Total number of plots in stratum *i*, time *t*; dimensionless

8.1.1.2 GHG emissions from biomass burning for land clearing ($E_{B,BiomassBurn,it}$)

As per Applicability Condition C in Section 4, it is assumed in the baseline scenario that all remaining biomass that is not harvested as timber would be cleared by fire to prepare the site for a new land use activity.

Therefore, it is assumed that tree vegetation is partially or totally harvested before burning and that:

- The carbon stock decrease in the harvested tree biomass is estimated using the methods outlined in Section 8.1.1.1 above;
- The aboveground biomass of the harvested trees is subtracted from the total aboveground biomass estimate used for the calculation of non-CO_2 emissions from burning;

Based on revised IPCC 1996 Guidelines for LULUCF, this type of emissions may be estimated (whenever double counting of carbon stock losses is avoided) as follows:

$$E_{B,BiomassBurn,it} = E_{B,Biomassburn,CO2,it} + E_{B,BiomassBurn,N2O,it} + E_{B,BiomassBurn,CH4,it} \quad (15)$$

where:

$E_{B,BiomassBurn,it}$ = total increase in CO_2-e emissions under the baseline scenario as a result of aboveground biomass burning for land clearing in stratum i at time t; t CO_2-e

$E_{B,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning under the baseline scenario in stratum i at time t; t CO_2-e

$E_{B,BiomassBurn,N2O,it}$ = N_2O emission from biomass burning under the baseline scenario in stratum i at time t; t CO_2-e

$E_{B,BiomassBurn,CH4,it}$ = CH_4 emission from biomass burning under the baseline scenario in stratum i at time t; t CO_2-e

and:

$$E_{B,BiomassBurn,CO2,it} = (C_{B,AC,it} \cdot PBB_{B,it} \cdot CE) \cdot \frac{44}{12} \quad (16)$$

where:

$E_{B,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning under the baseline scenario in stratum *i* at time *t*-; t CO_2-e

$C_{B,AC,it}$ = estimated above-ground biomass carbon stock before burning in the baseline scenario for stratum *i*, time *t*; t C (Equation 17)

$PBB_{B,it}$ = average proportion of $C_{B,AC,it}$ burnt under the baseline scenario in stratum *i*, time *t*; dimensionless

CE = average biomass combustion efficiency (see below for guidance on selecting appropriate value); dimensionless

Because the land is being cleared for another land use in the baseline scenario, all of the biomass that is not extracted as timber is assumed to be burned and therefore for this methodology the proportion burned in the baseline ($PBB_{B,it}$) is assumed to be equal to 1.

The combustion efficiencies (CE) may be chosen from the most up to date version of IPCC documentation (e.g. Table 2.6 of the 2006 *IPCC AFOLU Guidelines*) or applicable literature. If no appropriate combustion efficiency may be identified, the most recent IPCC default value must be used.

The aboveground carbon stock before burning ($C_{B,AC,it}$) is assumed to be equal to the difference between the carbon stock in the tree and non-tree pools prior to logging and the carbon extracted as timber during logging operations:

$$C_{B,AC,it} = \left[MC_{B,AG,it} * A_{B,it}^{cleared}\right] - C_{B,it}^{extracted} \tag{17}$$

where:

$C_{B,AC,it}$ = estimated above-ground biomass carbon stock before burning in the baseline scenario for stratum i, time t; t C

$MC_{B,AG,it}$ = Mean carbon stock in above-ground biomass under the baseline scenario in stratum i, time t; t C ha^{-1} (Equation 20)

$A_{B,it}^{cleared}$ = Area cleared under the baseline scenario for stratum *i*, in time *t*; ha

$C_{B,it}^{extracted}$ = carbon stocks from trees extracted under the baseline scenario in stratum *i* at time *t*; t C (Equation 8)

Emissions of non-CO_2 gases are given by:[9]

$$E_{B,BiomassBurn,N2O,it} = E_{B,Biomassburn,CO2,it} \cdot \frac{12}{44} \cdot (N/Cratio) \cdot ER_{N_2O} \cdot \frac{44}{28} \cdot GWP_{N_2O} \tag{18}$$

$$E_{B,BiomassBurn,CH4,it} = E_{B,Biomassburn,CO2,it} \cdot \frac{12}{44} \cdot ER_{CH_4} \cdot \frac{16}{12} \cdot GWP_{CH_4} \tag{19}$$

where:

$E_{B,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning under the baseline scenario in stratum i at time t; t CO_2-e

$E_{B,BiomassBurn,N2O,it}$ = N_2O emission from biomass burning under the baseline scenario in stratum i at time t; t CO_2-e

$E_{B,BiomassBurn,CH4,it}$ = CH_4 emission from biomass burning under the baseline scenario in stratum i at time t; t CO_2-e

N / Cratio = nitrogen-carbon ratio; dimensionless

ER_{N2O} = emission ratio for N_2O; t CO_2-e (t C)$^{-1}$

ER_{CH4} = emission ratio for CH_4; t CO_2-e (t C)$^{-1}$

GWP_{N2O} = Global Warming Potential for N_2O

[9] Refers to Table 5.7 in 2019 Revised IPCC Guideline for LULUCF and Equation 3.2.19 in IPCC GPG-LULUCF

GWP_{CH4} = Global Warming Potential for CH_4

The nitrogen-carbon ratio (N/C ratio) is approximated to be about 0.01. This is a general default value that applies to leaf litter, but lower values would be appropriate for fuels with greater woody content, if data are available. Emission factors for use with above equations may be selected from the latest IPCC guidance documents (e.g Tables 3.A.15 and 3.A.16 of IPCC GPG-LULUCF).

8.1.1.3 Mean carbon stocks in aboveground biomass ($MC_{B,AG,it}$)

Mean carbon stocks in aboveground biomass are expressed as the sum of biomass in the tree and non-tree components:

$$MC_{B,AG,it} = MC_{B,AG\_tree,it} + MC_{B,AG\_nontree,it} \quad \textbf{(20)}$$

where:

$MC_{B,AG,it}$ = Mean carbon stock in above-ground biomass under the baseline scenario in stratum i, time t; t C $ha^{-1}$$MC_{B,AG_tree,it}$ = Mean aboveground biomass carbon stock in tree biomass in stratum i at time t; t C ha^{-1} (Equation 36, 37, or 42)

$MC_{B,AG\_nontree,it}$ = Mean aboveground biomass carbon stock in non-tree biomass in stratum i at time t; t C ha^{-1} (Equation 21)

8.1.1.3.1 Estimation of mean carbon stocks in aboveground non-tree biomass ($MC_{B,AG\_nontree,it}$)

The non-tree woody aboveground biomass pool includes trees smaller than the minimum tree size measured in the tree biomass pool, all shrubs, and all other non-herbaceous live vegetation[10]. Non-tree vegetation may be sampled using destructive sampling frames and/or, where suitable, in sampling plots in combination with an appropriate allometric equation for shrubs.

The mean carbon stock in aboveground non-tree biomass is calculated for each land use/landcover stratum by adding together results calculated using the sampling frame method and the allometric equation method:

$$MC_{B,AG\_nontree,it} = MC_{AG\_nontree\_sample,it} + MC_{AG\_nontree\_allometric,it} \quad \textbf{(21)}$$

where:

$MC_{B,AG\_nontree,it}$ = Mean aboveground biomass carbon stock in non-tree biomass in stratum i at time t; t C ha^{-1}

$MC_{AG\_nontree\_sample,it}$ = Mean aboveground non-tree biomass carbon stock in stratum i at time t calculated from sampling frame method; t C ha^{-1}

[10] Pursuant to AR-WG 21 that the GHG emissions from removal of herbaceous vegetation are insignificant in A/R CDM project activities, these emissions may be neglected in A/R baseline and monitoring methodologies.

$MC_{AG\_nontree\_allometric,it}$ = Mean aboveground non-tree biomass carbon stock in stratum i at time t calculated from allometric equation method; t C ha^{-1}

8.1.1.3.1.1 Sampling Frame Method:

In strata where non-tree vegetation is spatially variable, large frames may be used (e.g., 1-2 m radius circle). Where non-tree vegetation is homogeneous, smaller frames may be used (e.g., 30 cm radius). Generally, the frame is placed at four random locations per randomly selected GPS point (or per plot, where mean carbon stocks in trees are also measured). At each location, all vegetation originating from inside the frame is cut at the base and weighed. The wet weight of the four sample frames is added together. These four sampling frames create one non-tree sample plot. One representative subsample from all four sub-sample frames is weighed and taken from field. The collected subsample is oven dried and weighed to determine the dry weight. The wet to dry ratio of the subsample is then used to estimate the dry weight of the original sample.

The mean carbon stock per unit area in the above ground non-tree biomass (sampling method) is calculated for each stratum as:

$$MC_{AG\_nontree\_sample,it} = 10 * \frac{1}{A_{SFP,i}} * \sum_{sf=1}^{SFP_i} MC_{AG\_nontree\_sample,sf,it} * CF_{non-tree} \quad (22)$$

$$A_{SFP,i} = \sum_{sfp=1}^{SFP_i} \sum_{SF=1}^{4} A_{sampleframe} \quad (23)$$

where:

$MC_{AG\_nontree\_sample,it}$ = Mean aboveground non-tree biomass carbon stock in stratum i at time t calculated from sampling frame method; t C ha^{-1}

$MC_{AG\_nontree\_sample,sf,it}$ = Carbon stock in above ground non-tree vegetation in sample plot sf in stratum i at time t from sampling frame method; kg d.m.

$CF_{non-tree}$ = Carbon fraction of dominant non-tree vegetation species; dimensionless

$A_{SFP,i}$ = Total area of all non-tree sampling plots in stratum i; m^{-2}

$A_{sampleframe}$ = Area of one sampling frame; m^{2}

sfp = 1, 2, 3 … SFP_i sample plots in stratum i

i = 1, 2, 3 … M strata

t = 1, 2, 3 … t years elapsed since the start of the project activity

sf = 1, 2, 3 up to 4 sampling frames per sample plot

10 = conversion factor between kg d.m. m^{-2} and t d.m. ha^{-1}

8.1.1.3.1.1.1 Allometric Equation Method:

The allometric equation method for estimating aboveground non-tree biomass carbon stocks may be used for shrubs, bamboo, or other vegetation types where individuals may be delineated clearly.

Step 1: Select or develop an appropriate allometric equation (species-specific if possible, otherwise for a similar species).

Step 2: Estimate carbon stock in above-ground biomass for each individual *l* in the sample plot *r* located in stratum *i* using the selected or developed allometric equation:

$$MC_{AG\_nontree\_allometric,i,r,t} = \sum_{l=1}^{N_{r,i,t}} f_q(vegetation\_parameters) * CF_q \quad \textbf{(24)}$$

where:

$MC_{AG\_nontree\_allometric,i,r,t}$	= Carbon stock in above-ground biomass of non-tree sample plot *r* in stratum *i* at time *t* from allometric equation method; t C
CF_q	= Carbon fraction of biomass for species *q*; t C t^{-1} d.m..
$f_q(vegetation_{parameters})$	= Allometric equation for species *q* linking parameters such as stem count, diameter of crown, height, or others to aboveground biomass of an individual; t. d.m. $individual^{-1}$
i	= 1, 2, 3 … M strata
r	= 1, 2, 3, …R non-tree allometric method sample plots in stratum i
q	= 1, 2, 3, … Q non-tree species
l	= 1, 2, 3, … $N_{l,i,sp,t}$ sequence number of individual trees in sample plot r in stratum i at time t
t	= *0, 1, 2, 3* … *t* years elapsed since the start of the project activity

Step 3: Calculate the mean carbon stock in aboveground biomass for each stratum, converted to carbon dioxide equivalents:

$$MC_{AG\_nontree\_allometric,it} = \frac{1}{Ar_i} * \sum_{r=1}^{R_i} MC_{AG\_nontree\_allometric,i,r,t} \quad \textbf{(25)}$$

where:

$MC_{AG\_nontree\_allometric,it}$	= Mean aboveground non-tree biomass carbon stock in stratum i at time t calculated from allometric equation method; t C ha^{-1}
$MC_{AG\_nontree\_allometric,i,r,t}$	= Aboveground biomass carbon stock in non-tree vegetation in sample plot r of stratum i at time t from non-tree allometric sample plots, t C
Ar_i	= Total area of all non-tree allometric method sample plots in stratum i; ha
r	= 1, 2, 3, …R non-tree allometric method sample plots in stratum i
i	= 1, 2, 3 … M strata
t	= 0, 1, 2, 3 … t years elapsed since the start of the project activity

8.1.1.3.1.2 Estimation of mean carbon stocks in aboveground tree biomass ($MC_{B,AG\_tree,it}$)

Three methods are available to measure aboveground tree biomass carbon in each stratum *i*: (1) the Aerial Imagery Method (AIM); (2) the Biomass Expansion Factor (BEF) method; and (3) the Allometric Equations method. Refer to Section 5.3.1 above for information regarding the number of plots required when setting up field and/or virtual plots.

8.1.1.3.1.2.1 Aerial Imagery Method

The aerial imagery method is preferable when carbon stocks must be estimated over large and/or inaccessible areas of forest. Methods in this section are based on Brown, et al. (2005) and Slaymaker (2003).

AIM Step 1: On the ground, measure diameter at breast height (DBH), total tree height and crown area of individual trees of varying diameters and species found within the project region. Sample size must be large enough to capture the variability in DBH and crown areas of trees in the project boundary. Estimate biomass of each tree using the allometric equations method that relates DBH or DBH and height to biomass (see Allometric Equations method below).

Crown area is estimated as the average area of two ellipses, where each ellipse is estimated based on canopy measurements in perpendicular compass directions:

$$A_{crown} = \frac{A_{ellipse1} + A_{ellipse2}}{2} \qquad (26)$$

and:

$$A_{ellipse1} = \pi \times \frac{(\cos(angle_N) * dist_N) + (\cos(angle_S) * dist_S) + \frac{dbh}{100}}{2} \times \frac{(\cos(angle_E) * dist_E) + (\cos(angle_W) * dist_W) + \frac{dbh}{100}}{2} \qquad (27)$$

$$A_{ellipse2} = \pi \times \frac{(\cos(angle_{NE}) * dist_{NE}) + (\cos(angle_{SW}) * dist_{SW}) + \frac{dbh}{100}}{2} \times \frac{(\cos(angle_{NW}) * dist_{NW}) + (\cos(angle_{SE}) * dist_{SE}) + \frac{dbh}{100}}{2} \qquad (28)$$

where:

A_{crown} = area of tree crown; m^2

$A_{ellipse1}$ = area of tree crown calculated using north, south, east and west-facing measurements; m^2

$A_{ellipse2}$ = area of tree crown calculated using northeast, southeast, northwest and southwest-facing measurements; m^2

$angle_N$ = angle formed between observer's eye and end of farthest observable canopy branch facing north; degrees

$angle_S$ = angle formed between observer's eye and end of farthest observable canopy branch facing south; degrees

$angle_E$ = angle formed between observer's eye and end of farthest observable canopy branch facing east; degrees

$angle_W$ = angle formed between observer's eye and end of farthest observable canopy branch facing west; degrees

$angle_{NE}$ = angle formed between observer's eye and end of farthest observable canopy branch facing northeast; degrees

$angle_{SE}$ = angle formed between observer's eye and end of farthest observable canopy branch facing southeast; degrees

$angle_{NW}$ = angle formed between observer's eye and end of farthest observable canopy branch facing northwest; degrees

$angle_{SW}$ = angle formed between observer's eye and end of farthest observable canopy branch facing southwest; degrees

$dist_N$ = distance from observer to end of first canopy branch facing north; meters

$dist_S$ = distance from observer to end of first canopy branch facing south; meters

$dist_E$ = distance from observer to end of first canopy branch facing east; meters

$dist_W$ = distance from observer to end of first canopy branch facing west; meters

$dist_{WE}$ = distance from observer to end of first canopy branch facing northeast; meters

$dist_{SE}$ = distance from observer to end of first canopy branch facing southeast; meters

$dist_{NW}$ = distance from observer to end of first canopy branch facing northwest; meters

$dist_{SW}$ = distance from observer to end of first canopy branch facing southwest; meters

dbh = diameter at breast height of tree; cm

To take measurements, observer stands against the trunk of the tree and moves around the trunk to each compass direction.

Tree height is estimated based on field measurements of angle and distance to top of tree from two vantage points:

$$H_{tree} = \frac{[dist_1 * \tan(angle_1)] + H_{eye} + [dist_2 * \tan(angle_2)] + H_{eye}}{2} \quad \textbf{(29)}$$

where:

H_{tree} = total height of tree; m

$dist_1$ = horizontal distance from observer to trunk of tree from first vantage point; m

$dist_2$ = horizontal distance from observer to trunk of tree from second vantage point; m

$angle_1$ = angle from ground to top of tree measured from first vantage point; degrees

$angle_2$ = angle from ground to top of tree measured from second vantage point; degrees

H_{eye} = height from ground to observer's eye; m

AIM Step 2: Create a relationship between a combination of the height and/or crown area and the biomass of each tree observed. Options include:

$$TB_{B,AG\_tree,tr} = f(H_{tree}) \quad \textbf{(30)}$$

$$TB_{B,AG\_tree,tr} = f(A_{crown}) \quad \textbf{(31)}$$

$$TB_{B,AG\_tree,tr} = f(A_{crown} \cdot H_{tree}) \quad \textbf{(32)}$$

where:

$TB_{B,AG\_tree,tr}$ = above-ground biomass of tree *tr* under the baseline scenario; kg tree^{-1}

H_{tree} = height of tree, m

A_{crown} = area of tree crown, m^2

$f(H_{tree})$ = an allometric equation linking above-ground tree biomass (kg tree^{-1}) to tree height

$f(A_{crown})$ = an allometric equation linking above-ground tree biomass (kg tree^{-1}) to crown area

$f(A_{crown} \cdot H_{tree})$ = an allometric equation linking above-ground tree biomass (kg tree^{-1}) to crown area multiplied by tree height

Using collected data, all equation types may be tested. It has been found that a regression equation based on crown area as the only independent variable works well for trees, otherwise a regression based on both crown area and height may be used if adding height improves the equation. A minimum coefficient of determination (R^2) of 0.70 may be attained, and an independent sample of 5-15 trees may be destructively harvested and used to verify the equation. At least 75% of actual biomass values must fall within the 95% prediction intervals of the predicted biomass values, with no systematic bias.

AIM Step 3: In a standard aircraft, collect high resolution (10-15 cm per pixel) imagery in systematically spaced, overlapping parallel transects evenly distributed over the project boundary where land cover change is expected to occur. Imagery collection components must include a high definition video camera, a real-time differential correction geographic positioning system, a laptop computer, drives capable of storing large amounts of data, and software that enables imagery and GPS information to be associated with each other.

AIM Step 4: Use software such as the ERDAS-IMAGINE Leica Photogrametry Suite to create overlapping high resolution images in each transect and uses the file's accuracy information, level and scale of overlapping images to create a 3-dimensional stereo view. The resulting digital stereo model may be viewed clearly on a computer monitor when the user wears glasses that enable 3-dimensional (3D) viewing.

AIM Step 5: Randomly select high resolution images to analyze and establish a virtual plot on each image selected. The selection of images must follow the same sampling scheme as in the selection of ground plots. Where stratification is needed, the images must be divided into the same strata as ground measurements and random images must be selected from each stratum. As with ground measurements, select a preliminary set of virtual plots for analysis for each stratum and convert to carbon in vegetation by following the steps below. Using the preliminary estimates of the variation, the actual number of virtual plots needed per stratum to sample with a targeted precision value may be calculated using methods outlined in Section. 5.3.1. Plots may then be equally spaced along transects in a systematic manner (e.g., select one stereo-pair of images out of every 10 images collected). The center point of each image selected must be designated as the plot center.

AIM Step 6: For each of the selected plots, create a feature project within Stereo Analyst that contains empty feature classes for plant types (typically broadleaf trees and palm trees for closed canopy tropical forest), and import a shapefile of the virtual plot. Stereo Analyst automatically performs 3D calculations such as the 3D coordinates (X, Y and Z coordinates) of a point, area and perimeter of a polygon. Create polygons around the crowns of each vegetation type. After digitization, the crown area (m^2) for each tree is calculated automatically by the software.

Tree height (m) of each digitized tree on the image is calculated as the difference between the Z coordinate at the top of the tree and the Z coordinate at a point on the ground close to the tree trunk. The software populates the Z coordinate of the top of the tree automatically for each digitized crown polygon, and the interpreter indicates the Z coordinate for a point on the ground. Since the images typically represent closed canopy forest, designating the Z coordinate for a point on the ground close to the base of the tree is not always possible. In cases where the ground is not visible, the Z coordinate of the average of three closest possible ground sites is recorded.

AIM Step 7: Estimate the biomass of each tree in the virtual plot by relating crown areas and/or heights to biomass using Equations 30, 31 or 32 chosen in AIM Step 2. Estimate carbon stock in above-ground biomass using the following equation (taken directly from AR-AM0004):

$$TC_{B,AG\_tree,tr} = TB_{B,AG\_tree,tr} \cdot CF_{tr} \tag{33}$$

where:

$TC_{B,AG\_tree,tr}$ = Carbon stock in above-ground biomass of a tree *tr* under the baseline scenario; kg tree^{-1}

$TB_{B,AG\_tree,tr}$ = Above-ground biomass of tree tr under the baseline scenario; kg tree^{-1}

CF_{tr} = Carbon fraction of biomass for tree species tr ; t C (tonne d.m.)$^{-1}$

AIM Step 8: Calculate the above-ground biomass carbon per plot on a per area basis by summing the biomass carbon per tree within each virtual plot and multiplying by a plot expansion factor which is proportional to the area of the measurement plot. This is divided by 1,000 to convert from kg to t.

$$PC_{B,AG\_tree,it} = \frac{\left(\sum_{tr=1}^{TR} TC_{B,AG\_tree,tr} \cdot XF\right)}{1000} \tag{34}$$

$$XF = \frac{10{,}000}{AP} \tag{35}$$

where:

$PC_{B,AG\_tree,it}$ = Plot level carbon stock in above ground biomass under the baseline scenario in stratum *i*, time *t*; t C ha^{-1}

$TC_{B,AG\_tree,tr}$ = Carbon stock in above-ground biomass per tree *tr* under the baseline scenario; kg C tree^{-1}

XF = Plot expansion factor from per plot values to per hectare values

AP = Plot area; m^2

tr = *1, 2, 3, …, TR* trees (TR = total number of trees in the plot)

AIM Step 9: Calculate mean carbon stock within each stratum by averaging across plots in a stratum or stand:

$$MC_{B,AG\_tree,it} = \frac{\left(\sum_{pl=1}^{PL_{it}} PC_{B,AG\_tree,it}\right)}{PL_{it}} \qquad \textbf{(36)}$$

where:

$MC_{B,AG\_tree,it}$ = Mean carbon stock in above-ground biomass under the baseline scenario in stratum i, time t; t C ha^{-1}.

$PC_{B,AG\_tree,it}$ = Plot level carbon stock in above ground biomass under the baseline scenario in stratum i, time t; t C ha^{-1}

pl = Plot number in stratum i; dimensionless

PL_{it} = Total number of plots in stratum i, time t; dimensionless

8.1.1.3.1.2.2 Biomass Expansion Factor Method

BEF Step 1: Measure the diameter at breast height (DBH, at 1.3 m above-ground) and preferably height of all the trees in the sample plots above a minimum DBH. The minimum DBH varies depending on tree species and climate, for instance, the minimum DBH may be as small as 2.5 cm in arid environments where trees grow slowly, whereas it could be up to 10 cm for humid environments where trees grow rapidly (IPCC GPG-LULUCF).

BEF Step 2: Estimate the volume of the commercial component of trees based on locally derived equations, then sum for all trees within a plot and express as volume per unit area (e.g., m^3/ha). It is also possible to combine step 1 and step 2 if there are field instruments (e.g. relascope) that measure volume of each tree directly.

BEF Step 3: Choose BEF: The BEF varies with local environmental conditions, species and age of trees, the volume of the commercial component of trees. These parameters may be determined by either developing a local regression equation or selecting from national inventoryies, IPCC default values (e.g. Annex 3A.1 Table 3A.1.10 of IPCC GPG LULUCF), or from published sources. If a significant amount of effort is required to develop local BEFs, involving, for instance, harvest of trees, then it is recommended not to use this method but rather to use the resources to develop local allometric equations as described in the allometric method below (refers to Chapter 4.3 in IPCC GPG LULUCF). If that is not possible either, national species specific defaults are for BEF may be used. Since BEF is age dependent, it is desirable to use age-dependent equations. Stem-wood volume may be very small in young stands and BEF may be very large, while for old stands BEF is usually significantly smaller. Therefore using average BEF value may result in significant errors for both young stands and old stands. It is preferable to use allometric equations, if the equations are available, and as a second best solution, to use age-dependent BEFs (but for very young trees, multiplying a small number for stemwood with a large number for the BEF may result in significant error). Below ground root biomass is an excluded pool and so is not estimated. It is assumed root biomass is captured in peat estimates.

BEF Step 4: Converting the volume of the commercial component of trees into carbon stock in above- ground biomass and below-ground biomass via basic wood density, BEF and carbon fraction, given by[11]:

$$MC_{B,AG\_tree,it} = MV_{B,AG\_tree,it} \cdot \phi_i \cdot BEF \cdot CF \quad \textbf{(37)}$$

where:

$MC_{B,AG\_tree,it}$	= mean carbon stock in above-ground biomass under the baseline scenario in stratum *i*, time *t*; t C ha^{-1}.
$MV_{B,AG\_tree,it}$	= Mean merchantable volume under the baseline scenario in stratum *i* at time *t*; m^3 ha^{-1}
ϕ_i	= specific wood density of harvested wood, for stratum *i,*; t d.m. m^{-3}
BEF	= biomass expansion factor for conversion of biomass of merchantable volume to above-ground biomass; dimensionless.
CF	= carbon fraction, t C (tonne d.m.)$^{-1}$

8.1.1.3.1.2.3 Allometric Method

Allo Step 1: Measure the diameter at breast height (DBH, at 1.3 m above ground) and possibly, depending on the form of the equation, height of all the trees in sample plots above a minimum DBH. The minimum DBH varies depending on tree species and climate, for instance, the minimum DBH may be as small as 2.5 cm in arid environments where trees grow slowly, whereas it could be up to 10 cm for humid environments where trees grow rapidly (IPCC GPG-LULUCF).

Allo Step 2: Choose or establish appropriate allometric equations.

$$TB_{B,AG\_tree,tr} = f(DBH, H_{tree}) \quad \textbf{(38)}$$

where:

$TB_{B,AG\_tree,tr}$	= above-ground biomass of a tree *tr* under the baseline scenario; kg tree^{-1}
$f(DBH,H_{tree})$	= an allometric equation linking above-ground tree biomass (kg tree^{-1}) to diameter at breast height (DBH) and possibly tree height (H_{tree}) measured in plots for stratum *i*, time *t*

The allometric equations are preferably local-derived and species-specific. When allometric equations developed from a biome-wide database (e.g. Annex 4A.2, Tables 4.A.1 and 4.A.2 of IPCC GPG LULUCF or an updated version of the document) are used, it is necessary to verify by destructively harvesting, within the project area but outside the sample plots, a few trees of different sizes and estimate their biomass and then compare against a selected equation. If the biomass estimated from the harvested trees is within about ±10% of that predicted by the equation, then it may be assumed that the selected equation is suitable for the project. If this is

[11] IPCC GPG-LULUCF Equation 4.3.1

not the case, it is recommended to develop local allometric equations for the project use. For this, a sample of trees, representing different size classes, is destructively harvested, and its total biomass is determined. The number of trees to be destructively harvested and measured depends on the range of size classes and number of species—the greater the heterogeneity the more trees are required. If resources permit, the carbon content may be determined in the laboratory. Finally, allometric equations are constructed relating the biomass with values from easily measured variables, such as the DBH and total height (see Chapter 4.3 in IPCC GPG LULUCF). Also generic allometric equations may be used, as long as it may be proven that they are wrong on the conservative side, i.e., they underestimate carbon sequestration.

Allo Step 3: Estimate carbon stock in above-ground biomass per tree using selected allometric equations applied to the tree measurements in Step 1.

$$TC_{B,AG\_tree,tr} = TB_{B,AG\_tree,tr} \cdot CF \quad (39)$$

where:

$TC_{B,AG\_tree,tr}$ = Carbon stock in above-ground biomass per tree under the baseline scenario; kg C $tree^{-1}$

$TB_{B,AG\_tree,tr}$ = Above-ground biomass of a tree *tr* under the baseline scenario; kg $tree^{-1}$

CF = Carbon fraction, t C $(tonne\ d.m.)^{-1}$

Allo Step 4: Calculate the above-ground biomass carbon per plot on a per area basis. Calculate by summing the biomass carbon per tree within each plot and multiplying by a plot expansion factor which is proportional to the area of the measurement plot. This is divided by 1,000 to convert from kg to t.

$$PC_{B,AG\_tree,it} = \frac{\left(\sum_{tr=1}^{TR} TC_{B,AG\_tree,tr} \cdot XF\right)}{1000} \quad (40)$$

$$XF = \frac{10,000}{AP} \quad (41)$$

where:

$PC_{B,AG\_tree,it}$ = Plot level carbon stock in above ground biomass under the baseline scenario in stratum i, time t; t C ha^{-1}

$TC_{B,AG\_tree,tr}$ = Carbon stock in above-ground biomass per tree tr under the baseline scenario; kg C $tree^{-1}$

XF = Plot expansion factor from per plot values to per hectare values

AP = Plot area; m^2

tr = 1, 2, 3, …, TR trees (TR = total number of trees in the plot)

Allo Step 5: Calculate mean carbon stock within each stratum. Calculate by averaging across plots in a stratum or stand:

$$MC_{B,AG\_tree,it} = \frac{\left(\sum_{pl=1}^{PL_{it}} PC_{B,AG\_tree,it}\right)}{PL_{it}} \quad (42)$$

where:

$MC_{AG,it}$ = Mean carbon stock in above-ground biomass under the baseline scenario in stratum i, time t; t C ha^{-1}.

$PC_{AG,it}$ = Plot level mean carbon stock in above-ground biomass under the baseline scenario in stratum i, time t; t C ha^{-1}

pl = Plot number in stratum i, time t; dimensionless

PL_{it} = Total number of plots in stratum i, time t; dimensionless

8.1.1.4 Estimation of increase in carbon stocks due to aboveground biomass growth of vegetation ($R_{B,growth,it}$)

In the baseline scenario, a new land use is established after merchantable trees are harvested and the remaining biomass is cleared with fire. To remain conservative, the baseline calculations must account for the removal of CO_2 that occurs due to biomass growth of living trees on the future land use. This biomass growth is estimated as:

$$R_{B,growth,it} = R_{ARB,it} \cdot A_{it}^{planted} \cdot \frac{44}{12} \quad (43)$$

where:

$R_{B,growth,it}$ = total annual increase in carbon stock due to growth of living trees on the future land-use in the baseline scenario for stratum *i* at time *t*; t CO_2-e

$R_{ARB,it}$ = average annual increase in carbon stock due to growth of living trees on the future land use in the baseline scenario for stratum *i* at time *t*; t C ha^{-1} yr^{-1} (Equation 45 or 46)

$A_{it}^{planted}$ = area of biomass growth on future land use in the baseline scenario in stratum *i* at time *t*; ha

$\frac{44}{12}$ = ratio of molecular weights of CO_2 and carbon; dimensionless

$R_{ARB,it}$ is estimated based on field measurements or literature values. The area planted in stratum *i* at time *t* must be estimated based on common practice as derived from field surveys at local companies or set equal to the area cleared per year. If the baseline land use class is represented within the project boundary, mean carbon stocks will be measured as part of the stratification procedure detailed in Section 8.2.1.2.1. However, carbon stocks must be estimated for a range of vegetation ages to estimate the annual increase in carbon stocks on the baseline future land use. For example, carbon stocks must be measured on young, intermediate and old sites at a minimum. To fulfil this requirement, carbon stocks may be measured at proxy sites outside the project boundary provided that site conditions are similar to those within the project area. To be conservative, all pools included in the estimation of current mean carbon stocks in aboveground biomass must also be included in the estimation of baseline future carbon stocks.

When measuring carbon stocks at proxy sites, refer to Section. 8.2.1.2.1 for measurement of trees. Refer to Section 5.3.1 for information regarding the number of plots required when setting up field and virtual plots.

If the future land use is not present within the project boundary and if proxy sites are not available to measure carbon stocks, then conservative estimates of biomass and/or carbon stock for different age classes must be obtained from relevant literature.

Using the collected data, estimate the average increase in carbon stock due to vegetation growth on the future land use ($R_{ARB,it}$) by establishing an appropriate equation that links average aboveground carbon stock ($MC_{FLU,AC,it}$) to stand age using whichever function (linear or non-linear) fits the available data:

Linear function: This is the simplest method to estimate annual increase in carbon stock over time; the average annual increase in carbon stock is estimated as the slope of the regression line when the intercept is forced through the origin:

$$MC_{FLU,AC,it} = slp \cdot age + b \quad \textbf{(44)}$$

and:

$$R_{ARB,it} = slp \quad \textbf{(45)}$$

where:

$MC_{FLU,AC,it}$	= mean carbon stock in above-ground biomass on the future land use under the baseline scenario in stratum i, time t; t C ha^{-1}.
age	= age of stand; years
slp	= slope of regression line of biomass accumulation function; t C ha^{-1} yr^{-1}
b	= intercept of regression line (=zero, when forced through the origin); t C ha^{-1}
$R_{ARB,it}$	= average annual increase in carbon stock due to growth of living trees on the future land use in the baseline scenario for stratum i at time t; t C ha^{-1} yr^{-1}

Non-linear function: A logistic (e.g., Chapman-Richards) function is often a better fit to detailed carbon stock measurements because biomass carbon typically accumulates quickly during early phases of stand establishment and levels off in later phases. If this is the case according to field data or literature values, the average annual increase in carbon stock due to biomass growth of living trees on the future land use may be estimated as:

$$R_{ARB,it} = MC_{FLU,AC,it} - MC_{FLU,AC,it-1} \quad \textbf{(46)}$$

and:

$$MC_{FLU,AC,it} = MaxYld * (1 - \exp(-prm1 \cdot age))^{prm2} \quad \textbf{(47)}$$

$$prm1 = -\frac{ln\left[1-(0.8)^{\frac{1}{prm2}}\right]}{age_{peak}} \quad (48)$$

$$prm2 = \frac{1}{1-prm3} \quad (49)$$

where:

$MC_{FLU,AC,it}$ = mean carbon stock in above-ground biomass on the future land use under the baseline scenario in stratum i, time t; t C ha^{-1}.

$MC_{FLU,AC,it-1}$ = mean carbon stock in above-ground biomass on the future land use under the baseline scenario in stratum i, time t-1; t C ha^{-1}.

$R_{ARB,it}$ = average annual increase in carbon stock due to biomass growth of living trees on the future land use under the baseline scenario for stratum i at time t; t C ha^{-1} yr^{-1}

age = age of stand; years

Max_{Yld} = Maximum peak carbon yield; t C ha^{-1}

prm1 = intermediate calculation using fitted parameter prm2 when estimating biomass accumulation using non-linear function; dimensionless

prm2 = fitted parameter where prm3 varies between 0 and 1 when fitting biomass accumulation values to a non-linear function; dimensionless

age_{peak} = age of stand at peak production; years

8.1.1.5 Estimation of GHG emissions from harvesting aboveground biomass on baseline future land use ($E_{harvest,it}$)

If short-rotation crops are envisaged to be planted as part of the new land use activity, then there would have been harvests taking place in the baseline scenario. Therefore, emissions that result from harvesting operations at the end of each rotation period must be accounted for. It is assumed that any biomass in the tree pool that is not harvested as timber at the end of the rotation period is burned to clear the land for the next rotation cycle.

Emissions from harvesting operations are estimated as:

$$E_{harvest,it} = \left(\frac{44}{12} \cdot \left(C_{BH,it}^{extracted} - C_{BH,it}^{woodproducts}\right)\right) + E_{BH,BiomassBurn,it} \quad (50)$$

where:

$E_{harvest,it}$ = emissions from harvesting operations in stratum i at time t; t CO_2-e

$C_{BH,it}^{extracted}$ = Carbon stocks of timber extracted at harvest H under the baseline scenario in stratum i at time t; t C (Equation 51)

$C_{BH,it}^{woodproducts}$ = carbon stocks from harvest H moving into long term wood products under the baseline scenario for stratum i at time t; t C (Equation 52)

$E_{BH,BiomassBurn,it}$ = total increase in CO_2-e emissions as a result of aboveground biomass burning at harvest H under the baseline scenario in stratum i at time t; t CO_2-e (Equation 55)

$\frac{44}{12}$ = ratio of molecular weights of CO_2 and carbon; dimensionless

and:

$$C_{BH,it}^{extracted} = MC_{FLU,AC,it} \cdot PBH \cdot A_{BH,it}^{cleared} \quad (51)$$

$$C_{BH,it}^{woodproducts} = C_{BH,it}^{extracted} \cdot p \quad (52)$$

where:

$C_{BH,it}^{extracted}$ = Carbon stocks from trees extracted at harvest H under the baseline scenario in stratum i at time t; t C

$C_{BH,it}^{woodproducts}$ = carbon stocks from harvest H moving into long term wood products under the baseline scenario for stratum i at time t; t C

$MC_{FLU,AC,it}$ = mean carbon stock in above-ground biomass on the future land use under the baseline scenario in stratum i, time t; t C ha^{-1} (Equation 47)

PBH = average proportion of aboveground carbon stock removed during harvest H under the baseline scenario for stratum i, time t; dimensionless (Equation 53)

$A_{BH,it}^{cleared}$ = Area cleared at harvest H under the baseline scenario for stratum i, in time t; ha

p = percent of harvest industrial roundwood going into long term wood products; dimensionless

The average proportion of aboveground carbon stock removed during harvest *H* (*PBH*) may be estimated by dividing the carbon removed during harvest operations by mean biomass carbon stocks in the year of harvest:

$$PBH = \frac{MC_{BH,timber,it}}{MC_{FLU,AC,it}} \quad (53)$$

where:

$MC_{BH,timber,it}$ = mean carbon stock removed during harvest H under the baseline scenario for stratum i, time t; t C ha^{-1} (Equation 54)

$MC_{FLU,AC,it}$ = mean carbon stock in above-ground biomass on the future land use under the baseline scenario in stratum i, time t; t C ha^{-1} (Equation 47)

The carbon removed during harvest H ($MC_{BH,timber,it}$) may be estimated from volume data (these data are typically collected by timber management companies) as follows:

$$MC_{BH,timber,it} = MV_{BH,timber,it} \cdot \phi_i \cdot CF \quad (54)$$

where:

$MC_{BH,timber,it}$ = mean carbon stock in timber removed during harvest H under the baseline scenario for stratum i, time t; t C ha^{-1}

$MV_{BH,timber,it}$ = Mean merchantable volume under the baseline scenario in stratum i at time t; m^3 ha^{-1}

φ_i = specific wood density of harvested wood, for stratum i,; t d.m. m^{-3}

CF = carbon fraction, tC (tonne d.m.)$^{-1}$

Emissions from aboveground biomass burning during harvesting operations ($E_{BH,BiomassBurn,it}$) are estimated based on revised IPCC 1996 Guidelines for LULUCF :

$$E_{BH,BiomassBurn,it} = E_{BH,Biomassburn,CO2,it} + E_{BH,BiomassBurn,N2O,it} + E_{BH,BiomassBurn,CH4,it} \quad \textbf{(55)}$$

where:

$E_{BH,BiomassBurn,it}$ = total increase in CO_2-e emissions as a result of aboveground biomass burning at harvest H under the baseline scenario in stratum i at time t; t CO_2-e.

$E_{BH,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning at harvest H under the baseline scenario in stratum i at time t; t CO_2-e (Equation 56).

$E_{BH,BiomassBurn,N2O,it}$ = N_2O emission from biomass burning at harvest H under the baseline scenario in stratum i at time t; t CO_2-e (Equation 57).

$E_{BH,BiomassBurn,CH4,it}$ = CH_4 emission from biomass burning at harvest H under the baseline scenario in stratum i at time t; t CO_2-e (Equation 58).

$$E_{BH,BiomassBurn,CO2,it} = \left(MC_{FLU,AC,it} \cdot (1 - PBH) \cdot A_{BH,it}^{cleared} \cdot PBB_{BH,it} \cdot CE\right) \cdot \frac{44}{12} \quad \textbf{(56)}$$

where:

$E_{BH,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning at harvest H under the baseline scenario in stratum i at time t; t CO_2-e.

$MC_{FLU,AC,it}$ = mean carbon stock in above-ground biomass on the future land use under the baseline scenario in stratum i, time t; t C ha^{-1} (Equation 47)

PBH = average proportion of aboveground carbon stock removed during harvest H under the baseline scenario for stratum i, time t; (Equation 53)

$A_{BH,it}^{cleared}$ = Area cleared at harvest H under the baseline scenario for stratum i, in time t; ha

$PBB_{BH,it}$ = average proportion of remaining aboveground carbon stocks burnt at harvest H under the baseline scenario in stratum i, time t; dimensionless

CE = average biomass combustion efficiency; dimensionless

$\frac{44}{12}$ = ratio of molecular weights of CO_2 and carbon; dimensionless

All of the tree biomass that is not extracted at harvest is assumed to be burned and therefore for this methodology the proportion of remaining aboveground carbon stocks (1-PBH) burned at harvest H in the baseline ($PBB_{BH,it}$) is assumed to be equal to 1.

The combustion efficiencies CE may be chosen from the most up to date version of IPCC documentation (e.g. Table 2.6 of the *IPCC AFOLU Guidelines*) or applicable literature. If no appropriate combustion efficiency may be identified, the most recent IPCC default value must be used.

Emissions of non-CO_2 gases are given by:[12]

$$E_{BH,BiomassBurn,N2O,it} = E_{BH,Biomassburn,CO2,it} \cdot \frac{12}{44} \cdot (N/Cratio) \cdot ER_{N_2O} \cdot \frac{44}{28} \cdot GWP_{N_2O} \quad \textbf{(57)}$$

$$E_{BH,BiomassBurn,CH4,it} = E_{BH,Biomassburn,CO2,it} \cdot \frac{12}{44} \cdot ER_{CH_4} \cdot \frac{16}{12} \cdot GWP_{CH_4} \quad \textbf{(58)}$$

where:

$E_{BH,Biomassburn,CO2,it}$ = CO_2 emission from aboveground biomass burning at harvest *H* under the baseline scenario in stratum *i*, time *t*; t CO_2-e.

$E_{BH,BiomassBurn,N2O,it}$ = N_2O emission from aboveground biomass burning at harvest *H* under the baseline scenario in stratum *i*, time *t*; t CO_2-e

$E_{BH,BiomassBurn,CH4,it}$ = CH_4 emission from aboveground biomass burning at harvest *H* under the baseline scenario in stratum *i*, time *t*; t CO_2-e

N/Cratio = nitrogen-carbon ratio; dimensionless

ER_{N_2O} = emission ratio for N_2O; t CO_2-e./t C

ER_{CH_4} = emission ratio for CH_4 ; t CO_2-e./t C

GWP_{N_2O} = Global Warming Potential for N_2O; t CO_2-e./t N_2O

GWP_{CH_4} = Global Warming Potential for CH_4; t CO_2-e./t CH_4

8.1.2 Estimation of GHG emissions from peat ($E_{B,p,jt}$)

In addition to aboveground changes in carbon stocks, baseline emissions in stratum *j* in the project year *t* as calculated with Equation 5 above also include increases in GHG emissions from peat. Baseline GHG emissions from peat impacted by land use conversion may be estimated as:

$$E_{B,p,t} = E_{B,drainage,t} + E_{B,PeatBurn,t} + E_{B,DOC,t} \quad \textbf{(59)}$$

where:

$E_{B,p,t}$ = total baseline GHG emissions from drained peat under the baseline scenario at time t; t CO_2-e

$E_{B,drainage,t}$ = GHG emissions from drainage activities on peatlands on-site under the baseline scenario at time t; t CO_2-e (Equation 60)

$E_{B,PeatBurn,t}$ = GHG emissions from peat burning under the baseline scenario at time t; t CO_2-e (Equation 64)

$E_{B,\ DOC,\ t}$ = GHG emissions from dissolved organic carbon exported from drained organic soils under the baseline scenario at time t; t CO_2-e (Equation 68)

[12] Refers to Table 5.7 in 2019 Revised IPCC Guideline for LULUCF and Equation 3.2.19 in IPCC GPG-LULUCF

t = 1, 2, 3, …t* years elapsed since the start of the project activity

8.1.2.1 Estimation of $E_{B,Drainage,t}$ (GHG emissions from drained peatlands)

Emissions calculations in this section use the PDT stratification (*j*) completed in Step 4 of Section 5.3.2.

This methodology separately calculates GHG emissions for CO_2, CH_4, and NO_2 on drained peatlands in order to take into consideration the different factors that impact these emissions. Total on-site GHG emissions on drained peatlands are estimated as:

$$E_{B,drainage,t} = E_{B,drainage,CO_2,t} + E_{B,drainage,CH_4,t} + E_{B,drainage,N_2O,t} \quad \textbf{(60)}$$

where:

$E_{B,drainage,t}$ = GHG emissions from drainage activities on peatlands on-site under the baseline scenario at time *t*; t CO_2-e

$E_{B,drainage,CO_2,t}$ = annual baseline CO_2 emissions from drained peat under the baseline scenario at time *t*; t CO_2-e (Equation 61)

$E_{B,drainage,CH_4,t}$ = annual baseline CH_4 emissions from drained peat under the baseline scenario at time *t*; t CO_2-e (Equation 62)

$E_{B,drainage,N_2O,t}$ = annual baseline N_2O emissions from drained peat under the baseline scenario at time *t*; t CO_2-e (Equation 63)

As these peat drainage calculations use the PDT stratification (j) completed in Section 5.3.2, Equation 60 and the sub-equations below do not require any additional consideration of PDT.

8.1.2.1.1 Estimation of GHG drainage emissions from CO_2 ($E_{B,drainage,CO_2,t}$)

Emissions of CO_2 are the primary source of greenhouse gases in drained peatlands. As peatlands are drained, soil is exposed in drainage ditches, allowing for peat oxidation and conversion of soil carbon to CO_2 gas. Alongside oxidation, drained peatlands are subject to peat subsidence. As peat is compacted, drained, oxidized, and eroded, the soil peat layer shrinks, causing the release of carbon in the atmosphere and decreasing potential for carbon sequestration. This methodology uses an emissions factor equation to depict the relationship of peat drainage and carbon loss. While much information related to peat CO_2 emissions is still broad, projects should justify emissions factors from localized studies that may accurately portray local conditions and carbon release. For further information about the relationships between peat drainage and carbon loss, see section 5.3.2.

Peat drainage CO_2 emissions resulting from land clearing activities for a baseline land-use activity are estimated for all strata in which PDT exceeds project year *t* (i.e. when *t* exceeds the value for stratum *j*). As no emissions may occur from strata in which the project year exceeds

PDT for a specific stratum, $EF_{\mathrm{B,drainage},t}$.=0 tCO_2 ha^{-1} for all strata in which *t* exceeds PDT. Baseline CO_2 emissions from drained peat are estimated as[13]:

$$E_{B,drainage,CO_2,t} = \sum_{j=0}^{j^*} (A_{B,drain,j} \cdot EF_{\mathrm{B,drainage},jt,CO_2}) \quad \textbf{(61)}$$

where:

$E_{B,drainage,CO_2,t}$ = annual CO_2 emissions from drained organic soils in project year t; tCO_2e

$A_{B,drain,j}$ = land area of drained organic soils under the baseline scenario in stratum j; ha

$EF_{B,drainage,jt,CO_2}$ = emissions factor for drained organic soils in stratum j, time t; t CO_2 ha^{-1}

j = 0, 1, 2, 3, …j* baseline PDT stratum

As recent literature has demonstrated that peat oxidation over time is not linear, but begins rapidly and decreases over time (Hooijer, et al., 2012), project proponents may choose to apply a time component to an EF. However, if a variable rate for $EF_{B,drainage,jt,CO_2}$ is used, it will be necessary to demonstrate that a variable subsidence rate ($S_{y,l}$) was used for the calculations of PDT as described in Section 5.3.2. Emissions from peat exposed to aerobic decomposition through piling, dredging, or channelization may be included in the parameter $EF_{B,drainage,jt,CO_2}$ by selecting an appropriate value from literature. However, these emissions may be conservatively omitted as they will be greater in the baseline scenario.

If a project is not able to justify localized emissions factors from literature or monitoring data, default values may be selected from the most recently updated and relevant IPCC documentation (e.g. Table 2.1 of the *2013 IPCC Wetlands Supplement*).

8.1.2.1.2 Estimation of GHG drainage emissions from CH_4 ($E_{B,drainage,CH_4,t}$)

Annual CH_4 emissions occur from drained land surfaces and drainage ditch networks constructed during the drainage of peat soils. These CH_4 emissions occur as methane is transferred through the soil matrix, and as methane is produced in ditches due to the creation of anoxic conditions, where methanogenic bacteria thrive. Methane emissions due to peat drainage resulting from land clearing activities for a baseline land-use activity are estimated as[14]:

$$E_{B,drainage,CH_4,t} = \sum_{j=0}^{j^*} (A_{B,drain,j} \cdot ((1 - Frac_{ditch}) * EF_{CH_4,land,jt} + Frac_{ditch} * EF_{CH_4,ditch,jt})) * \mathrm{GWP}_{CH_4} \quad \textbf{(62)}$$

Where:

$E_{B,drainage,CH_4,t}$ = annual baseline CH_4 emissions from drained peat under the baseline scenario at time t; t CO_2-e

[13] Adapted from Equation 2.3 of the *2013 IPCC Wetlands Supplement*

[14] Adapted from Equation 2.6 of the *2013 IPCC Wetlands Supplement*

$A_{B,drain,j}$ = entire land area of drained organic soils under the baseline scenario in stratum j; ha

$EF_{CH4,land,jt}$ = emission factors for direct CH_4 emissions from drained organic soils in stratum j, project year t; t CH_4 ha^{1} yr^{-1}

$EF_{CH4,ditch,jt}$ = emission factors for CH_4 emissions from drainage ditches in stratum j, project year t; t CH_4 $ha^{-1}yr^{-1}$

$Frac_{ditch}$ = fraction of the total area of drained organic soil which is occupied by ditches; unitless

GWP_{CH_4} = GWP for CH_4. Must be updated based on latest guidance from IPCC.

No emissions occur from strata in which the project year exceeds PDT of a stratum. Since data on methane emissions from drainage ditches is limited, this methodology provides a tier 1 approach using the most recently updated default values provided by the IPCC (e.g IPCC Wetlands Supplement (2013)). However, project proponents must update this value based on available literature at the time of baseline reevaluation. In the case that no local emissions factor data exists for CH_4 on land or in drainage ditches, projects may use the latest default values provided by the IPCC (e.g Table 2.4 of the 2013 IPCC Wetlands Supplement).

While project proponents may use default values for $Frac_{ditch}$, they should look to update this value using remote sensing imagery within a proxy area. The ditch area may be calculated as the width of ditches multiplied by their total length. Where ditches are cut vertically, ditch width may be calculated as the average distance from bank to bank. Where ditch banks are sloping, ditch width must be calculated as the average width of open water plus any saturated fringing vegetation. Satellite imagery or other aerial imagery of sufficient resolution may be used to calculate ditch fraction, calculating average width of open water plus any saturated fringing vegetation as a fraction of total project land.

8.1.2.1.3 Estimation of GHG drainage emissions from N_2O ($E_{B,drainage,N_2O,t}$)

In addition to including GHG drainage emissions from CH_4, the 2013 IPCC Wetlands Supplement likewise added GHG drainage emissions from N_2O, which have been found to emit significant amounts of N_2O (Kasimir-Klemedtsson, et al., 1997; Flessa, Wild, Klemisch, & Pfadenhauer, 1998; Couwenberg, et al., 2011). Nitrous oxide emissions from drained peat are the result of microbial nitrification and denitrification as the organic matter from drained soils decomposes and mineralizes (IPCC, 2014). In addition, fertilizer run off and residues from organic soil amendments that are often used in the farming of oil palm contribute to nitrogen emissions in peat drainage.

Nitrous oxide emissions from peat drainage resulting from land clearing activities for a baseline land-use activity are estimated as:

$$E_{B,drainage,N_2O,t} = \sum_{j=0}^{j^*}(A_{B,drain,j} \times EF_{N_2O,jt}) * GWP_{N_2O} \quad (63)$$

where:

$E_{B,drainage,N_2O,t}$ = annual baseline N_2O emissions from drained peat under the baseline scenario at time t; tCO_2e

$A_{B,drain,j}$ = entire land area of drained organic soils under the baseline scenario in stratum j; ha

$EF_{N_2O,jt}$ = emissions factor for annual N_2O emissions per hectare within drained peat in stratum j and project year t; t N_2O $ha^{-1}yr^{-1}$

GWP_{N_2O} = GWP for N_2O at time t. To be updated based on latest guidance from IPCC.

In the case that no local emissions factor data exists for nitrogen, projects must select a default value from the latest applicable IPCC report or conservatively exclude this emissions source. If project year t exceeds the PDT for stratum j, $EF_{N_2O,jt}$ must be equal to 0 t N_2O $ha^{-1}yr^{-1}$.

8.1.2.1.4 Area of peat drainage ($\sum_{j=t}^{j^*} A_{B,\ drain,\ j}$)

It is assumed that the area of peat drained in the baseline scenario will be equal to sum of all areas with a PDT strata (j) value greater than the project year t. Once drained, emissions continue in subsequent years until *PDT* is reached, such that drainage emissions are cumulative as new areas are cleared over time. Once PDT is reached within a stratum, it is conservatively estimated that peat drainage emissions in that stratum ceases. Areas outside the project boundary may be impacted by drainage activities inside the project boundary in the baseline case, but these areas are conservatively ignored.

8.1.2.2 Estimation of GHG Emissions from peat burning ($E_{B,PeatBurn,t}$)

After peat drainage occurs, the upper layer of peat is assumed to be intentionally burned along with aboveground biomass when the land is cleared with fire to prepare the site for the new land use. GHG emissions from peat burning as a result of land clearing are estimated by the following:

$$E_{B,PeatBurn,t} = E_{B,PeatBurn,CO2,t} + E_{B,PeatBurn,CH4,t} \quad (64)$$

$$E_{B,PeatBurn,CO2,t} = \frac{M_{B,p,t} * EF_{CO_2}}{10^6} \quad (65)$$

$$E_{B,PeatBurn,CH4,t} = \frac{M_{B,p,t} * EF_{CH_4}}{10^6} * GWP_{CH_4} \quad (66)$$

$$M_{B,p,t} = \sum_{b,t}^{b^*,t} (D_{B,burn,bt} * A_{B,burn,bt,D}) * 10000 * BD_b \qquad (67)$$

where:

$E_{B,PeatBurn,CO2,t}$ = GHG emissions from peat burning under the baseline scenario at time *t*; t CO_2-e

$E_{B,PeatBurn,CO2,t}$ = total CO_2 emissions from peat burning under the baseline scenario at time *t*; t CO_2e

$E_{B,PeatBurn,CH4,t}$ = total CH_4 emissions from peat burning under the baseline scenario at time *t*; t CO_2e

$M_{B,p,t}$ = mass of peat burned under the baseline scenario at time *t*; tons

EF_{CO_2} = CO_2 emissions factor for the combustion of peat; g CO_2 (t peat)$^{-1}$

EF_{CH_4} = CH_4 emissions factor for the combustion of peat, g CH_4 (t peat)$^{-1}$

$D_{B,burn,bt}$ = depth of peat burned (D) under the baseline scenario in stratum *b* at time *t*; meters

$A_{B,burn,bt,D}$ = area of peat burned at depth D under the baseline scenario in stratum *b* at time *t*; ha

BD_b = bulk density of peat in stratum *b* (g cm^{-3} = t m^{-3})

10000 = scaling factor from ha to square meters; dimensionless

8.1.2.2.1 Estimation of mass of peat burned under the baseline scenario ($M_{B,p,t}$)

Areas outside the plantation boundary may have burned in the baseline case, but these areas are conservatively ignored. As the peat burn stratification described in Step 2 of Section 5.3.2 already estimates the area burned at each possible depth, no additional stratification is necessary to calculate the area burned at time t. The appropriate peat burn depth must be applied to the appropriate area at time t. For example, if in year 1 of the baseline scenario 1,000 hectares would be burned to the default max of 34 cm and 10 cm of peat on an additional 1,000 hectares would be burned, the total mass burned would be estimated by summing the mass in 1,000 hectares of peat at a depth of 34 cm and the mass in 1,000 hectares of peat at a depth of 10 cm. If the approach recommended in Section 5.3.2 is used, the last two digits may be used to easily identify the peat burn depth while the digits prior to that will represent the year *t* that the peat was burned.

8.1.2.2.2 Estimation of peat bulk density (BD_b)

Measurements of peat bulk density must be taken across each stratum within the project boundary. Determining the locations and distribution of samples must be determined prior to field work and may be combined with the sampling strategy outlined in Section 5.3.2 above for constructing a peat depth map.

Peat bulk density may be measured using either specialized peat samplers or standard soil bulk density cylinders. All vegetation and litter must be removed before sampling occurs. The soil corer/probe is inserted steadily to a standard depth (e.g., 30 cm). If the probe will not penetrate to the full depth, it is likely that woody material is blocking its route and therefore the core must be inserted in a new location. If the depth of peat at the sampling point is less than the standard depth measured, then the depth of the peat sampled must be recorded. Sampling to 30-50 cm depth is appropriate because it is the top layer of peat that would be disturbed under the baseline scenario. The volume of the corer must be calculated based on the dimensions of the corer. Peat must be extracted from the probe and placed into a cloth bag with a unique identification number. To reduce variability, sampling is repeated for a total of five locations per sampling point. Dry bulk density samples in an oven at 105 ºC for a minimum of 48 hours then weigh. Peat bulk density must be measured and calculated separately for each stratum. One value may be used if mean values do not differ significantly across strata.

If peat bulk density measurements are made *ex post* rather than *ex ante*, literature values may be used to estimate peat bulk density values *ex ante*. Couwenberg et al. (2009) summarized bulk density values measured in tropical peatlands and reported a mean value of 0.14 g cm^{-3} (Table 3). Another review of bulk density values for surface peat (i.e., the top ≤ 34 cm that is burned in the baseline scenario) yields a similar value of 0.14 g cm^{-3} as the lower bound of the range (Table 4). Therefore, this value of 0.14 may be used in *ex ante* baseline calculations but must be replaced with *ex post* measurements taken from within the project area once these data become available.

Table 3: Bulk density values for tropical peat. From Couwenberg et al. (2009)

Reference	Bulk Density (g cm^{-3})
Page et al. 2002	0.100
Limin, et al. (2004)	0.160 (0.100-0.220)
Sahario & Munoz, 2005	0.155 (0.060-0.220)
Mean	**0.144**

Table 4: Bulk density values for tropical peat (surface values) in Indonesia

Study	Location	Low	High	Midpoint
Andriesse, 1974	Sarawak	0.09	0.12	0.11
Driessen & Rochimah, 1976	Durian-Rasau, West Kalimantan	0.08	0.23	0.16
Driessen & Rochimah, 1976	Sebangau, Central Kalimantan	0.11	0.14	0.13
Brady, 1997	Sarawak	0.10	0.19	0.15
Kurnain, Notohadikusumo, Radjagukguk, & Hastuti, 2002	Central Kalimantan	0.15	0.17	0.16
Sajarwan, Notohadiprawiro, Radjagukguk, & Hastuti, 2002	Central Kalimantan, 0-50 cm	0.20	0.24	0.22

Drajad et al. 2003	South Kalimantan, 0-25 cm	0.39	0.62	0.51
Jaya, 2005	Central Kalimantan, surface	0.10	0.12	0.11
Shimamura & Momose, 2005	Sumatra	0.01	0.12	0.07
Melling, Hatano, & Goh, 2005	Sarawak, surface drained	0.15	0.15	0.15
Sumawinata, Mulyanto, Djajakirana, & Pulunggono, 2007	Central Kalimantan, surface	0.17	0.17	0.17
Average		**0.14**	**0.21**	**0.17**

8.1.2.2.3 Estimation of CO_2 and CH_4 emission factors (EF_{CO2}, EF_{CH4})

Muraleedharan, Radojevic, Waugh, & Caruana (2000) measured direct emissions from the combustion of tropical peat at two temperatures (smouldering stage: 480 ºC and flaming stage: 600 ºC). The most abundant C-containing combustion product was CO_2, followed by CO and CH_4. Emission factors for CO_2 and CH_4 are summarized in Table 5. The emission factors for peat combustion at the lower temperature must be assumed in the *ex ante* baseline estimates, as this results in lower overall GHG emissions (CO_2 + CH_4 reported as CO_2 equivalents) and thus a conservative baseline scenario.

Table 5: Greenhouse gas emissions from the combustion of peat. From Muraleedharan et al. (2000).

Component	Temperature (°C)	
	480	600
	g (ton peat)$^{-1}$	
CO_2	185,000	149,591
CH_4	5,785	11,338

8.1.2.3 Estimation of GHG emissions from exported dissolved organic carbon ($E_{B,DOC,t}$)

Projects must account for baseline emissions from dissolved organic carbon (DOC) for any post-conversion land use in the baseline scenario that requires drainage ditches, such as oil palm plantations. Dissolved organic carbon has been identified by the IPCC (2014) as the largest source of carbon loss in waterborne carbon. Waterborne carbon consists of DOC, particulate organic carbon (POC), and dissolved gasses. Waterborne carbon export represents a major part of carbon emissions from drained organic soils. In this methodology, DOC is considered the main source of waterborne carbon in drained peat soils, while POC and dissolved gases are typically low and conservatively excluded (IPCC, 2014). All exported and waterborne carbon not accounted for as being converted to CO_2 is conservatively assumed to be buried and is not included as an emissions source in the baseline scenario.

DOC is reactive carbon from peat soil. Soil is eroded and lost in drainage ditches and canals. Instead of simply being transferred from one location to another, it is instead converted to CO_2 as it reacts in aquatic ecosystems (IPCC, 2014). As there is limited data on whether or not these DOC emissions continue after an area has reached its PDT, it is conservatively assumed that they do not. Thus, once the project year exceeds the PDT of a stratum, no further DOC emissions may be included in baseline accounting.

The applied emissions factor, $EF_{B,DOC,jt}$, must account for both the proportional increase in DOC flux of a drained site compared to an undrained site as well as the proportion of DOC converted to CO_2 following site export.

These GHG emissions from exported DOC for a baseline land-use activity in which drainage ditches are present are estimated as[15]:

$$E_{B,DOC,t} = \sum_{j=0}^{j^*} (A_{B,drain,j} \cdot EF_{B,DOC,jt}) \tag{68}$$

The parameter $EF_{B,DOC,jt}$ is calculated as[16]:

$$EF_{B,DOC,jt} = DOC_{FLUX_{NATURAL},jt} * (1 + \Delta DOC_{drain}) * Frac_{DOC\_CO2} \tag{69}$$

where:

$E_{B,DOC,t}$	= annual off-site CO_2 emissions due to dissolved organic carbon loss from drained peat soil under the baseline scenario at project year t, CO_2-e
$A_{B, drain, j}$	=land area of drained organic soils under the baseline scenario in stratum j; ha
$EF_{B,DOC,jt}$	= emissions factor for annual CO_2 emissions due to DOC loss from drained peat soils in stratum j and project year t; t CO_2e ha^{-1}
$DOC_{FLUX_{NATURAL},jt}$	= flux of DOC from natural/undrained organic soil in stratum j at baseline year t; tCO_2e $ha^{-1}yr^{-1}$
ΔDOC_{drain}	= proportional increase in DOC flux from drained sites relative to undrained sites; unitless

[15] Adapted from Equation 2.4 of the *2013 IPCC Wetlands Supplement*

[16] Adapted from Equation 2.5 of the *2013 IPCC Wetlands Supplement*

$Frac_{DOC\_CO2}$ = conversion factor for proportion of DOC converted to CO_2 following export from site; unitless

If available, project developers may calculate an appropriate emissions factor from country-level data. In the absence of available data, appropriate default values must be selected from updated IPCC documentation.

8.1.3 Calculation of *Ex Post* Net Baseline GHG Emissions

Baseline carbon stock changes do not need to be monitored after the project is established, because the accepted baseline approach assumes continuation of existing changes in carbon pools within the project boundary from the time of project validation. However, technical progress and an increase in data availability may occur, requiring altered baseline estimates for the next 10-year period at baseline reassessment.

8.2 Project Emissions

Monitoring land use change within the project boundary must occur to ensure that any GHG benefits achieved by project activities during the crediting period are real, permanent and secure. Therefore, any decreases in carbon stocks or increases in peat emissions that occur inside the project boundary after the start of the project must be accounted for, including the GHG emissions from any land cover change that may occur within the project area over the crediting period. For example, emissions from fires and degradation may continue to occur. These emissions must also be accounted for over the crediting period, along with any unanticipated land use change.

Within the project boundary, three sources of emissions will lead to significant reductions in project carbon stocks: (1) GHG emissions due to selective logging (degradation); (2) GHG emissions due to fire; and (3) GHG emissions due to deforestation (including biomass and peat drainage):

$$C_{PRJ,t} = E_{P,t}^{logging} + E_{P,t}^{fire} + E_{P,t}^{LCC} + E_{P,drainage,t} \quad \textbf{(70)}$$

where:

$C_{PRJ,t}$ = sum of emissions that occur within the project boundary as a result of emissions that were unanticipated and/or unable to be avoided by project activities in monitoring year t; t CO_2-e.

$E_{P,t}^{logging}$ = GHG emissions due to logging in monitoring year t; t CO_2-e (Equation 71)

$E_{P,t}^{fire}$ = GHG emissions due to fire in monitoring year t; t CO_2-e (Equation 87)

$E_{P,t}^{LCC}$ = GHG emissions due to land use/cover change in monitoring year t; t CO_2-e (Equation 98)

$E_{P,drainage,t}$ = GHG emissions from peat drainage from deforestation or logging in monitoring year t;

tCO_2e (Equation 100)

8.2.1 Estimation of GHG emissions from biomass due to logging ($E_{P,t}^{logging}$)

The carbon impact of logging is calculated as the difference in carbon stocks between a forest that has been harvested and one that has not. GHG emissions that occur due to logging are a result of changes in live and dead biomass caused by the extraction of timber and damage to residual trees from the logging activities.

The monitoring methodology was designed to enable project participants to estimate an average emission factor per logging gap prior to the start of the project if desired; thus the only monitoring that is necessary over the crediting period is to detect the number of logging gaps and area of new peat drainage present within the project boundary in a given year *t*. Methods for estimating the carbon impacts of logging activities have been documented previously in literature (e.g. Pearson, Walker, Grimland, & Brown, 2006 and Brown, Pearson, Moore, & Parveen, 2006).

The logging emission factor is estimated to link a readily monitored component (number of logging gaps detected in the monitoring year) with the total aboveground carbon impact. An initial set of ground measurements in logging gaps may be completed at the beginning of the project or over the life of the project. The size of each gap (*g*), the dimensions of the felled tree and commercial log and trees that are severely damaged or killed as a result of the treefall are measured. Steps are outlined below to translate field measurements of logging impacts into an average emission factor per stratum. The area of new canal construction is also monitored to estimate emissions from peat drainage over the monitoring interval.

The GHG emissions attributable to logging within the project boundary within the monitoring year are therefore estimated as:

$$E_{P,t}^{logging} = \sum_{i=1}^{M_{PS}} (N_{P,it}^{gaps} \cdot EF_{logging,i}) \quad \textbf{(71)}$$

where:

$E_{P,t}^{logging}$ = GHG emissions due to logging in the project area; t CO_2-e

$N_{P,it}^{gaps}$ = number of logging gaps detected within stratum i in monitoring year t within the project area; dimensionless

$EF_{logging,i}$ = average logging emission factor for stratum i; t CO_2-e (logging gap)$^{-1}$

i = 1, 2, 3, …m_{PS} project scenario land use/landcover strata

8.2.1.1 Estimation of logging emissions factor ($EF_{logging,i}$)

An average emission factor ($EF_{logging,i}$) for each stratum may be derived prior to the start of project activities or before the first monitoring event by collecting field measurements in recent logging gaps in the project region. Emission factors for different strata may be similar enough to allow their merging so that one general emission factor value is used. The emission factor for selective logging detected in each stratum *i* may be estimated as:

$$EF_{logging,i} = \frac{\sum_{g=1}^{G} C_{P,ig}^{extracted} + C_{P,ig}^{damaged}}{G} * \frac{44}{12} \quad \textbf{(72)}$$

where:

$EF_{logging,i}$ = logging emission factor in stratum i; t CO_2-e (logging gap)$^{-1}$

$C_{P,ig}^{extracted}$ = average carbon extracted as timber per logging gap g in stratum i; t C

$C_{P,ig}^{damaged}$ = average carbon damaged as a result of logging per logging gap g in stratum i; t C (gap)$^{-1}$

g = 1, 2, 3, …, G logging gaps; dimensionless

To be conservative, all emissions from biomass damaged during timber extraction $C_{P,ig}^{damaged}$ is assumed to be emitted immediately along with $C_{P,ig}^{extracted}$. Carbon storage in wood products is conservatively ignored.

To apply Equation 72 above, field measurements must be collected to estimate average values of carbon extracted ($C_{P,ig}^{extracted}$) and carbon damaged ($C_{P,ig}^{damaged}$) per logging gap *g*. The number of gaps to be measured will depend on the number of gaps available for measurement, accuracy and costs. The number of gaps measured and a summary of logging gap field measurements must be presented in the PD.

Steps to estimate the average values of carbon extracted and damaged per logging gap are outlined below.

Step 1. Measure dimensions of the timber tree(s) within each logging gap *g* and estimate average carbon extracted per logging gap ($C_{P,ig}^{extracted}$)

Step 1a. On each timber tree *tr* in each measured logging gap g in each stratum i, the following measurements must be recorded:

1. the diameter at the stump end of each commercial log ($D_{bottom,tr,ig}$)
2. the diameter at the crown end of each commercial log ($D_{top,tr,ig}$)
3. the distance between the stump and crown (length of timber log extracted) ($L_{log,tr,ig}$)
4. the height of the stump ($H_{s,tr,ig}$)
5. the diameter of the stump ($D_{s,tr,ig}$)
6. the length, top diameter and bottom diameter of any pieces of bole from the timber tree left behind on the forest floor ($L_{piece,tr,ig}$, $D_{piece\text{-}b,tr,ig}$, $D_{piece\text{-}t,tr,ig}$). $L_{log,tr,ig}$ must be adjusted by subtracting the length of any pieces of bole left on site from the initial distance measured between the stump and crown.

Step 1b. Estimate the volume of each extracted log by multiplying log length by the average of the cross- sectional areas at the foot and crown ends of each log:

$$V_{log,tr,ig} = \frac{1}{3} \cdot L_{log,tr,ig} \cdot \pi \cdot \left[\left(\frac{D_{bottom,tr,ig}}{200} \right)^2 + \left(\frac{D_{top,tr,ig}}{200} \right)^2 + \left(\frac{D_{bottom,tr,ig}}{200} \cdot \frac{D_{top,tr,ig}}{200} \right) \right] \quad (73)$$

where:

$V_{log,tr,ig}$ = volume of log extracted from timber tree tr in stratum i, gap g; m^3

$L_{log,tr,ig}$ = length of log extracted from timber tree tr in stratum i, gap g, measured as the distance from stump to base of crown, less the length of any pieces of bole left on site; m

$D_{bottom,tr,ig}$ = diameter at the stump end of log extracted from timber tree tr in stratum i, gap g; cm

$D_{top,tr,ig}$ = diameter at the crown end of log extracted from timber tree tr in stratum i, gap g; cm

Step 1c. Estimate the biomass carbon of each commercial log by multiplying the estimated volume by the wood density and carbon fraction:

$$C_{log,tr,ig} = V_{log,tr,ig} \cdot \phi_i \cdot CF \quad (74)$$

where:

$C_{log,tr,ig}$ = biomass carbon of log extracted in stratum i, gap k; t C

$V_{log,tr,ig}$ = volume of log extracted from timber tree tr in stratum i, gap g; m^3

φ_i = wood density[17] of extracted log in stratum i, t m^{-3}

CF = carbon fraction of extracted log

Step 1d. Estimate the total biomass carbon and volume of all commercial logs in gap *g*:

$$C_{ig}^{extracted} = \sum_{tr=1}^{TR} C_{log,tr,ig} \quad (75)$$

where:

$C_{log,tr,ig}$ = biomass carbon in extracted log of tree tr in stratum i, gap g; t C

$C_{ig}^{extracted}$ = biomass carbon extracted from all trees in stratum i, in gap g; t C

tr = 1, 2, 3, …, TR timber trees in gap g; dimensionless

Step 2. Estimate carbon damage to vegetation as a result of logging ($C_{ig}^{damaged}$)

The total carbon damage caused by logging in each gap *g* is estimated as the sum of the biomass carbon in the crown, stump, any remaining pieces of bole left behind from the felled trees, and the biomass of snapped and uprooted trees:

[17] A species-specific density is used when the species is identified or a mean tree density may be used if the species was not known.

$$C_{P,ig}^{damaged} = C_{c+s,ig} + C_{pieces,ig} + C_{incdam,ig} \quad (76)$$

where:

$C_{P,ig}^{damaged}$	= total carbon damage caused by logging in stratum i, gap g; t C
$C_{incdam,ig}$	= incidental carbon damage in stratum i, gap g due to logged tree; t C
$C_{c+s,ig}$	= biomass carbon in crown and stump of logged tree in stratum i, gap g; t C
$C_{pieces,ig}$	= biomass carbon in remaining pieces of bole from the timber tree in stratum i, gap g; t C

Step 2a. Use stump measurements to estimate DBH of the logged tree and calculate total aboveground biomass of the felled timber tree:

$$DBH_{tr,ig} = D_{s,tr,ig} - \left[\frac{D_{s,tr,ig} - D_{top,tr,ig}}{L_{log,tr,ig} \cdot 100}\right] \times \left(130 - H_{s,tr,ig}\right) \quad (77)$$

$$B_{AG,tr,ig} = f\left(DBH_{tr,ig}, H_{tr,ig}\right) \quad (78)$$

$$C_{AG,tr,ig} = \frac{B_{AG,tr,ig} \cdot CF}{1000} \quad (79)$$

where:

$B_{AG,tr,ig}$	= total aboveground biomass of felled tree tr in stratum i, gap k; kg
$f(DBH_{tr,ig},H_{tr,ig})$	= an allometric equation linking above-ground tree biomass (kg tree^{-1}) to diameter at breast height (DBH) and possibly tree height (H)
$C_{AG,tr,ig}$	= aboveground biomass carbon of tree tr in stratum i, gap g; t C
$B_{AG,tr,ig}$	= aboveground tree biomass of tree tr in stratum i, gap g; kg
CF	= carbon fraction, t C (t d.m.)$^{-1}$
$D_{s,tr,ig}$	= diameter of the stump of the logged timber tree tr in stratum i, gap g; cm
$D_{top,tr,ig}$	= diameter at the crown end of log extracted from timber tree tr in stratum i, gap g, cm
$H_{tr,ig}$	= tree height of tree tr in stratum i, gap g; m
$H_{s,tr,ig}$	= stump height of tree tr in stratum i, gap g; cm
$L_{log,tr,ig}$	= length of log extracted from timber tree tr in stratum i, gap g, measured as the distance from stump to base of crown, less the length of any pieces of bole left on site; m

Step 2b. Estimate the total carbon of all remaining log pieces left at the site:

$$C_{pieces,tr,ig} = \sum_{pce=1}^{PCE}\left[\frac{\left(0.01 \cdot D_{pce-b,tr,ig}\right) + \left(0.01 \cdot D_{pce-t,tr,ig}\right)}{2}\right]^2 \cdot \pi \cdot L_{pce,tr,ig} \cdot \phi_i \cdot CF \quad (80)$$

where:

$C_{pieces,tr,ig}$ = carbon of remaining log pieces left in the logging gap from timber tree tr in stratum i, gap g; t C
$D_{pce\text{-}b,tr,ig}$ = diameter of bottom end of piece pce left from timber tree tr in stratum i, gap g; cm
$D_{pce\text{-}t,tr,ig}$ = diameter of top end of piece pce left from timber tree tr in stratum i, gap g; cm
$L_{pce,tr,ig}$ = length of piece pce left from timber tree tr in stratum i, gap g; m
φ_i = wood density of piece pce left from timber tree tr in stratum i, gap g; t d.m.m^{-3}
CF = carbon fraction, t C (t d.m.)$^{-1}$
pce = 1, 2, 3, …, PCE; pieces

The biomass carbon of the remaining pieces for all logged trees in gap *g* is calculated as:

$$C_{pieces,ig} = \sum_{tr=1}^{TR} C_{pieces,tr,ig} \tag{81}$$

where:
$C_{pieces,ig}$ = biomass carbon in remaining pieces of bole from the timber tree in stratum i, gap g; t C
$C_{pieces,tr,ig}$ = carbon of remaining log pieces left in the logging gap from timber tree tr in stratum i, gap g; t C
tr = 1, 2, 3, …, TR timber trees in gap g; dimensionless

Step 2c. Estimate carbon in the remaining tree crown and stump by subtracting the biomass of the extracted log and any remaining pieces from the total biomass of the felled tree as calculated in Equation 82:

$$C_{c+s,tr,ig} = C_{AG,tr,ig} - C_{log,tr,ig} - C_{pieces,tr,ig} \tag{82}$$

where:
$C_{c+s,tr,ig}$ = biomass carbon in crown and stump of logged tree tr in stratum i, gap g; t C
$C_{AG,tr,ig}$ = aboveground biomass carbon in tree tr in stratum i, gap g; t C
$C_{log,tr,ig}$ = biomass carbon of log extracted from tree tr in stratum i, gap g, t C
$C_{pieces,tr,ig}$ = biomass carbon of remaining log pieces of tree tr in stratum i, gap g; t C

The biomass carbon of the remaining tree crown and stumps for all logged trees in gap g is calculated as:

$$C_{c+s,ig} = \sum_{tr=1}^{TR} C_{c+s,tr,ig} \tag{83}$$

where:
$C_{c+s,tr,ig}$ = biomass carbon in crown and stump of logged tree tr in stratum i, gap g; t C
$C_{c+s,ig}$ = biomass carbon in crown and stump of all logged trees in stratum i, gap g; t C
tr = 1, 2, 3, …, TR timber trees in stratum i, gap g; dimensionless

Step 2d. Estimate the incidental damage to surrounding vegetation due to logging:

Damaged trees are those trees in a logging gap *g* that were severely impacted by tree fall. Damage trees are classified as either 1) snapped stem or 2) uprooted. To estimate the amount of damaged vegetation in each gap, the general biomass equation (Equation **74** above) is applied to measurements of DBH of the damaged trees. Total incidental damage is calculated as:

$$C_{incdam,ig} = \sum_{tr\_d=1}^{TR\_d} C_{AG,tr\_d,ig} \quad \textbf{(84)}$$

and:

$$C_{AG,tr\_d,ig} = \frac{B_{AG,tr\_d,ig} \cdot CF}{1000} \quad \textbf{(85)}$$

$$B_{AG,tr\_d,ig} = f(DBH, H) \quad \textbf{(86)}$$

where:

$C_{incdam,ig}$	= incidental carbon damage in stratum i, gap g due to logged tree; t C
$C_{AG,tr\_d,ig}$	= aboveground tree biomass carbon of damaged tree tr_d in stratum i, gap g; t C
$B_{AG,tr\_d,ig}$	= aboveground tree biomass of damaged tree tr_d in stratum i, gap g; kg
CF	= carbon fraction, t C (t d.m.)$^{-1}$
f(DBH,H)	= an allometric equation linking above-ground tree biomass (kg tree^{-1}) to diameter at breast height (DBH) and possibly tree height (H)
tr_d	= 1, 2, 3, …, tr_d damaged trees in stratum i, gap g, time t

8.2.1.2 Estimation of number of logging gaps ($N_{P,it}^{gaps}$)

At each monitoring event, use aerial photographs or other aerial imagery or high resolution remote sensing data to monitor the number of tree gaps present in the project area. Imagery must be collected annually.

At the time the imagery is collected, it is conservative to overestimate the number of gaps by assuming that all gaps are caused by commercial logging and not by natural treefall. The canopy gaps detected during each monitoring event will most likely be from the past year's logging activities; if there is uncertainty about whether a gap was formed during the year the monitoring is taking place or from a previous year, this gap must be included in the count because it is conservative to overestimate the number of trees logged. A minimum gap size threshold must be determined and documented in the first monitoring year to ensure a standardized count of logging gaps throughout the crediting period.

8.2.2 Estimation of GHG emissions due to fire ($E_{P,t}^{fire}$)

All fires that occur inside the project boundary must be accounted for over the life of the project, along with the associated GHG emissions resulting from these fires.

The GHG emissions attributable to fires that occur within the project boundary over the monitoring period are therefore estimated as:

$$E_{P,t}^{fire} = \sum_{i=1}^{M_{PS}} (A_{P,burn,it} \cdot EF_{P,BiomassBurn,it}) + \sum_{k=0}^{k^*} (A_{P,burn,kt} \cdot EF_{P,PeatBurn,kt}) \quad (87)$$

where:

$E_{P,t}^{fire}$ = GHG emissions due to fire in the project area in monitoring year t; t CO_2-e

$A_{P,burn,it}$ = area burned in stratum i, monitoring year t within in the project area; ha

$EF_{P,BiomassBurn,it}$ = average fire emission factor for stratum i, monitoring year t; t CO_2-e ha^{-1} burnt (Equation 88)

$A_{P,burn,kt}$ = peat area burned in stratum k, time t in the project area; ha

$EF_{P,PeatBurn,kt}$ = average peat fire emission factor for stratum k, monitoring year t; t CO2-e ha-1 burnt (Equation 94)

Determination of the presence or absence of burning must be done prior to adopting the methods and procedures proposed to measure area burnt in the project area under this methodology. Steps are outlined below to estimate the area burnt in each monitoring year and an emission factor per area burnt.

Step 1: Determine presence/absence of burning and monitor area burnt within project boundary

Monitoring for fire must occur annually.

At the end of the fire season, determine the presence or absence of burning within the project boundary in a given monitoring year by analyzing medium to high-resolution remote sensing data such as Landsat, SPOT, Moderate Resolution Imaging Spectroradiometer (MODIS), or other high-resolution remote sensing products (e.g., high resolution aerial digital imagery collected over the project area).

If no fires are detected within the project boundary or within a 1 km buffer zone around the project boundary in the monitoring year, then it is assumed that there were no GHG emissions associated with burning within the project boundary and $E_{P,t}^{fire}$= 0.

If burned areas are detected within the project boundary or within a 1 km buffer of the project boundary in the monitoring year, then georeferenced, high resolution aerial imagery or georeferenced ground measurements must be collected over these areas and the location and area of all fire scars must be calculated and recorded. The area of burning must be tracked directly using an accuracy assessment criterion of 80% or more.

The location of these burns must be digitized within a GIS and the total area of burn within each landcover stratum i ($A_{P,burn,it}$) and average peat depth stratum k ($A_{P,burn,kt}$) must be calculated for each year (t) of the monitoring period.

Step 2: Estimate an average emission factor for burning of aboveground biomass ($EF_{P,BiomassBurn,fire,it}$)

An average emission factor ($EF_{P,BiomassBurn,it}$) for each stratum may be derived prior to the start of project activities or before the first monitoring event. Emission factors for different strata or different years may be similar enough to allow their merging so that one general emission factor value is used. The emission factor for aboveground biomass burning may be estimated as follows:

$$EF_{P,BiomassBurn,it} = EF_{P,Biomassburn,CO2,it} + EF_{P,BiomassBurn,N2O,it} + EF_{P,BiomassBurn,CH4,it} \quad \textbf{(88)}$$

where:

$EF_{P,BiomassBurn,it}$ = total increase in CO2-e emissions as a result of aboveground biomass burning in the project case in stratum i, monitoring year t; t CO_2-e ha^{-1} burnt

$EF_{P,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning under the project case in stratum i, monitoring year t; t CO_2-e ha^{-1} burnt

$EF_{P,BiomassBurn,N2O,it}$ = N_2O emission from biomass burning under the project case in stratum i, monitoring year t; t CO_2-e ha^{-1} burnt

$EF_{P,BiomassBurn,CH4,it}$ = CH_4 emission from biomass burning under the project case in stratum i, monitoring year t; t CO_2-e ha^{-1} burnt

$$EF_{P,BiomassBurn,CO2,it} = \left(MC_{B,BB,AG,it} \cdot PBB_{P,it} \cdot CE\right) \cdot \frac{44}{12} \quad \textbf{(89)}$$

where:

$EF_{P,BiomassBurn,CO2,it}$ = CO_2 emission from biomass burning under the project case in stratum i, monitoring year t; t CO_2-e

$MC_{B,BB,AG,it}$ = average above-ground biomass carbon stock in the baseline scenario for stratum i, monitoring year t; t C ha^{-1}

$PBB_{P,it}$ = average proportion of $MC_{B,BB,AG,it}$ burnt under the project case for stratum i, time t; dimensionless

CE = average biomass combustion efficiency; dimensionless[18]

The CO_2e emissions resulting from a fire are dependent on the proportion of carbon stocks burned ($PBB_{P,it}$) and the combustion efficiency (CE). The average aboveground carbon stocks of the land cover stratum after a fire may be monitored, otherwise conservative default values may be applied.

[18] Current IPCC default is likely 0.5 for most projects, but must be selected from Table 2.6 of the *IPCC AFOLU Guidelines*

The combustion efficiencies CE may be chosen from the most up to date version of IPCC documentation (e.g. Table 2.6 of the *IPCC AFOLU Guidelines*) or applicable literature. If no appropriate combustion efficiency may be identified, the most recent IPCC default value must be used.

Baseline measurements of carbon stocks in unburned areas within stratum *i* may be paired with field measurements within the same stratum in areas where fire occurred during the monitoring event to estimate the proportion of carbon stocks burned:

$$PBB_{P,it} = 1 - \left(MC_{P,AG,it}^{burned} / MC_{B,BB,AG,it}\right) \quad \textbf{(90)}$$

where:

$PBB_{P,it}$ = average proportion of $MC_{B,BB,AG,it}$ burnt under the project case for stratum i, time t; dimensionless

$MC_{B,BB,AG,it}$ = estimated aboveground carbon stock in the baseline scenario before burning for stratum i, time t; t C ha^{-1}

$MC_{P,AG,it}^{burned}$ = estimated aboveground carbon stock after burning under the project case for stratum *i*, time *t*; t C ha^{-1}

If no field measurements are available of carbon stocks in stratum *i* after burning, then the CO_2 average proportion of above-ground biomass burnt ($PBB_{P,it}$) must be conservatively estimated as equal to 1. This assumes that all above-ground biomass is burnt in stratum *i*:

$$EF_{P,BiomassBurn,CO2,it} = (MC_{B,AG,it} \cdot PBB_{P,it} * CE) \cdot \frac{44}{12} \quad \textbf{(91)}$$

where:

$EF_{P,BiomassBurn,CO2,it}$ = CO_2 emissions factor for biomass burning under the project case in stratum i, monitoring year t; t CO_2-e

$MC_{B,AG,it}$ = average above-ground biomass carbon stock in the baseline scenario for stratum i, monitoring year t; t C ha^{-1}

$PBB_{P,it}$ = average proportion of $MC_{B,BB,AG,it}$ burnt under the project case for stratum i, time t; dimensionless

CE = average biomass combustion efficiency (IPCC default); dimensionless

$\frac{44}{12}$ = ratio of molecular weights of CO_2 and carbon; dimensionless

Non-CO_2 emission factors are calculated as:

$$EF_{P,BiomassBurn,N2O,it} = EF_{P,Biomassburn,CO2,it} \cdot \frac{12}{44} \cdot (N/Cratio) \cdot ER_{N_2O} \cdot \frac{44}{28} \cdot GWP_{N_2O} \quad \textbf{(92)}$$

$$EF_{P,BiomassBurn,CH4,it} = EF_{P,Biomassburn,CO2,it} \cdot \frac{12}{44} \cdot ER_{CH_4} \cdot \frac{16}{12} \cdot GWP_{CH_4} \quad \textbf{(93)}$$

where:

$EF_{P,BiomassBurn,CO2,it}$ = CO_2 emission from aboveground biomass burning under the project case in stratum i, monitoring year t; t CO_2-e ha^{-1}

$EF_{P,BiomassBurn,N2O,it}$ = N_2O emission from aboveground biomass burning under the project case in stratum i, monitoring year t; t CO_2-e ha^{-1}

$EF_{P,BiomassBurn,CH4,it}$ = CH_4 emission from aboveground biomass burning under the project case in stratum i, monitoring year t; tCO_2-e ha^{-1}

N / Cratio = nitrogen-carbon ratio (IPCC default = 0.01); dimensionless

ER_{N2O} = emission ratio for N_2O (IPCC default value = 0.007); t CO_2-e (t C)$^{-1}$

ER_{CH4} = emission ratio for CH_4 (IPCC default value = 0.012); t CO_2-e (t C)$^{-1}$

GWP_{N2O} = Global Warming Potential for N_2O; t CO_2-e (t N_2O)$^{-1}$

GWP_{CH4} = Global Warming Potential for CH_4; t CO_2-e (t CH_4)$^{-1}$

The nitrogen-carbon ratio (N/C ratio) is approximated to be about 0.01. This is a general default value that applies to leaf litter, but lower values would be appropriate for fuels with greater woody content, if data are available. Emission factors for use with above equations may be selected from the latest IPCC guidance documents (e.g Tables 3.A.15 and 3.A.16 of IPCC GPG-LULUCF).

Step 3: Estimate an average fire emission factor for peat burning ($EF_{P,PeatBurn,fire,kt}$)

An emission factor for peat burning may be estimated as follows:

$$EF_{P,PeatBurn,kt} = EF_{P,PeatBurn,CO2,kt} + EF_{P,PeatBurn,CH4,kt} \tag{94}$$

and:

$$EF_{P,PeatBurn,CO2,kt} = \frac{M_{P,peat,t} * EF_{CO_2}}{10^6} \tag{95}$$

$$EF_{P,PeatBurn,CH4,kt} = \frac{M_{P,peat,t} * EF_{CH_4}}{10^6} * GWP_{CH_4} \tag{96}$$

$$M_{P,peat,t} = D_{P,burn,kt} * 10000 * BD_k \tag{97}$$

where:

$EF_{P,PeatBurn,kt}$ = total increase in CO_2-e emissions as a result of peat burning under the project scenario in stratum k, time t; t CO_2e ha^{-1}

$EF_{P,PeatBurn,CO2,kt}$= total CO_2 emissions from peat burning under the project scenario in stratum k, time t; t CO_2e ha^{-1}

$EF_{P,PeatBurn,CH4,kt}$= total CH_4 emissions from peat burning under the project scenario in stratum k time t; t CO_2e ha^{-1}

$M_{P,peat,kt}$ = mass of peat burned under the project scenario in stratum k time t; tons

EF_{CO2} = CO_2 emissions from the combustion of peat, g CO_2/ton peat

EF_{CH4} = CH_4 emissions from the combustion of peat, g CO_2/ton peat

GWP_{CH4} = Global Warming Potential for CH_4; t CO_2-e. (t CH_4)$^{-1}$

$M_{P,peat,kt}$ = total mass of peat burned under the project scenario in stratum k, time t; tons ha^{-1}

$D_{P,burn,kt}$ = depth of peat burned under the project scenario in stratum k at time t; meters
BD_k = bulk density of peat in stratum k (g cm^{-3} = t m^{-3})

The depth of peat burned ($D_{P,burn,kt}$) per fire may be measured in the field or conservatively estimated based on literature values. Based on a literature review in Couwenberg et al. (2009), the peat depth burnt in peat fires averages 34 cm across six studies from 1988 to 2002. A conservative value for burn depth would be the upper end of the range reported, which is 55 cm. If literature values are used, verification must be conducted using limited ground sampling to ensure the actual burn depths measured fall within the uncertainty range of the literature value applied. Burn depth may be measured by monitoring active fire fronts within or in the vicinity of the project area and installing sample posts to measure total peat depth before and after burning. Alternative methodologies for measuring the depth of peat burned may also be considered, such as interferometric analysis of land subsidence using radar data, user of airborne lidar, etc. All technologies used must be described in detail in the PD and/or monitoring reports.

Researchers have found that the depth of peat burned decreases significantly based on the number of fire events observed in an area (Konecny, 2016). Thus, project proponents may choose to apply a lower peat burn depth for an area that has been repeatedly burned within 10 years of the project start date. To justify a lower peat burn depth for stratum *k* at time *t,* the project proponent must provide literature or monitoring data applicable to the project area demonstrating that repeated burns within the project area decrease in depth. Demonstrable proof must also be provided to auditors that an area had been burned previously. This proof may include remote sensing data (such as MODIS), aerial images, or field measurements and observations.

EF_{CO2} and EF_{CH4} may be estimated using the same methodology as outlined for the baseline in Section 8.1.2.2.3 and may use the default values provided in Table 5 if no monitoring data is available.

8.2.3 Estimation of GHG emissions from biomass due to land clearing (deforestation)

The area of land cover change that occurs within the project area that is not due to fire or logging, along with the associated GHG emissions, also must be accounted for at each monitoring event. Monitoring may occur using a variety of remote sensing imagery including georeferenced aerial imagery or other remote sensing imagery such as Landsat or radar imagery verified with field measurements. An accurate land cover map must exist at the start of the project. Medium-resolution remote sensing data or high resolution aerial images must be collected and processed in each monitoring year to estimate the area of land cover change. This imagery may be the same as was used to detect the area of fire and/or selective logging within the project boundary. The area of deforestation must be tracked directly using an accuracy assessment criterion of 80% or more. A description of the methods used to detect land cover change may be included in the PD.

Monitoring for land cover change must occur annually.

The GHG emissions attributable to deforestation that occur within the project boundary over the monitoring year *t* are therefore estimated as:

$$E_{P,t}^{LCC} = \sum_{i=1}^{m_{PS}} (A_{P,LCC,it} \cdot EF_{P,LCC,AG,it}) \quad \textbf{(98)}$$

where:

$E_{P,t}^{LCC}$ = GHG emissions from biomass due to land cover change in the project area over the monitoring year t; t CO_2-e

$A_{P,LCC,it}$ = area that underwent land cover change in stratum i, monitoring year t; ha

$EF_{P,LCC,AG,it}$ = average deforestation emission factor for stratum i, monitoring year t; t CO_2-e ha^{-1} (Equation 99)

Determination of the presence or absence of deforestation must be done prior to adopting the methods and procedures proposed to measure area deforested in the project area under this methodology.

The location and area of all land cover change must be calculated and recorded in monitoring year *t* based on georeferenced aerial imagery or other remote sensing data. The area of land cover change must be tracked directly using an accuracy assessment criterion of 80% or more. Carbon stocks of the land cover type after the deforestation occurred may be estimated if desired, but it is conservative in the project case to ignore the accumulation. If increases are to be estimated, permanent sample plots must be installed to measure increases in carbon stocks. See Section 8.1.1.3 for methods on calculating tree biomass.

$$EF_{P,LCC,AG,it} = MC_{B,AG,it} \cdot \frac{44}{12} \quad \textbf{(99)}$$

Where:

$EF_{P,LCC,AG,it}$ = average deforestation emission factor for stratum i, monitoring year t; t CO_2-e ha^{-1}

$MC_{B,AG,it}$ = mean carbon stock in above-ground living biomass under the baseline scenario for stratum i, time t; t C ha^{-1}

It is conservative to assume that the area of peat affected by land cover change is equal to 100% of the converted area ($A_{P,LCC,it}$), but project proponent may instead use the stratum *k* to identify if a disturbed area is on peat. If canals are detected in the imagery (e.g. built from a main river to the area of land cover change), then the area of peat affected increases beyond the area of converted land because canals drain additional peat. This increase must be accounted for (see Section 8.2.4 below).

8.2.4 Estimation of GHG emissions from peat caused by canal construction ($E_{P,drainage,kt}$)

If logging or deforestation occurs within the project area, small canals may be created in the peat to extract logs to major rivers for transport during the wet season. There are difficulties of knowing the distance effect of canal drainage, as this will vary between extremes of dry and wet seasons. Small canals in forest are virtually impossible to detect from space and difficult and time-consuming to find on the ground; most are not linear. There are few data on the distance from these canals that is affected by drainage, especially at the scale of the small-scale illegal logging that is most likely in the project scenario. The steps outlined below provide a methodology that conservatively estimates the impact of small canals on peat based on current data and scientific understanding.

$$E_{P,drainage,t} = E_{P,drainage,CO_2,t} + E_{P,drainage,CH_4,t} + E_{P,drainage,N_2O,t} \quad \textbf{(100)}$$

Where:

$E_{P,drainage,t}$ = annual monitored emissions from all GHG sources in drained peat under the project scenario in monitoring year *t*; t CO_2-e

$E_{P,drainage,CO_2,t}$ = annual monitored CO_2 emissions from drained peat under the project scenario in monitoring year *t*; t CO_2-e (Equation 101)

$E_{P,drainage,CH_4,t}$ = annual monitored CH_4 emissions from drained peat under the project scenario in monitoring year *t*; t CO_2-e (Equation 104)

$E_{P,drainage,N_2O,t}$ = annual monitored N_2O emissions from drained peat under the project scenario in monitoring year *t*; t CO_2-e (Equation 105)

8.2.4.1 Estimation of GHG drainage emissions from CO_2 ($E_{P,drainage,CO_2,t}$)

Emissions of CO_2 are calculated similarly to baseline emissions in Section 8.1.2.1.1. :

$$E_{P,drainage,CO_2,t} = \sum_{k=0}^{k^*} \left(A_{P,drain,k} \cdot EF_{\mathrm{P,drainage},kt,CO_2}\right) \quad \textbf{(101)}$$

where:

$E_{P,drainage,CO_2,t}$ = annual monitored CO_2 emissions from drained peat in monitoring year t; t CO_2-e

$A_{P,drain,k}$ = land area of drained organic soils under the project scenario in stratum k; ha

$EF_{P,drainage,kt,CO_2}$ = CO_2 emissions factor for drained organic soils in stratum k for monitoring year t; t CO_2 ha^{-1}

k = 0, 1, 2, 3, ...k* peat depth strata

t = 1, 2, 3, ...t* monitoring years elapsed since the start of the project activity

Section 8.2.4.4 discusses the monitoring of the area of drained peat in the project scenario ($A_{P,\ drain,\ k}$). An appropriate emissions factor must be selected with guidance from the following section.

8.2.4.1.1 Relationship between CO2 emissions and drainage depth

An appropriate emissions factor for CO_2 emissions must be selected using relevant literature appropriate to the project. In the absence of relevant literature, the following default equations may be used:

$$EF_{peat,drainage,kt} = ME_{dd,kt} \quad (102)$$

$$ME_{dd,kt} = f(D_{drain,kt}) \quad (103)$$

where:

$EF_{peat,drainage,kt}$ = average deforestation emission factor for peat drainage in stratum k and monitoring year t; t CO_2-e ha^{-1}

$ME_{dd,kt}$ = average peat CO_2 emissions under the project scenario in stratum k and monitoring year t due to land cover change in the project area, t CO2-e ha^{-1}

$D_{drain,kt}$ = average depth of peat drainage or average depth to water table in the deforested area under the project scenario in stratum k, time t; cm

It is known that the relationship between drainage depth and CO_2 emissions (Equation 103) may be non-linear. However, given a lack of extensive field data available for tropical peat forests, projects with no data must apply a linear relationship derived from a compilation of field measurements collected throughout peatlands of Southeast Asia (e.g. Hooijer, Silvius, Wosten, & Page, 2006; Couwenberg, Dommain, & Joosten, 2009) where $ME_{dd,kt} = 0.91 \cdot D_{drain,kt}$ (or $ME_{P,dd,kt}$ = 9 t CO_2 ha^{-1} for each 10 cm of drainage depth) until additional data become available. This is a conservative emissions factor for project emissions as canals in the project scenario are likely much shallower and less extensive than the plantation canals studied to derive the above relationship. Methods to monitor the appropriate drainage emissions factor are discussed in Section 8.2.4.4.

8.2.4.2 Estimation of GHG drainage emissions from CH_4 ($E_{B,drainage,CH_4,kt}$)

As drainage canals in the project area are likely to be minimal, CH_4 emissions from peat (excluding burning) are also likely to be minimal. However, they must still be conservatively included in project emissions using the following equation:

$$E_{P,drainage,CH_4,t} = \sum_{k=0}^{k^*}(A_{P,drain,k} \cdot ((1 - Frac_{ditch}) * EF_{CH_4,,land,kt} + Frac_{ditch} * EF_{CH_4,,ditch,kt})) * \text{GWP}_{CH_4} \quad (104)$$

Where:

$E_{P,drainage,CH_4,t}$ = annual monitored CH_4 emissions from drained peat under the project scenario in monitoring year t; t CO_2-e

$A_{P,drain,k}$ = land area of drained organic soils under the project scenario in stratum k, time t; ha

$EF_{CH4,land,kt}$ = emission factors for direct CH_4 emissions from drained organic soils in stratum k in monitoring year t; t CH_4 ha^{1} yr^{-1}

$EF_{CH4,\ ditch,kt}$ = emission factors for CH_4 emissions from drainage ditches in stratum k in monitoring year t; t CH_4 $ha^{-1}yr^{-1}$

$Frac_{ditch}$ = fraction of the total area of drained organic soil which is occupied by ditches; unitless

GWP_{CH_4} = GWP for CH_4. Must be updated based on latest guidance from IPCC.
k = 0, 1, 2, 3, ...k* peat depth strata

Project proponents may optionally monitor $Frac_{ditch}$ using field data and remote sensing data, but may also conservatively use the same emission factors and values for $Frac_{ditch}$ as they used in the baseline scenario (Section 8.1.2.1.2). This is conservative as ditches in the project scenario are likely small compared to those in the baseline scenario. Also, as the area drained in the project scenario is likely quite small, monitoring of the size of the canals themselves may not be worth the costs and effort.

8.2.4.3 Estimation of GHG drainage emissions from N_2O ($E_{P,drainage,N_2O,kt}$)

Drainage emissions from N_2O are estimated similarly to baseline drainage emissions:

$$E_{P,drainage,N_2O,t} = \sum_{k=0}^{k^*} (A_{P,drain,k} \times EF_{N_2O,kt}) * GWP_{N_2O} \quad (105)$$

where:

$E_{P,drainage,N_2O,t}$ = annual monitored N2O emissions from drained peat under the project scenario in monitoring year t; t CO_2-e

$A_{P,drain,k}$ = land area of drained organic soils under the project scenario in stratum k t; ha

$EF_{N_2O,kt}$ = emissions factor for annual N_2O emissions per hectare within drained peat in stratum k at time t; t N_2O ha^{-1}

GWP_{N_2O} = GWP for N_2O. Must be updated based on latest guidance from IPCC.

k = 0, 1, 2, 3, ...k* peat depth strata

In the case that no local emissions factor data exists for N_2O emissions from drained peatlands appropriate for the project scenario, projects may select an appropriate default value following the rules and requirements of the VCS Standard.

8.2.4.4 Area of peat drainage ($A_{P, drain, k}$)

Peat areas may become drained from either canals dug for logging or peat areas becoming deforested. The following steps must be followed to monitor the area impacted:

Step 1. During the first monitoring event, geo-reference all logging gaps and deforested areas as detected in the high resolution imagery collected during the monitoring event.

Step 2. Geo-locate (as GPS points) known exit points for logs that end up on rivers and large canals to be transported off-site.

Step 3. On the ground during the wet season, map the existing network of logging canals by traveling up the canals from the exit points to each georeferenced logging gap, collecting point-specific location information (e.g., GPS points) along the routes taken and following the canal network's non-linearities where they occur to ensure complete coverage.

Step 4. Enter the coordinates of the canals into a GIS and estimate the total length of canals and canal segments.

Step 5. Independently consult with at least two peat experts to estimate conservatively the distance of impact of small, hand-dug canals constructed for logging activities. These estimates must be estimated from field measurements or output from validated hydrological models. For any data provided by experts, the PD and/or monitoring reports must record the expert's name, affiliation, and principal qualification as an expert– plus inclusion of a 1-page summary CV for each expert consulted, included in an annex.

Step 6. In a GIS, construct a buffer width on each side of the canal network mapped in Step 3 that is equal to the conservatively-defined distance of impact determined in Step 5. Calculate the total area of the resulting polygon created in the GIS with an average peat depth ($D_{Peat,k,t=0}$) greater than the peat depth threshold for the project area (Applicability Condition 1). This area must be defined as the area of peat impact ($A_{P,drain,k}$) of canals in each stratum k.

Step 7. At each monitoring event, repeat Steps 1-6, estimating the new total area of impact of canals constructed for logging activities. Monitoring canals is conducted at regular (annual) intervals to account for changes in the total length of the canal network due to potential expansion of canals into new areas over time. Once a canal has been created, it is conservative to include this in the network during each subsequent monitoring event even if it is no longer active. If a project proponent may demonstrate through monitoring data that a canal is no longer active (e.g. drainage depth = 0 cm), the drainage area of that canal may be removed from $A_{P,drain,k}$.

Step 8: In the field, measure the average drainage depth along transects perpendicular to the canals. The measurement where the water table is lowest must be assumed to be the depth to which peat is drained across the entire area of impact ($A_{P,drain,k}$). The sampling plan for estimating average drainage depth must be outlined in the monitoring report. Improved data must be applied if and when these data become available. After a drainage depth is defined, estimate average CO2 emissions per area of drained peat using Equation 103.

8.3 Leakage

Leakage (*LK*) represents the increase in GHG emissions by sources which occur outside the project boundary that are measurable and attributable to the project activity. Leakage is assumed to occur as a result of the displacement of economic activities (i.e., planned land use conversion) to areas outside the project that lead to deforestation and land use change, estimated in units of t CO_2-e. Thus, as a result of the project activity, the baseline activity of planned land use change may be temporarily or permanently displaced from within the project boundary to areas outside the project boundary. When REDD project activities result in reductions in wood harvest, it is likely that production could shift to other areas of the country to compensate for the reduction, and thus leakage as a result of market effects must also be considered in this scenario.

Determination of the presence or absence of activity displacement that likely leads to increased GHG emissions must be done prior to adopting the methods and procedures proposed to measure the activity displacement under this methodology.

Emissions that result from market effects and displacement of pre-project activities to areas outside the project boundary are estimated as:

$$LK_t = LK_{MarketEffects,t} + LK_{ActivityDisplacement,t} + LK_{Ecological,t} \quad (106)$$

where:

LK_t = Leakage emissions resulting from displacement of economic activities, market effects, and ecological effects at time *t*; t CO_2-e

$LK_{MarketEffects,t}$ = Total GHG emissions due to market effects leakage through decreased timber harvest at project year *t*; t CO_2-e (Equation 107)

$LK_{ActivityDisplacement,t}$ = Total GHG emissions due to activity shifting leakage for projects preventing planned deforestation at project year *t*; t CO_2-e (Equation 110)

$LK_{Ecological,t}$ = Total GHG emissions due to ecological leakage at project year *t*; tCO_2e

8.3.1 Market Leakage

When REDD project activities result in reductions in wood harvest, it is likely that production could shift to other areas of the country to compensate for the reduction. Therefore, in cases where the project area would be harvested for commercial timber before clearing the site for a new land use, market effects leakage must be estimated as the baseline emissions from logging multiplied by a leakage factor:

$$LK_{MarketEffects,t} = \sum_{i=1}^{m_{LK}} LK_{ME,it} \quad (107)$$

$$LK_{ME,it} = LF_{ME,i} * C_{B,XBT,it} \quad (108)$$

where:

$LK_{MarketEffects,t}$ = Total GHG emissions due to market effects leakage through decreased harvest; t CO_2e

$LK_{ME,it}$ = Total GHG emissions due to market effects leakage through decreased harvest in stratum i at time t; t CO_2-e

$LK_{ME,i}$ = Leakage factor for market effects calculations; dimensionless

$C_{B,XBT,it}$ = Carbon emission due to displaced timber harvests in the baseline scenario in stratum i at time t; t CO_2-e (Equation 109)

The amount of leakage is determined by where harvesting would likely be displaced to. If in the forests to which displacement would occur a lower proportion of biomass in commercial species is in merchantable material than in the project area, then more trees will need to be cut to supply the same volume and thus higher emissions should be expected. In contrast, if a higher proportion of biomass of commercial species is merchantable in the displacement forest than in the project forest, then a smaller area would need to be harvested and lower emissions would result.

Each project thus must calculate within each stratum the proportion of total biomass in commercial species that is merchantable (PMP_i). Merchantable biomass per stratum is conservatively defined as the total volume (converted to biomass) of all commercially valuable trees within a stratum that are above the minimum size class sold in the local timber market (see Applicability Condition J). PMP_i is therefore equal to the merchantable biomass as a proportion of total aboveground tree biomass for stratum *i* within the project boundaries. PMP_i must then be compared to the mean proportion of total biomass that is merchantable for each forest type (PML_{FT}) to which displacement is likely to occur.

The following deduction factors ($LF_{ME,i}$) must be used:

PML_{FT} is equal (±0.15) to PMP_i	$LF_{ME,i}$	=	0.4
PML_{FT} is > 0.15 less than PMP_i	$LF_{ME,i}$	=	0.7
PML_{FT} is >0.15 greater than PMP_i	$LF_{ME,i}$	=	0.2

Where:

PML_{FT} = Mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type; dimensionless

PMP_i = Merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundaries; dimensionless

$LF_{ME,i}$ = Leakage factor for stratum i market-effects calculations; dimensionless

Instead of applying the default market leakage discounts, project proponents may opt to estimate the project's market leakage effects across the entire country and/or use analysis(es) from other similar projects to justify a different market leakage value. A description of the market leakage assessment, including steps for determining where leakage is likely to occur (i.e., to which forest types leakage is likely to occur) and what the carbon stocks of those lands are, must be outlined in the PD. The outcome of this assessment conducted at first VCU issuance (whether using default discounts or project specific analysis(es)) may be subject to the VCS double approval process. Market leakage assessments conducted at validation stage and at verification other than the first VCU issuance are not required to undergo the double approval process.

The next step is to estimate the emissions associated with the displaced logging activity – this is based on the total volume that would have been logged in the project area in the baseline scenario. The emission due to the displaced logging has two components: the biomass carbon of the extracted timber and the biomass carbon in the forest damaged in the process of timber extraction:

$$C_{B,XBT,it} = \left(\left[V_{B,it} * \phi_i * CF\right] + \left[V_{B,it} * LDF\right]\right) * \frac{44}{12} \quad (109)$$

Where:

$C_{B,XBT,it}$ = Carbon emission due to displaced timber harvests in the baseline scenario in stratum i at time t; t CO_2-e

$V_{B,it}$ = Volume to be extracted under the baseline scenario in stratum i at time t; m^3

φ_i = volume-weighted average wood density; t d.m. m^{-3} merchantable volume

CF = carbon fraction of dry matter (0.5 t C / t biomass); dimensionless

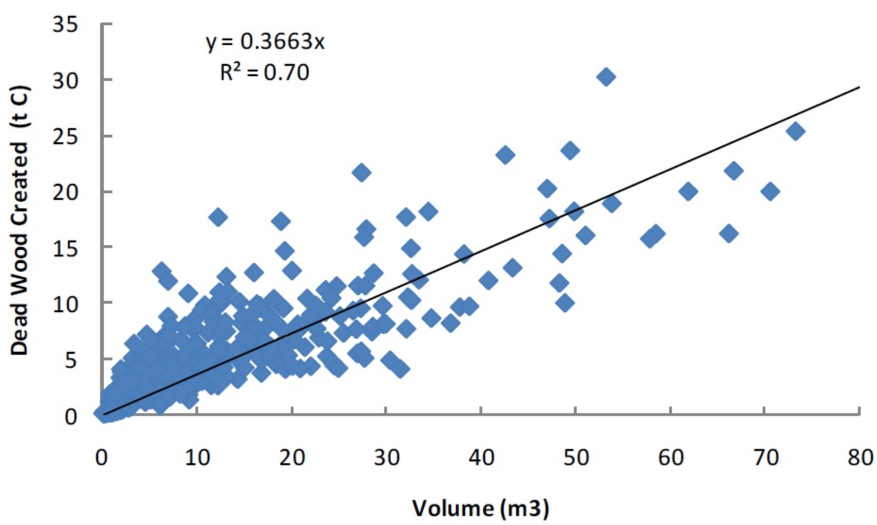
LDF = Logging damage factor; t C m^{-3} (default 0.37 t C m^{-3})

i = 1, 2, 3, …, m_{BL} baseline strata

t = 1, 2, 3, …, t* years elapsed since the projected start of the REDD project activity

The total volume to be extracted under the baseline scenario in stratum *i* at time *t* ($V_{B,it}$) may be estimated by multiplying the plot-level volume per stratum ($PV_{B,it}$, see Equation 10) by the area cleared or logged in stratum *i* at time *t* ($A^{cleared}_{B,it}$, or $A^{logged}_{B,it}$ if different from $A^{cleared}_{B,it}$).

The logging damage factor (LDF) is a representation of the quantity of emissions that will ultimately arise per unit of extracted timber (m^3). These emissions arise from the non-commercial portion of the felled tree (the branches and stump) and trees incidentally killed during tree felling. The default value given here comes from the slope of the regression equation between carbon damaged and volume extracted based on 534 logging gaps measured by Winrock International in Bolivia, Belize, Mexico, the Republic of Congo, Brazil, and Indonesia:



Methods used by Winrock are described in Pearson, Brown, & Casarim (2014) and in reports to US Agency for International Development[19].

8.3.2 Activity Displacement Leakage

Leakage due to activity displacement represents the increase in GHG emissions by sources which occur outside the project boundary that are measurable and attributable to the project

[19] Deliverables 9, 10, 13a, 17, 21, and 24 under Carbon and Co-Benefits from Sustainable Land-Use Management project: Cooperative Agreement No. EEM-A-00-03-00006-00.

activity. Thus, as a result of the project activity, the baseline activity of planned land use change may be temporarily or permanently displaced from within the project boundary to areas outside the project boundary. Under Applicability Condition H in Section 4, the parcel(s) of peat swamp forest to be converted to another land use must not contain human settlements (towns, villages, etc.) or any human activities that lead to deforestation such as agriculture or grazing. Thus the only activity displacement considered in this methodology is the shift of pre-project planned activities to outside the project boundary. No increases in GHG emissions caused by displacement of activities associated with the project are expected and LK = 0 if it may be demonstrated that all pre-project activities are displaced to degraded, non-forest land on mineral soils outside the project boundary that have negligible aboveground carbon stocks and that have been non-forest for at least ten years. Evidence of this displacement must be presented in the PD at the time of project validation.

In situations other than that described above, the assessment and quantification of activity displacement and land use change must be undertaken using the methods outlined below. Baseline agents of deforestation (including private companies or local/national governments) may control multiple parcels of forest land within the country that could be used to make up for the generation of goods and/or services lost through implementation of the carbon project. In such cases, the project must demonstrate that the management plans and/or land-use designations of other lands controlled by the baseline agent of deforestation have not materially changed as a result of the planned project (e.g., designating new lands as plantation concessions, increasing harvest rates in lands already managed for plantation products, clearing intact forests for plantation establishment); if they have changed, the project must quantify the impact of these management changes and deduct the associated reductions in carbon stocks or increases in GHG emissions from C_{BSL}.

Determination of the presence or absence of activity displacement that likely leads to increased GHG emissions must be done prior to adopting the methods and procedures proposed to measure the activity displacement under this methodology.

The *area* of activity shifting leakage must be assessed for five full years beyond the date at which deforestation was projected to occur in the baseline. However, *emissions* resulting from activity shifting leakage must be tracked beyond the initial year of clearing where applicable to account for emissions from peat and mineral soils that continue after the initial year of clearing. Additional guidance for calculation of emissions is given in Section 8.3.2.2 below.

At each verification, documentation must be provided covering the other lands controlled by the baseline agent where leakage could occur, including, at a minimum, their location(s), area and type of existing land use(s), and management plans. It must also be demonstrated that the total area of government permits (for deforestation activities) that have been granted to the baseline agent of deforestation has not increased due to the implementation of project activities.

In each stratum, GHG emissions due to activity shifting leakage at time *t* consist of two components: (1) the initial changes in carbon stocks and GHG emissions that are accounted for in the year of clearing; and (2) continued changes in carbon stocks and GHG emissions that occur in subsequent years as a result of peat drainage or clearing land on mineral soils for annual cropland.

Emissions that result from displacement of pre-project activities to areas outside the project boundary are estimated as:

$$LK_{ActivityDisplacement,t} = \sum_{i=1}^{m_{LK}} \left(LKA_{planned,it} \times \Delta C_{it_{init}}\right) + \sum_{k=0}^{k^*} \left(LKA_{planned,kt} \times \Delta C_{kt_{continued}}\right) \quad (110)$$

where:

$LK_{ActivityDisplacement,t}$ = Total GHG emissions due to activity shifting leakage for projects preventing planned deforestation at project year t; t CO_2-e

$LKA_{planned,it}$ = The area of activity shifting leakage in stratum i at time t; ha

$LKA_{planned,kt}$ = The area of activity shifting leakage in stratum k at time t; ha

ΔC_{it_init} = average initial carbon stock changes and greenhouse gas emissions in stratum i at time t (excluding timber emissions where applicable); t CO_2-e ha^{-1}.

$\Delta C_{kt_{continued}}$ = average carbon stock changes and greenhouse gas emissions in stratum k at time t as a result of continued emissions; t CO_2-e ha^{-1}

i = 1, 2, 3, ...m_{LK} leakage land use/landcover strata

k = 0, 1, 2, 3, ...k* peat depth strata

t = 1, 2, 3, ...t* years elapsed since the start of the project activity

The second term of the equation (continued emissions) should be included only in years after the initial year of clearing.

8.3.2.1 Area of activity shifting leakage ($LKA_{planned,it}$)

Considering that pre-project activities may or may not be displaced to areas that are similar to those found in the project area (i.e., activities may or may not be displaced to a baseline stratum), it may necessary to stratify the area of activity displacement for leakage analysis. If the baseline agent of deforestation manages only lands of similar type as fall within the project area, then m_{BL} = m_{LK} (baseline strata = leakage strata). However, if the baseline agent of deforestation manages strata not found within the project boundary, then $m_{BL} < m_{LK}$ (there will be additional strata to include in the leakage analysis). More guidance on stratification is provided in Section 5.3 above.

The overall approach for calculating the area of activity shifting leakage is to first calculate the total area over which deforestation is forecast to occur across all of the land managed by the baseline agent of deforestation in year *t*, including the baseline projected deforestation within the project boundaries. Second, the area of deforestation predicted to occur within the project boundary in year *t* is subtracted from the total area deforested in year *t* across all of the land managed by the baseline agent of deforestation, which yields the expected area of deforestation in year *t* by the focal agent if no leakage had occurred. Third, the difference between the expected area of deforestation in year *t* under the no leakage scenario and the observed area of deforestation over each of the first five years after project implementation results in the area of leaked deforestation.

STEP 1: Determine the baseline area of forest clearance in year *t* for the deforestation agent

Two options exist for estimating the baseline rate of forest clearance by the deforestation agent. If a historic trend analysis (Option 1.1) is not feasible, Option 1.2 must be used.

Option 1.1 Baseline deforestation rate based on historic deforestation trend

With this approach, the baseline annual deforestation rate by the baseline deforestation agent may be estimated by extrapolating the historical annual trend using a linear regression. Survey the deforestation agent and examine official records (which may include permits for concessions or permits to deforest for agricultural/commercial purposes) to determine the total area deforested by the deforestation agent within each leakage stratum each year over the last 5-10 years within the country. To use this option, annual data for a minimum of five years and a maximum of ten years must be used to create the linear regression. The results of the analysis must produce a statistically significant regression with a $p<0.05$ and an adjusted R^2 of >0.75, otherwise Option 1.2 (“historical average”) must be used. The linear regression is as follows:

$$WoPA_{it} = a + (WoPR_{it} * t) \quad \textbf{(111)}$$

Where:

$WoPA_{it}$ = Total (cumulative) area of forest cleared by the baseline agent of planned deforestation in stratum i at project year t; ha

a = Estimated intercept of the regression line; ha

$WoPR_{it}$ = Slope of the linear regression, i.e., rate of deforestation by the baseline agent in the absence of the project in stratum i; ha cleared at time t

i = 1, 2, 3, …, m_{LK} strata

t = 1, 2, 3, …, t* years elapsed since the start of the planned deforestation reference period

The annual area of deforestation by the baseline agent in the absence of the project in stratum i at time t is therefore equal to the slope of the regression line, or $WoPR_{it}$.

Option 1.2: Baseline deforestation rate based on historic deforestation average

Under this approach, the baseline annual deforestation rate by the deforestation agent is assumed to be equal to the average cleared area during the past 5-10 years.

To implement this option, survey the deforestation agent and, if available, examine official records to determine the total area deforested by the deforestation agent within each leakage stratum over the previous five to ten years within the country. Official records may include permits for concessions or permits to deforest for agricultural/commercial purposes.

$$WoPR_{it} = \frac{HistHa_i}{n_{yrs}} \quad \textbf{(112)}$$

Where:

$WoPR_{it}$ = Rate of deforestation by the baseline agent in the absence of the project in stratum *i*; ha cleared at time *t*

$HistHa_i$ = Total number of hectares of forest cleared by the baseline agent of the planned deforestation in the *n* years prior to project implementation in stratum *i*; ha

i = 1, 2, 3, …, m_{LK} strata

n_{yrs} = number of years included in the analysis of deforestation; dimensionless

Where there is no history of deforestation within a given stratum and no verifiable plans for controlled lands and future-controlled lands by the deforestation agent, then $WoPR_{it}$ must be set to the planned baseline rate for the project.

STEP 2: Estimate the new rate of forest clearance by the focal agent of deforestation with project implementation if no leakage is occurring

For each stratum *i* at each time *t*, subtract the area of planned deforestation for within the project area from the historic area of deforestation by the agent of deforestation to calculate the new "zero leakage" area of forest cleared at time *t*.

$$NewR_{it} = WoPR_{it} - A_{B,it}^{cleared} \quad (113)$$

Where:

$NewR_{it}$ = New calculated area of forest clearance in stratum i and time t by the baseline agent of planned deforestation where no leakage is occurring; ha

$WoPR_{it}$ = Area of deforestation by the baseline agent of the planned deforestation in stratum i at time t in the absence of the project; ha

$A_{B,it}^{cleared}$ = Area cleared under the baseline scenario for stratum i, in time t; ha

i = 1, 2, 3, …, m_{LK} leakage strata

t = 1, 2, 3, …, t* years elapsed since the start of the project activity

STEP 3: Monitor all areas deforested by baseline agent of deforestation through the years in which planned deforestation was forecast to occur

All areas deforested by the baseline agent must be monitored through the first five years in which planned deforestation was forecast to occur. Areas of deforestation may be in the project region or anywhere in the host country, but will include only those lands controlled by the deforestation agent. There is no requirement to track international leakage.

$$LKA_{planned,it} = A_{defLK,it} - NewR_{it} \quad (114)$$

Where:

$LKA_{planned,it}$ = The area of activity shifting leakage in stratum i at time t; ha

$NewR_{it}$ = New calculated area of forest clearance by the baseline agent of the planned deforestation in stratum i at time t when no leakage is occurring; ha

$A_{defLK,it}$ = The total observed area of deforestation by the baseline agent in stratum i at time t; ha

i = 1, 2, 3, ..., m_{LK} leakage strata

t = 1, 2, 3, ..., t* years elapsed since the start of the project activity

If $NewR_{it}$ exceeds $A_{defLK,it}$ (i.e., the area of deforestation under the no leakage scenario exceeds the actual observed rate), then $LKA_{planned,it}$ must be set as zero, as positive leakage is not considered under the VCS.

8.3.2.2 Net carbon stock changes and GHG emissions (ΔC_{it_init} and $\Delta C_{jt\_continued}$)

8.3.2.2.1 Initial emissions resulting from land use conversion (ΔC_{it_init})

ΔC_{it_init} represents the average initial carbon stock changes and greenhouse gas emissions caused by deforestation activities in a leakage stratum *i* at time *t*.

The equation for estimating ΔC_{it_init} depends on the area of activity displacement leakage, $LKA_{planned,it}$ (Equation 114), relative to the area deforested in the baseline scenario, $A_{B,it}^{cleared}$. If $LKA_{planned,it}$ is less than 40% of $A_{B,it}^{cleared}$, then leaked emissions from timber harvesting are excluded from the calculation because they are accounted for in market effects leakage calculations (Section 8.3.1). The rationale for using this 40% threshold is that the VCS market leakage table assumes a market leakage factor of 0.4 (40%) in cases where the likely source of timber is similar to the project conditions. If activity shifting leakage leads to timber production less than or equal to this 40% threshold, then emissions have already been covered by market leakage. In cases where $LKA_{planned,it}$ is greater than 40% of $A_{B,it}^{cleared}$, then not all timber emissions will have been covered under market leakage and the additional emissions need to be accounted for in activity displacement leakage.

Both calculations include other emission sources (non-timber biomass cleared for site preparation, emissions from the burning and drainage of peat).

For leakage strata that are also included as baseline strata, ΔC_{it_init} is calculated as follows:

If $LKA_{planned,it} \leq 40\%$ of $A_{B,it}^{cleared}$:

$$\Delta C_{it\_init} = \left[\frac{44}{12} \times MC_{B,AG,it} - C_{ML,it}\right] + \frac{E_{B,p,t}}{A_{B,it}^{cleared}} \quad (115)$$

$$C_{ML,it} = \left(B_{B,it}^{logged} \times CF\right) + \left(MV_{B,AG\_tree,it} \times LDF\right) \quad (116)$$

where:

ΔC_{it_init} = average initial carbon stock changes and GHG emissions for stratum i at time t; t CO_2e ha^{-1}

$C_{ML,it}$ = average carbon stocks accounted for as timber emissions under market leakage; t C ha^{-1}

$MC_{B,AG,it}$	= mean carbon stock in above-ground living biomass under the baseline scenario for stratum i, time t; t C ha^{-1} (Equation 20)
$B_{B,it}^{logged}$	= timber biomass logged under the baseline scenario for stratum i at time t; t d.m. ha-1 (Equation 14)
CF	= carbon fraction of dry matter
$A_{B,it}^{cleared}$	= Area cleared under the baseline scenario for stratum i, in time t; ha
$E_{B,p,t}$	= total baseline GHG emissions from peat under the baseline scenario at time t; t CO2-e (Equation 59)
$MV_{B,AG\_tree,it}$	= mean merchantable volume under the baseline scenario in stratum i at time t; m^3 ha^{-1}
LDF	= Logging damage factor; t C m^{-3} (default 0.37 t C m^{-3})

If $LKA_{planned,it}$ > 40% of $A_{B,it}^{cleared}$:

$$\Delta C_{it\_init} = \left\{\frac{44}{12} \times \left[\left(LKP_{unaccounted,it} \times C_{ML,it}\right) + \left(MC_{B,AG,it} - C_{ML,it}\right)\right]\right\} + \frac{E_{B,p,t}}{A_{B,it}^{cleared}} \tag{117}$$

$$LKP_{unaccounted,it} = \frac{LKA_{planned,it}}{A_{B,it}^{cleared}} - 0.4 \tag{118}$$

where:

ΔC_{it_init}	= average initial carbon stock changes and GHG emissions for stratum i at time t; t CO_2e ha^{-1}
$C_{ML,it}$	= average carbon stocks accounted for as timber emissions under market leakage; t C ha^{-1}
$LKP_{unaccounted,it}$	= unaccounted proportion of timber emissions not accounted for under market leakage, dimensionless
$LKA_{planned,it}$	= The area of activity shifting leakage at time t; ha
$A_{B,it}^{cleared}$	= Area cleared under the baseline scenario for stratum i, in time t; ha
$MC_{B,AG,it}$	= mean carbon stock in above-ground living biomass under the baseline scenario for stratum i, time t; t C ha^{-1} (Equation 20)
$E_{B,p,t}$	= total baseline GHG emissions from peat under the baseline scenario at time t; t CO_2-e (Equation 59)

In some cases, activities may be displaced to leakage strata that do not exist as baseline strata (e.g., activities are displaced from peat forests to forests on mineral soils), and new estimates of average carbon stock changes and GHG emissions will need to be developed (except in the case where activities are displaced to areas with negligible aboveground carbon stocks on mineral soils, in which case LK=0). In leakage strata that are not included as baseline strata, no timber was to be extracted under the baseline scenario and so $V_{B,it}$ = 0, $C_{B,XBT,it}$ = 0, and $LK_{ME,it}$ = 0. Therefore, $LK_{AD,it}$ for leakage strata not included as baseline strata is calculated using the average carbon stock value without a deduction for the carbon stocks in merchantable biomass:

$$\Delta C_{ikt\_init} = \left(\frac{44}{12} \times MC_{LK,AG,it}\right) + \Delta SOC_{kt} \tag{119}$$

Where:

ΔC_{ikt_init} = average initial carbon stock changes and GHG emissions for landcover stratum i and peat stratum k at time t; t CO_2e ha^{-1}

$MC_{LK,AG,it}$ = mean carbon stocks in aboveground biomass in leakage stratum i at time t; t C ha^{-1}

ΔSOC_{kt} = mean change in soil carbon stocks in stratum k at time t after conversion to annual cropland; t CO_2-e ha^{-1}

ΔSOC_{kt} may be defined as zero if activities displaced to leakage stratum *k* involve clearing land for perennial cropland (e.g., oil palm, rubber, etc.). Where displaced activities involve clearing land for annual cropland, the change in soil carbon stocks in stratum *k* at time *t* must be estimated as:

$$\Delta SOC_{kt} = \frac{44}{12} \times \left(\frac{C_{soil,kt} - \left(C_{soil,kt} \times F_{LU} \right)}{20} \right) \quad (120)$$

Where:

ΔSOC_{kt} = mean change in soil carbon stocks in stratum k at time t after conversion to annual cropland; t CO_2-e ha^{-1}

$C_{soil,kt}$ = average soil carbon stocks to 30 cm depth in stratum k at time t before conversion to annual cropland; t C ha^{-1}

F_{LU} = land-use factor for calculating relative soil carbon stock changes; dimensionless

Equation 120 for calculating the change in soil carbon stocks is based on the methodology outlined in Section 5.3.3.4 of the 2006 IPCC AFOLU Guidelines. Default values for F_{LU} must be selected by climate type from the latest IPCC documentation (e.g. Table 5.5 of the IPCC AFOLU Guidelines). Management and input factors are conservatively ignored in this methodology. Average soil carbon stocks in leakage stratum *i* before conversion to annual cropland must be estimated using field measurements made in proxy areas or conservative default values from the literature.

8.3.2.2.2 Continued emissions resulting from peat drainage and/or soil carbon loss ($\Delta C_{kt\_continued}$)

For displaced activities involving conversion to annual cropland on mineral soils or peat drainage, greenhouse gas emissions must be accounted for beyond the initial year of clearing, because these emissions will continue in years after the initial land use conversion.

Average continued leakage emissions for all strata on peat must be calculated as:

$$\Delta C_{kt\_continued} = ME_{B,dd,kt} \quad (121)$$

Average continued leakage emissions for all strata on mineral soils that are converted to annual cropland must be calculated as:

$$\Delta C_{kt\_continued} = \Delta SOC_{kt} \quad (122)$$

Where:

$\Delta C_{kt\_continued}$ = average greenhouse gas emissions resulting from continued peat drainage or soil emissions in stratum k; t CO_2-e ha^{-1}.

$ME_{B,dd,kt}$ = mean CO_2 emissions from drained peat in stratum k, time t; t CO_2 ha^{-1}

ΔSOC_{kt} = mean change in soil carbon stocks in stratum k at time t after conversion to annual cropland; t CO_2-e ha^{-1}

ΔSOC_{kt} must be accounted for in the year of initial clearing as well as the following 19 years. Continued peat drainage emissions in the leakage area may be calculated following the same procedures as in Section 8.1.2.1. If a stratified peat depth map is unavailable for the leakage area, existing soil and remote sensing data may be combined to differentiate peat and mineral soils and continued peat drainage emissions will only be accounted for in areas identified as peat. If there is no information on peat depth, it is conservative to assume that PDT is greater than the project lifetime and to account for peat drainage emissions for every year following the draining of the leakage area.

8.3.3 Ecological Leakage

Ecological leakage occurs in WRC projects where a project activity causes changes in GHG emissions or fluxes of GHG emissions in hydrologically connected areas outside the project area. As this methodology is only applicable to projects conserving and protecting existing wetlands, the risk of ecological leakage is low and there is no ecological leakage in projects that meet the applicability conditions of this methodology Applicability Condition K of this methodology requires that the project area either be hydrologically independent from adjacent areas or that activities are designed and the project site is selected so that there is no ecological leakage. If the project is hydrologically connected to areas outside the project area a hydrological buffer zone must be established and monitored to demonstrate that project activities do not result in increased emissions from hydrologically connected areas. Thus, if a project meets the applicability conditions of this methodology, $LK_{Ecological,t}$=0.

Project proponents must use module VMD0044 to demonstrate that the applicability conditions relevant to ecological leakage are met. This module provides more information on project design decisions and monitoring procedures within the buffer zone.

8.4 Net GHG Emission Reductions and Removals

Net Emissions Reductions (NERs) are calculated for year *t* with the following equation:

$$NER_t = C_{BSL,t} - C_{PRJ,t} - LK_t \tag{123}$$

NER_t = Net Emissions Reductions (NERs) calculated for year t

$C_{BSL,t}$ = sum of changes in aboveground carbon stocks and peat emissions in year t of the baseline scenario; t CO_2-e (Equation 5)

$C_{PRJ,t}$ = sum of emissions that occur within the project boundary as a result of emissions that were unanticipated and/or unable to be avoided by project activities in monitoring year t; t CO_2-e (Equation 70)

LK_t = Leakage emissions resulting from displacement of economic activities, market effects, and ecological effects at time t; t CO_2-e (Equation 106)

8.4.1 *Ex Ante* Net Anthropogenic GHG Emissions Avoided

The ex-ante net anthropogenic GHG emissions avoided as a result of stopping baseline activities is the estimated baseline net emissions minus leakage, in t CO_2-e:

$$C_{REDD,t} = C_{BSL,t} - LK_t \quad (124)$$

where:

$C_{REDD,t}$ = net reduction in emissions from deforestation at project year t; t CO_2-e

$C_{BSL,t}$ = baseline greenhouse gas emissions at project year t (Equation 5); t CO_2-e

LK_t = Leakage emissions resulting from displacement of economic activities, market effects, and ecological effects at project year *t* (Equation 106); t CO_2-e

The actual net greenhouse gas emissions avoided represent the sum of the avoided net decreases in carbon stocks and avoided peat emissions within the project boundary (C_{BSL}), minus any GHG emissions from the baseline scenario that are not prevented within the project boundary in the project case (C_{PRJ}), such as logging, fire, or other land use changes that lead to an increase in emissions. The calculations must be performed annually according to the monitoring plan. Therefore:

$$C_{ACTUAL,t} = C_{BSL,t} - C_{PRJ,t} \quad (125)$$

where:

$C_{ACTUAL,t}$ = actual net greenhouse gas emissions avoided at project year t; t CO_2-e.

$C_{BSL,t}$ = sum of peat emissions and carbon stock changes in aboveground biomass under the baseline scenario at project year t; t CO_2-e

$C_{PRJ,t}$ = sum of peat emissions and carbon stock changes in aboveground biomass under the project scenario at project year t; t CO_2-e

8.4.2 *Ex Post* Net Anthropogenic GHG Emissions Avoided

The *ex post* net anthropogenic GHG emissions avoided is calculated as the difference between the actual GHG emissions avoided minus leakage, therefore the following general formula may be used to calculate the net anthropogenic GHG emissions avoided by a project activity (C_{REDD}), in t CO_2-e:

$$C_{REDD,t} = C_{ACTUAL,t} - LK_t \quad (126)$$

where:

$C_{REDD,t}$ = net reduced emissions from deforestation for project year t; t CO_2-e

$C_{ACTUAL,t}$ = actual net greenhouse gas emissions avoided for project year t; t CO_2-e

LK_t = total leakage emissions for project year t; t CO_2-e

Calculation of VCUs

Total annual VCUs are calculated using the following equation:

$$VCUs_{,t} = C_{REDD,t} - BRR_t \quad \textbf{(127)}$$

Where:

$VCUs_{,t}$ = number of Verified Carbon Units for project year t

$C_{REDD,t}$ = net reduced emissions from deforestation for project year t; t CO_2-e

BRR_t = portion of carbon credits to be withheld as a buffer reserve for project year *t*

Buffer reserve must be calculated using *VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination*.

8.4.3 Estimating Maximum Project Crediting

The maximum GHG emissions reductions may not exceed the difference between soil carbon stocks 100 years after the project start date (i.e., *t*=100). Procedures for calculating SOC stocks in the baseline and project scenarios are found in the Stock Loss Approach of the VM0007 Module VMD0016. In order to demonstrate the permanence of soil carbon stocks within the project area, the difference between baseline and project scenario soil carbon stocks must be estimated for time *t*=100 with the following equation:

$$\Delta C_{PS,BS,SOC,t=100} = C_{PS,SOC,t=100} - C_{BS,SOC,t=100} \quad \textbf{(128)}$$

where:

$\Delta C_{PS,BS,t=100}$ = Net difference between baseline and project soil carbon stocks at year 100 of the project, the maximum crediting allowed for the project; t CO_2e

$C_{BS,t=100}$ = soil organic carbon stock in project scenario at t=100; t CO_2-e.

$C_{BS,t=100}$ = soil organic carbon stock in baseline scenario at t=100; t CO_2-e.

8.4.4 Accounting for Uncertainties

See Section 9.3.4.1 for information on QAQC procedures to be applied to the project. The following sections below detail how uncertainty must be included in all emissions calculations.

8.4.4.1 Uncertainties and Conservative Approach

Assessment of uncertainties must follow latest guidance offered by the IPCC (e.g. IPCC 2000, IPCC GPG-LULUCF and IPCC AFOLU). Particular examples of assessment of uncertainty related to expert judgement, use of default values, allometric equations used and methods to combine uncertainties are provided below.

8.4.4.2 Uncertainty estimation for individual baseline parameters

This methodology allows for the estimation of uncertainty in emissions and removals associated with REDD project activities. Use of the methodology while planning the project may assure that measurements are of sufficient intensity to minimize uncertainty deductions. Procedures including stratification and the allocation of sufficient measurement plots may help the project to ensure that low uncertainty in carbon stocks results and ultimately full crediting may result. It is good practice to apply this methodology at an early stage to identify the data sources with the highest uncertainty to allow the opportunity to conduct further work to diminish uncertainty.

Uncertainty is defined as the 90% confidence interval as a percentage of the mean:

$$U_s(\%) = \frac{(90\% ConfidenceIntervalWidth)}{\mu} * 100 \qquad \textbf{(129)}$$

Where:

U_s = percentage uncertainty on the estimate of the mean parameter value; %

μ = sample mean value of the parameter

A precision target of a 90% confidence interval equal to or less than 10% of the mean recorded value must be targeted. This is especially important in terms of project planning for measurement of carbon stocks where sufficient measurement plots must be included to achieve this precision level across the measured stocks.

Alternatively, (indisputably) conservative estimates may also be used instead of uncertainties, provided that they are based on verifiable literature sources or expert judgement. In this case the uncertainty is assumed to be zero.

Estimated carbon emissions and removals arising from REDD activities have uncertainties associated with measures/estimates of: area or other activity data, carbon stocks, biomass growth rates, expansion factors, and other coefficients. It is assumed that the uncertainties associated with the estimates of the various input data are available, either as estimates based on sound statistical sampling, default values from well-referenced peer reviewed literature or other well- established published sources, or expert judgement.

8.4.4.2.1 Uncertainty in parameters involving expert judgement

Expert judgement usually will consist of a range, perhaps quoted together with a most likely value. Under these circumstances the following rules apply:

- Where experts only provide an upper and a lower limiting value, assume the probability density function is uniform and that the range corresponds to the 90% confidence interval.
- Where experts also provide a most likely value, assume a triangular probability density function using the most likely values as the mode and assuming that the upper and lower limiting values each exclude 5% of the population. The distribution need not be symmetrical.

8.4.4.2.2 Uncertainty in allometric equations

Uncertainty in allometric equations used to estimate tree biomass must be assessed by testing actual values obtained from site-specific field data against predicted values. If field data were used to develop the allometric equation, then an independent dataset must be used to verify it.

Verification is demonstrated in cases where at least 75% of measured values fall within the 90% prediction intervals of the mean predicted response and show no systematic bias. Provided this is demonstrated, no further quantification of uncertainty in allometric equations is required. If less than 75% of measured values fall within the 90% prediction intervals then a new, site-specific allometric equation must be derived. Data showing the verification of the allometric equation must be outlined in the PD.

8.4.4.2.3 Uncertainty in literature values

All parameter values derived from data reported in the literature must include both the mean and standard deviation. A 90% confidence interval must be calculated and reported as the uncertainty around the mean value applied.

Where an uncertainty value is not known or may not be simply calculated, then a project must justify that it is using an indisputably conservative number and an uncertainty of 0% may be used for this component.

8.4.4.2.4 Uncertainty in the Rate of Deforestation

In this methodology, deforestation rates are based on actual deforestation plans by the baseline agent of deforestation, therefore assume the uncertainty of this baseline rate of clearing is zero.

8.4.4.2.5 Conservative choice and application of default data

When using default data, the following rules must be applied when selecting sources of data[20]:

- If an approved A/R CDM or VCS methodology requires application of a default value and provides its numerical value then the value must be considered as the conservative one;
- Values may be species- or location-specific, with selection from the following data sources (given in order of priority; highest first):

[20] Adapted from CDM EB 50 Report, Annex 23: “Guidelines on conservative choice and application of default data in estimation of the net anthropogenic GHG removals by sinks”, Version 02.

- Local peer-reviewed studies under similar climate/soil conditions – provided the smaller datasets typical of local studies are considered sufficiently reliable; or
- Regional or national values for the same ecological zone (that is, the same broad climate zone, and similar soil fertility and type (i.e., peat); or
- International or global values, including IPCC literature, for the same ecological zone.

- If species-specific default data are not available, data may be selected from studies in the same ecological zone for the same genus and regarded as conservative. Default data may also be selected from studies in the same ecological zone for the same family, provided the applicability of the data is checked. The priority for selection of default data sources must be that given in the bullet point above.
- If default data are available for conditions that are similar to the project, then mean values of the data are considered as conservative;
- In all other circumstances:
    - The mean values of default data may be considered as conservative if they have been checked against field measurements and the mean measured data fall within ±10% of the mean default value;
    - If the applicability of mean values of default data is not to be verified by field measurement, conservative values of default data may be assessed using the approach provided below:
    - If standard deviation is quoted, then the conservative value is defined as being one standard deviation above (or below, as appropriate) mean values;
    - If a standard error and the number of samples are quoted, then calculate the standard deviation by multiplying the standard error by the square root of the number of samples. The conservative value is defined as being one standard deviation above (or below, as appropriate) mean values;
    - If a range of data is quoted, but without a standard deviation, then assume the range represents the upper and lower 90% confidence limits of a normally distributed dataset. In this case the conservative value is that which falls halfway between the mean and the limits of the range;
    - If none of the above area provided, project participants must use estimates of standard deviations provided in paragraph iii below and assess the conservative value as being one standard deviation above (or below, as appropriate) mean values.
- If only mean data are quoted in reports or studies considered to otherwise contain credible data, or if the datasets are small and so it is considered the range of values may not be an adequate estimate of the standard deviation of the particular parameter, the following nominal values must be assumed for standard deviations, expressed here as percentages of the mean (as estimated from the range in IPCC data for these parameters):
    - Aboveground biomass of existing woody vegetation: 50%
    - BEFs of existing woody vegetation based on biomass stocks: -40% below the mean to +100% above

8.4.4.2.6 Uncertainty of the product of several terms

The percentage uncertainties on quantities that are the product of several terms are then estimated using the following equation[21]:

$$U_{B,SS,t} = \sqrt{U_1^2 + U_2^2 + \cdots U_n^2} \tag{130}$$

Where:

$U_{B,SS,t}$ = percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case (1,2,...n represent difference carbon pools and/or GHG sources); %

U_i = percentage uncertainties associated with each term of the product (parameters and activity data)

The equations assume that there is no significant correlation among emission and removal estimates and that uncertainties are relatively small. However, it still may be used to give approximate results where uncertainties are relatively large.

8.4.4.3 Estimate of total uncertainty in baseline scenario

Because the uncertainty associated with rates of deforestation are assumed to be zero in the case of planned deforestation, the total uncertainty estimate for each stratum is equal to $Uncertainty_{B,it}$ or $Uncertainty_{B,jt}$ (Equations131 and 132).

The percentage uncertainty on quantities that are the sum or difference of several terms (such as the sum of carbon stocks and greenhouse gas sources in the baseline case) may be estimated using the following simple error propagation equation[22]:

$$Uncertainty_{B,it} = \frac{\sqrt{\left(U_{B,SS1,it} * E_{B,SS1,it}\right)^2 + \left(U_{B,SS2,it} * E_{B,SS1,it}\right)^2 \cdots + \cdots \left(U_{B,SSn,it} * E_{B,SSn,it}\right)^2}}{E_{B,SS1,it} + E_{B,SS2,it} \cdots + \cdots E_{B,SSn,it}} \tag{131}$$

$$Uncertainty_{B,jt} = \frac{\sqrt{\left(U_{B,SS1,jt} * E_{B,SS1,jt}\right)^2 + \left(U_{B,SS2,jt} * E_{B,SS2,jt}\right)^2 \cdots + \cdots \left(U_{B,SSn,jt} * E_{B,SSn,jt}\right)^2}}{E_{B,SS1,jt} + E_{B,SS2,jt} \cdots + \cdots E_{B,SSn,jt}} \tag{132}$$

Where:

$Uncertainty_{B,it}$ = Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case of stratum i at time t; %

$Uncertainty_{B,jt}$ = Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case of stratum j at time t; %

[21] Equation 5.2.1 in GPG LULUCF

[22] Refers to equation 5.2.2 in GPG LULUCF

$U_{B,SS,it}$ = Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions of stratum i in the baseline scenario at time t (1,2…n represent different carbon pools and/or GHG sources); %

$U_{B,SS,jt}$ = Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions of stratum j in the baseline scenario at time t (1,2…n represent different carbon pools and/or GHG sources); %

$E_{B,SS,it}$ = Carbon stock, GHG sources or leakage emissions from aboveground biomass in stratum i at time t (1,2…n represent different carbon pools and/or GHG sources) in the baseline scenario; t CO_2-e

$E_{B,SS,jt}$ = Carbon stock, GHG sources or leakage emissions from peat in stratum j at time t (1,2…n represent different carbon pools and/or GHG sources) in the baseline scenario; t CO_2-e

To assess uncertainty across combined strata:

$$Uncertainty_{BSL,t} = \frac{\sqrt{\sum_{i=1}^{m_{BL}}\left(Uncertainty_{B.it} * E_{B,it}\right)^2}}{\sum_{i=1}^{m_{BL}} E_{B,it}} + \frac{\sqrt{\sum_{j=0}^{j^*}\left(Uncertainty_{B,jt} \times E_{B,jt}\right)^2}}{\sum_{j=0}^{j^*} E_{B,jt}} \quad (133)$$

where:

$Uncertainty_{BSL,t}$ = Total uncertainty in baseline scenario at time t; %

$Uncertainty_{B,it}$ = Uncertainty in the baseline scenario for stratum i at time t; %

$Uncertainty_{B,jt}$ = Uncertainty in the baseline scenario for stratum *j* at time *t*; %

$E_{B,it}$ = sum of peat emissions and carbon stock changes in aboveground biomass of stratum i under the baseline scenario at time t; t CO_2-e.

$E_{B,jt}$ = sum of peat emissions and carbon stock changes in peat of stratum j under the baseline scenario at time t; t CO_2-e.

8.4.4.4 Estimate of total uncertainty in the ex-post project scenario

In the ex-post project scenario, uncertainty for each landcover strata *i* and peat strata *k* are calculated as:

$$Uncertainty_{P,it} = \frac{\sqrt{\left(U_{P,SS1,it} * E_{P,SS1,it}\right)^2 + \left(U_{P,SS2,it} * E_{P,SS2,it}\right)^2 \cdots + \cdots \left(U_{P,SSn,it} * E_{P,SSn,it}\right)^2}}{E_{P,SS1,it} + E_{P,SS2,it} \cdots + \cdots E_{P,SSn,it}} \quad (134)$$

$$Uncertainty_{P,kt} = \frac{\sqrt{\left(U_{P,SS1,kt} * E_{P,SS1,kt}\right)^2 + \left(U_{P,SS2,kt} * E_{P,SS2,kt}\right)^2 \cdots + \cdots \left(U_{P,SSn,kt} * E_{P,SSn,kt}\right)^2}}{E_{P,SS1,kt} + E_{P,SS2,kt} \cdots + \cdots E_{P,SSn,kt}} \quad (135)$$

Where:

$Uncertainty_{Pi,t}$ = Uncertainty in the with-project scenario for stratum i at time t; %

$Uncertainty_{Pk,t}$ = Uncertainty in the with-project scenario for stratum k at time t; %

$U_{P,SS,it}$ = Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions of stratum i in the with-project case at time t (1,2…n represent different carbon pools and/or GHG sources); %

$U_{P,SS,kt}$ = Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions of stratum k in the with-project case at time t (1,2…n represent different carbon pools and/or GHG sources); %

$E_{P,SS,it}$ = Carbon stock, GHG sources or leakage emissions from aboveground biomass in stratum i at time t (1,2…n represent different carbon pools and/or GHG sources) in the with-project case; t CO_2-e

$E_{P,SS,kt}$ = Carbon stock, GHG sources or leakage emissions from peat in stratum k at time t (1,2…n represent different carbon pools and/or GHG sources) in the with-project case; t CO_2-e

t = 1, 2, 3, …t* years elapsed since the start of the project activity

To assess uncertainty across combined strata:

$$Uncertainty_{P,t} = \frac{\sqrt{\sum_{i=1}^{M}\left(Uncertainty_{P,it} \times E_{P,it}\right)^2}}{\sum_{i=1}^{M} E_{P,it}} + \frac{\sqrt{\sum_{k=0}^{k^*}\left(Uncertainty_{P,kt} \times E_{P,kt}\right)^2}}{\sum_{k=0}^{k^*} E_{P,kt}} \quad \textbf{(136)}$$

$$E_{P,it} = C_{P,it} + LK_{AD,it} + LK_{ME,it} \quad \textbf{(137)}$$

$$E_{P,kt} = C_{P,kt} + LK_{AD,kt} + LK_{ME,kt} \quad \textbf{(138)}$$

Where:

$Uncertainty_{P,t}$ = Total uncertainty in project scenario at time t; %

$Uncertainty_{Pi,t}$ = Uncertainty in the with-project scenario for stratum i at time t; %

$Uncertainty_{Pk,t}$ = Uncertainty in the with-project scenario for stratum *k* at time *t*; %

$E_{P,it}$ = sum of emissions and carbon stock changes in aboveground biomass of stratum *i* project year *t*; t CO_2-e.

$E_{P,kt}$ = sum of emissions and carbon stock changes in peat of stratum *k* at project year *t*; t CO_2-e

$C_{P,it}$ = Total project area emissions in stratum *i* at project year *t*; tCO_2-e

$LK_{AD,it}$ = Total emissions from activity-shifting leakage in stratum *i* at project year *t*; tCO_2-e

$LK_{ME,it}$ = Total emissions from market leakage in stratum *i* at project year *t*; tCO_2-e

$C_{P,kt}$ = Total project area emissions in stratum *k* at project year *t*; tCO_2-e

$LK_{AD,kt}$ = Total emissions from activity-shifting leakage in stratum *k* at project year *t*; tCO_2-e

$LK_{ME,kt}$ = Total emissions from market leakage in stratum *k* at project year *t*; tCO_2-e

t = 1, 2, 3, …*t** years elapsed since the start of the project activity

8.4.4.5 Total Error in REDD Project Activity

$$C_{REDD\_ERROR,t} = \frac{\sqrt{\left(Uncertainty_{BSL,t} \times C_{BSL,t}\right)^2 + \left(Uncertainty_{P,t} \times \left(C_{PRJ,t} + LK_t\right)\right)^2}}{C_{BSL,t} + C_{PRJ,t} + LK_t} \quad (139)$$

Where:

$C_{REDD\_ERROR,t}$	= Total uncertainty for REDD project activity at time t; %
$Uncertainty_{BSL,t}$	= Total uncertainty in baseline scenario at time t; % (Equation 133)
$Uncertainty_{P,t}$	= Total uncertainty in the with-project scenario at time *t*; % (Equation 136)
$C_{BSL,t}$	= sum of changes in aboveground carbon stocks and peat emissions in year *t* of the baseline scenario; t CO_2-e (Equation 5)
$C_{PRJ,t}$	= sum of emissions that occur within the project boundary as a result of emissions that were unanticipated and/or unable to be avoided by project activities in monitoring year *t*; t CO_2-e (Equation 70)
LK_t	= Leakage emissions resulting from displacement of economic activities, market effects, and ecological effects at time *t*; t CO_2-e (Equation 106)

8.4.4.6 Implications for Project Accounting

The allowable uncertainty under this methodology is +/- 10% of $C_{REDD,t}$ at the 90% confidence level. Where this precision level is met, then no deduction for uncertainty is required. Where uncertainty exceeds 10% of $C_{REDD,t}$ at the 90% confidence level then the deduction must be equal to the amount that the uncertainty exceeds the allowable level. If uncertainty exceeds this threshold, $C_{REDD,t}$ must be replaced by the adjusted value for $C_{REDD,t}$ (Adjusted_$C_{REDD,t}$) in final VCU calculations (Equation 127).

The adjusted value for $C_{REDD,t}$ to account for uncertainty must be calculated as:

$$Adjusted\_C_{REDD,t} = C_{REDD,t} * \frac{\left(100 - C_{REDD\_ERROR,t} + 10\right)}{100} \quad (140)$$

Where:

$C_{REDD,t}$	= Net anthropogenic greenhouse emission reductions at time t; t CO_2-e
$C_{REDD\_ERROR,t}$	= Total uncertainty for REDD project activity; %
Adjusted_$C_{REDD,t}$	= Adjusted value for $C_{REDD,t}$ to account for uncertainty; t CO_2-e

9 MONITORING

9.1 Data and Parameters Available at Validation

Data / Parameter	$A_{PD_D,k,t=0}$
Data unit	Hectares
Description	Area in stratum k at a peat depth of D as of the beginning of the baseline crediting period
Equations	1
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	PD_D
Data unit	cm
Description	Peat depth of area at depth D
Equations	1
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of	See Section 5.3.2

measurement methods and procedures applied	
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	A_k
Data unit	Hectares
Description	Total area of stratum k
Equations	1
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$PD_{D,min,k}$
Data unit	cm
Description	Minimum bound of peat depth D within stratum k
Equations	1
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project

Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$PD_{D,max,k}$
Data unit	cm
Description	Maximum bound of peat depth D within stratum k
Equations	1
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	k
Data unit	strata
Description	1, 2, 3, …k^* peat depth strata
Equations	1
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps,

	vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	m_{BL}
Data unit	Strata
Description	Number of ex ante defined baseline strata i
Equations	N/A, used to determine baseline stratification (Section 5.3.1)
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	The factors influencing carbon stock changes in carbon pools are defined. From there, local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified are collected. It is from this information that the project and leakage areas are stratified, creating a dynamic stratification with diverse considerations.
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	m_{PS}
Data unit	Strata

Description	Number of strata i in the project scenario as determined ex ante
Equations	N/A, used to determine project scenario stratification (Section 5.3.1)
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	The factors influencing carbon stock changes in carbon pools are defined. From there, local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified are collected. It is from this information that the project and leakage areas are stratified, creating a dynamic stratification with diverse considerations.
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	m_{LK}
Data unit	Strata
Description	Number of strata i in the leakage scenario
Equations	N/A, used to determine leakage stratification (Section 5.3.1)
Source of data	Local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	The factors influencing carbon stock changes in carbon pools are defined. From there, local site classification maps/tables, the most updated land use/cover maps, land planning maps, aerial imagery, satellite images, soil maps, vegetation maps, landform maps, peat depth maps, and literature reviews of site information concerning key factors identified are collected. It is from this information that the leakage is stratified, creating a dynamic stratification with diverse considerations.
Purpose of Data	Calculation of leakage

Comments	N/A

Data / Parameter	$D_{Peat,B,pb,k}$
Data unit	cm
Description	Average depth of peat following the burning of biomass and peat in the baseline scenario for strata k; cm
Equations	2
Source of data	Section 5.3.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$D_{Peat,k,t=0}$
Data unit	cm
Description	Average peat depth in stratum k at the project start date; cm
Equations	2
Source of data	Peat maps built through peat monitoring
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$D_{peatburn,B,k}$
Data unit	cm
Description	Depth of peat burned in the baseline scenario for stratum k, (cannot exceed the maximum peat depth burned
Equations	2
Source of data	Section 5.3.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$PDT_{y,l}$
Data unit	years
Description	Years after land-clearing/burning in stratum l in which peat oxidation ceases (PDT); years t
Equations	3, 4
Source of data	Peat surveys
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$S_{y,l}$
Data unit	cm yr^{-1}
Description	Subsidence rate in stratum l at year y
Equations	3
Source of data	Section 5.3.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	l
Data unit	cm
Description	Average depth of peat following the burning of biomass and peat in the baseline scenario for strata k; cm
Equations	3
Source of data	Section 5.3.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	z

Data unit	years
Description	Number of years t after the project start date at which peat is depleted and/or peat oxidation no longer continues in the baseline scenario
Equations	4
Source of data	Section 5.3.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	j
Data unit	stratum
Description	1, 2, 3, …j* baseline PDT stratum
Equations	
Source of data	Section 5.3.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions Calculation of project emissions Calculation of leakage emissions
Comments	N/A

Data / Parameter	$t_{cleared}$

Data unit	years
Description	Number of years after the project start date in which area is cleared; years t
Equations	4
Source of data	Section 5.3.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$C_{BSL,t}$
Data unit	t CO_2-e
Description	sum of changes in aboveground carbon stocks and peat emissions in year t of the baseline scenario; t CO_2e.
Equations	5
Source of data	See Section 8.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$\Delta C_{B,AG,it}$

Data unit	t CO_2-e
Description	sum of carbon stock changes in aboveground biomass under the baseline scenario for stratum i at time t; t CO_2e
Equations	5, 6
Source of data	See Section 8.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,p,t}$
Data unit	t CO_2-e
Description	total baseline GHG emissions from peat under the baseline scenario at time t
Equations	5, 59
Source of data	Section 8.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	i

Data unit	unitless
Description	1, 2, 3, …m_{BL} baseline land use/landcover strata
Equations	All equations requiring calculations using LULC stratification
Source of data	Section 5.3.1
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.1
Purpose of Data	Calculation of baseline emissions Calculation of project emissions Calculation of leakage emissions
Comments	N/A

Data / Parameter	b
Data unit	strata
Description	1, 2, 3, …b* baseline peat burn depth stratum in year t
Equations	N/A
Source of data	See Section 5.3.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.2
Purpose of Data	Calculation of baseline emissions Calculation of project emissions Calculation of leakage emissions
Comments	N/A

Data / Parameter	t
Data unit	years
Description	1, 2, 3, …t* years elapsed since the start of the project activity
Equations	N/A
Source of data	Project start date
Value applied	N/A, dependent on project start date and project crediting period
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Calculation of baseline emissions Calculation of project emissions Calculation of leakage emissions
Comments	N/A

Data / Parameter	$E_{timber,it}$
Data unit	t CO_2-e
Description	Sum of carbon stock changes in aboveground biomass due to timber extraction prior to land clearing in stratum i at time t
Equations	6, 7
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$C_{B,it}^{extracted}$
Data unit	t C
Description	carbon stocks from trees extracted under the baseline scenario in stratum i at time t
Equations	7, 8, 17
Source of data	Section 8.1.1.1
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$C_{B,it}^{woodproducts}$
Data unit	t C
Description	carbon stocks moving into long-term wood products under the baseline scenario for stratum i at time t
Equations	7, 9
Source of data	Current, relevant, and local literature or surveys from an appropriate proxy area
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$B_{B,it}^{logged}$
Data unit	t d.m. ha^{-1}
Description	timber biomass logged under the baseline scenario for stratum i at time t
Equations	8
Source of data	Current, relevant, and local literature or surveys from an appropriate proxy area
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	CF
Data unit	Dimensionless
Description	Carbon fraction of dry matter
Equations	8, 24, 33, 37, 39, 54, 74, 79, 80, 85, 109, 116
Source of data	Locally-derived values, literature, or IPCC default
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.1.1
Purpose of Data	Calculation of baseline emissions Calculation of project emissions Calculation of leakage emissions
Comments	N/A

Data / Parameter	$A^{logged}_{B,it}$
Data unit	Ha
Description	Area of land logged under the baseline scenario for stratum i, in time t
Equations	8
Source of data	LULC classification of project area and planned conversion areas
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 5.3.1 and 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	p
Data unit	%
Description	percent of harvest industrial roundwood going into long term wood products
Equations	9
Source of data	Current, relevant literature or surveys from an appropriate proxy area
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$PV_{B,it}$

Data unit	m^3 ha^{-1}
Description	Plot level volume to be extracted under the baseline scenario in stratum i at time t
Equations	10, 11
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$PB_{B,it}$
Data unit	t d.m. ha^{-1}
Description	Plot level biomass to be extracted under the baseline scenario in stratum i at time t
Equations	12, 13
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$TV_{B,tr}$

Data unit	m^3 $tree^{-1}$
Description	Volume per tree tr in trees to be extracted under the baseline scenario
Equations	10
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$TB_{B,tr}$
Data unit	t d.m. $tree^{-1}$
Description	Biomass per tree tr in trees to be extracted under the baseline scenario
Equations	12
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	XF
Data unit	Dimensionless

Description	Plot expansion factor from per plot values to per hectare values
Equations	10, 12, 13
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	ϕ_i
Data unit	t d.m. m^{-3} merchantable volume
Description	volume-weighted average wood density
Equations	11
Source of data	Current, relevant, and local literature or surveys from an appropriate proxy area
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	BEF
Data unit	Dimensionless

Description	biomass expansion factor for conversion of biomass of merchantable volume to above-ground biomass
Equations	11
Source of data	Current, relevant, and local literature
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	AP
Data unit	m^2
Description	Plot area
Equations	13
Source of data	Aerial imagery; inventory protocol
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	tr
Data unit	trees

Description	1, 2, 3, …, TR trees (TR = total number of trees in the plot expected to be extracted)
Equations	10, 12
Source of data	Inventory data
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$B_{B,it}^{logged}$
Data unit	t d.m. ha^{-1}
Description	Timber biomass logged under the baseline scenario for stratum i at time t
Equations	14
Source of data	Section 8.1.1.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,BiomassBurn,it}$
Data unit	t CO_2-e

Description	sum of carbon stock changes in aboveground biomass due to biomass burning for stratum i at time t under the baseline scenario
Equations	6, 15
Source of data	Section 8.1.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,BiomassBurn,CO2,it}$
Data unit	t CO_2-e
Description	CO_2 emission from biomass burning under the baseline scenario in stratum i at time t
Equations	15, 16, 18, 19
Source of data	Section 8.1.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,BiomassBurn,N2O,it}$
Data unit	t CO_2-e

Description	N_2O emission from biomass burning under the baseline scenario in stratum i at time t
Equations	15, 18
Source of data	Section 8.1.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,BiomassBurn,CH_4,it}$
Data unit	t CO_2-e
Description	CH_4 emission from biomass burning under the baseline scenario in stratum i at time t
Equations	15, 19
Source of data	section 8.1.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$C_{B,AC,it}$
Data unit	t C

Description	Estimated above-ground biomass carbon stock before burning in the baseline scenario for stratum i, time t
Equations	16, 17
Source of data	Section 8.1.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$PBB_{B,it}$
Data unit	Dimensionless
Description	Average proportion of $C_{B,AC,it}$ burnt under the baseline scenario in stratum i, time t
Equations	16
Source of data	Section 8.1.1.2
Value applied	1
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter:	$MC_{B,AG,it}$
Data unit:	t C ha^{-1}

Description:	Mean carbon stock in above-ground living biomass under the baseline scenario for stratum *i*, time *t*
Equations	17, 20, 91, 99, 115, , 117
Source of data:	Plot measurements
Description of measurement methods and procedures to be applied:	See sections 8.1.1.3 8.2.2, 8.2.3, 8.3.2.1, and 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review of plot measurements
Purpose of data:	Calculation of project emissions
Calculation method:	See sections 8.2.2, 8.2.3, 8.3.2.1, and 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$A_{B,it}^{cleared}$
Data unit:	ha
Description:	Area cleared under the baseline scenario for stratum i, in time t
Equations	17, 113, 116, 118
Source of data:	Carbon accounting calculations based on relevant local literature and field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.2.1 and 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare satellite imagery and field reports

Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1 and 8.3.2.2.1
Comments:	N/A

Data / Parameter	$R_{B,growth,it}$
Data unit	t CO_2-e
Description	Total annual increase in carbon stock due to growth of living trees on the future land-use in the baseline scenario for stratum i at time t
Equations	6, 43
Source of data	Section 8.1.1.4
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.4
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{harvest,it}$
Data unit	t CO_2-e
Description	Emissions from harvesting operations in stratum i at time t
Equations	6, 50
Source of data	Section 8.1.1.5
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.5

Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$C_{BH,it}^{extracted}$
Data unit	tC
Description	Carbon stocks of timber extracted at harvest H under the baseline scenario in stratum i at time t
Equations	50, 51
Source of data	Section 8.1.1.5
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.5
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$C_{BH,it}^{woodproducts}$
Data unit	tC
Description	Carbon stocks from harvest H moving into long term wood products under the baseline scenario for stratum i at time t
Equations	50, 52
Source of data	Current, relevant, and local literature or surveys from an appropriate proxy area
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.1.5

Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,Drainage,t}$
Data unit	t CO_2-e
Description	GHG emissions from drainage activities on peatlands on-site under the baseline scenario at time t
Equations	59, 60
Source of data	Section 8.1.2.1
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.2.1
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,PeatBurn,t}$
Data unit	t CO_2-e
Description	GHG emissions from peat burning under the baseline scenario at time t
Equations	59, 64
Source of data	Section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.2.2

Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B, DOC, t}$
Data unit	t CO_2-e
Description	GHG emissions from dissolved organic carbon exported from drained organic soils under the baseline scenario at time t
Equations	59, 68
Source of data	Section 8.1.2.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.2.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,drainage,CO2,t}$
Data unit	t CO_2-e
Description	Annual baseline CO2 emissions from drained peat under the baseline scenario at time t
Equations	60, 61
Source of data	Section 8.1.2.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See sections 8.1.2.1 and 8.1.2.1.2

Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,drainage,CH_4,t}$
Data unit	t CO_2-e
Description	Annual baseline CH_4 emissions from drained peat under the baseline scenario at time t
Equations	60, 62
Source of data	section 8.1.2.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See sections 8.1.2.1 and 8.1.2.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,drainage,N_2O,t}$
Data unit	t CO_2-e
Description	Annual baseline N_2O emissions from drained peat under the baseline scenario at time t
Equations	60, 63
Source of data	See sections 8.1.2.1 and 8.1.2.1.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See sections 8.1.2.1 and 8.1.2.1.3

Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$A_{B,drain,j}$
Data unit	Ha
Description	Entire land area of drained organic soils under the baseline scenario in stratum j
Equations	61, 62, 63
Source of data	Section 8.1.2.1.4
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See Section 8.1.2.1.4
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$EF_{B,drainage,jt,\ CO_2}$
Data unit	t CO_2 ha^{-1}
Description	Emissions factor for drained organic soils in stratum j, time t
Equations	61
Source of data	IPCC default, current, relevant, and local literature, or field surveys
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.1.1
Purpose of Data	Calculation of baseline emissions

Comments	N/A

Data / Parameter	$EF_{CH4,land,jt}$
Data unit	t CH_4 ha^{1} yr^{-1}
Description	Emission factors for direct CH_4 emissions from drained organic soils in stratum j, project year t
Equations	62
Source of data	Current, relevant, and local literature or field surveys
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$EF_{CH4,ditch,jt}$
Data unit	t CH_4 $ha^{-1}yr^{-1}$
Description	Emission factors for CH_4 emissions from drainage ditches in stratum j, project year t
Equations	62
Source of data	section 8.1.2.1.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.1.2
Purpose of Data	Calculation of baseline emissions

Comments	N/A

Data / Parameter	$Frac_{ditch}$
Data unit	Unitless
Description	Fraction of the total area of drained organic soil which is occupied by ditches
Equations	62
Source of data	Current, relevant, and local literature or field surveys from an appropriate proxy area
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.1.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$EF_{N_2O,jt}$
Data unit	t N_2O ha^{-1} yr^{-1}
Description	Emissions factor for annual N_2O emissions per hectare within drained peat in stratum j at time t
Equations	63
Source of data	IPCC Guidelines, Current, relevant, and local literature or field surveys
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.1.3
Purpose of Data	Calculation of baseline emissions

Comments	N/A

Data / Parameter	GWP_{N_2O}
Data unit	Dimensionless
Description	GWP for N_2O at time *t*
Equations	63
Source of data	*IPCC Guidelines*
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.1.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,PeatBurn,bt}$
Data unit	t CO2e
Description	Total increase in CO_2-e emissions as a result of peat burning under the baseline scenario in stratum *b*, time *t*
Equations	64
Source of data	See section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,PeatBurn,CO2,bt}$
Data unit	t CO2e
Description	Total CO2 emissions from peat burning under the baseline scenario in stratum b, time t
Equations	64, 65
Source of data	section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	*N/A*

Data / Parameter	$E_{B,PeatBurn,CH4,bt}$
Data unit	t CO2e
Description	Total CH_4 emissions from peat burning under the baseline scenario in stratum *b* time *t*
Equations	64, 66
Source of data	Section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$M_{B,p,bt}$
Data unit	tons
Description	Mass of peat burned under the baseline scenario in stratum b, time t
Equations	65, 66, 67
Source of data	Section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	EF_{CO2}
Data unit	g CO2 t $peat^{-1}$
Description	CO2 emissions factor for the combustion of peat
Equations	65
Source of data	Current, relevant, and local literature or field surveys/IPCC Guidelines
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	EF_{CH4}

Data unit	g CH_4 t peat^{-1}
Description	CH4 emissions factor for the combustion of peat
Equations	66
Source of data	Current, relevant, and local literature or field surveys/IPCC Guidelines
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$D_{B,burn,bt}$
Data unit	Meters
Description	Depth of peat burned (D) under the baseline scenario in stratum b at time t
Equations	67
Source of data	Section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	*N/A*

Data / Parameter	$A_{B,burn,bt,D}$
Data unit	Ha

Description	Area of peat burned at depth D under the baseline scenario in stratum b at time t
Equations	67
Source of data	Section 8.1.2.2
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	BD_b
Data unit	g cm-3 = t m-3
Description	Bulk density of peat in stratum b
Equations	67
Source of data	Current, relevant, and local literature or field surveys
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.2
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{B,DOC,t}$
Data unit	tCO_2-e
Description	Annual off-site CO_2 emissions due to dissolved organic carbon loss from drained peat soil under the baseline scenario at project year t

Equations	68
Source of data	Section 8.1.2.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$EF_{B,DOC,jt}$
Data unit	t CO_2e ha^{-1}
Description	Emissions factor for annual CO_2 emissions due to DOC loss from drained peat soils in stratum j and project year t
Equations	68
Source of data	section 8.1.2.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$DOC_{FLUX_{NATURAL},jt}$
Data unit	$tCO_2e\ ha^{-1}yr^{-1}$
Description	Flux of DOC from natural/undrained organic soil in stratum j at baseline year t
Equations	68

Source of data	Section 8.1.2.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	ΔDOC_{drain}
Data unit	Unitless
Description	Proportional increase in DOC flux from drained sites relative to undrained sites
Equations	69
Source of data	section 8.1.2.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$Frac_{DOC\_CO2}$
Data unit	Unitless
Description	Conversion factor for proportion of DOC converted to CO_2 following export from site
Equations	69

Source of data	Section 8.1.2.3
Value applied	N/A, varies from project to project
Justification of choice of data or description of measurement methods and procedures applied	See section 8.1.2.3
Purpose of Data	Calculation of baseline emissions
Comments	N/A

9.2 Data and Parameters Monitored

9.2.1 Data to be Collected and Archived for *Ex Post* Net Actual GHG Emissions Avoided

Data / Parameter:	k
Data unit:	Strata
Description:	1, 2, 3, …k* peat depth strata
Equations	1
Source of data:	Stratification of project and leakage areas as of the beginning of the baseline crediting period
Description of measurement methods and procedures to be applied:	See section 5.3.2
Frequency of monitoring/recording:	Estimated at beginning of baseline crediting period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 5.3.2.
Comments:	N/A

Data / Parameter:	$C_{PRJ,t}$
Data unit:	t CO_2-e
Description:	Sum of emissions that occur within the project boundary as a result of emissions that were unanticipated and/or unable to be avoided by project activities in monitoring year t
Equations	70
Source of data:	Monitoring data from most recent monitoring period
Description of measurement methods and procedures to be applied:	See section 8.2
Frequency of monitoring/recording:	Estimated annually
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.
Comments:	N/A

Data / Parameter:	$E_{P,t}^{logging}$
Data unit:	t CO_2-e
Description:	GHG emissions due to logging in monitoring year t;
Equations	70, 71
Source of data:	Field surveys or satellite imagery from monitoring period.
Description of measurement methods and procedures to be applied:	See sections 8.2 and 8.2.1

Frequency of monitoring/recording:	Once per monitoring period.
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.
Comments:	N/A

Data / Parameter:	$E_{P,t}^{fire}$
Data unit:	t CO_2-e
Description:	GHG emissions due to fire in monitoring year t
Equations	70, 87
Source of data:	Field surveys or satellite imagery from monitoring period.
Description of measurement methods and procedures to be applied:	See sections 8.2 and 8.2.2.
Frequency of monitoring/recording:	Once per monitoring period.
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2.
Comments:	N/A

Data / Parameter:	$E_{P,t}^{LCC}$
Data unit:	t CO_2-e

Description:	GHG emissions due to land use/cover change in monitoring year t
Equations	70, 98
Source of data:	Field surveys or satellite imagery from monitoring period.
Description of measurement methods and procedures to be applied:	See sections 8.2 and 8.2.3
Frequency of monitoring/recording:	Once per monitoring period.
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.3.
Comments:	N/A

Data / Parameter:	$E_{P,drainage,t}$
Data unit:	tCO_2e
Description:	GHG emissions from peat drainage from deforestation or logging in monitoring year *t*
Equations	70, 100
Source of data:	Field surveys, peat depth samples, or satellite imagery from monitoring period.
Description of measurement methods and procedures to be applied:	See sections 8.2 and 8.2.4
Frequency of monitoring/recording:	Once per monitoring period.
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4
Comments:	N/A

Data / Parameter:	$N_{P,it}^{gaps}$
Data unit:	Dimensionless
Description:	Number of logging gaps detected in stratum *i* time *t* in the project area
Equations	71
Source of data:	Satellite imagery or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1
Comments:	N/A

Data / Parameter:	$EF_{logging,i}$
Data unit:	t CO_2-e (logging gap)$^{-1}$
Description:	Average logging emission factor for stratum *i*
Equations	71, 72

Source of data:	Field measurements
Description of measurement methods and procedures to be applied:	See sections 8.2.1 and 8.2.1.1
Frequency of monitoring/recording:	Once at validation
QA/QC procedures to be applied:	Comparison with literature values.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{P,ig}^{extracted}$
Data unit:	t C
Description:	Average carbon extracted as timber per logging gap *g* in stratum *i*
Equations	72
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once at validation
QA/QC procedures to be applied:	Comparison with literature values.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1

Comments:	N/A

Data / Parameter:	$C_{P,ig}^{damaged}$
Data unit:	t C (gap)$^{-1}$
Description:	Average carbon damaged as a result of logging per logging gap *g* in stratum *i*
Equations	72, 76
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once at validation
QA/QC procedures to be applied:	Comparison with literature values.
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	g
Data unit:	Dimensionless
Description:	1, 2, 3, …, G logging gaps
Equations	72
Source of data:	Field surveys or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with field reports
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$V_{log,tr,ig}$
Data unit:	m^3
Description:	Volume of log extracted from timber tree *tr* in stratum *i*, gap *g*
Equations	73
Source of data:	Timber tree measurements
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$L_{log,tr,ig}$
Data unit:	m

Description:	Length of log extracted from timber tree *tr* in stratum *i*, gap *g*, measured as the distance from stump to base of crown, less the length of any pieces of bole left on site
Equations	73
Source of data:	Timber tree measurements
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$D_{bottom,tr,ig}$
Data unit:	cm
Description:	Diameter at the stump end of log extracted from timber tree *tr* in stratum *i*, gap *g*
Equations	73
Source of data:	Timber tree measurements
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$D_{top,tr,ig}$
Data unit:	cm
Description:	Diameter at the crown end of log extracted from timber tree *tr* in stratum *i*, gap *g*
Equations	73
Source of data:	Timber tree measurements
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{log,tr,ig}$
Data unit:	t C
Description:	Biomass carbon of log extracted in stratum *i*, gap *k*
Equations	74
Source of data:	Timber tree measurements

Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	ϕ_i
Data unit:	t m^{-3}
Description:	Wood density[23] of extracted log in stratum *i*
Equations	74
Source of data:	Timber tree measurements
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1

[23] A species-specific density is used when the species is identified or a mean tree density may be used if the species was not known.

Comments:	N/A

Data / Parameter:	CF
Data unit:	t C (t d.m.)$^{-1}$
Description:	Carbon fraction of extracted log
Equations	74, 75
Source of data:	IPCC Guidelines
Description of measurement methods and procedures to be applied:	See section 8.2.1.1 and IPCC Guidelines
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See IPCC Guidelines
Comments:	N/A

Data / Parameter:	$C_{ig}^{extracted}$
Data unit:	t C
Description:	biomass carbon extracted from all trees in stratum *i*, in gap *g*
Equations	75
Source of data:	Timber measurements
Description of measurement methods and procedures to be applied:	See section 8.2.1.1

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	tr
Data unit:	Dimensionless
Description:	1, 2, 3, …, *TR* timber trees in gap *g*
Equations	75
Source of data:	Surveys of timber harvests
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review of timber harvest measurements
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{incdam,ig}$
Data unit:	t C

Description:	Incidental carbon damage in stratum *i*, gap *g* due to logged tree
Equations	76
Source of data:	Timber surveys, satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{c+s,ig}$
Data unit:	t C
Description:	Biomass carbon in crown and stump of logged tree in stratum *i*, gap *g*
Equations	76
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field values to local literature

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{pieces,ig}$
Data unit:	t C
Description:	Biomass carbon in remaining pieces of bole from the timber tree in stratum *i*, gap *g*
Equations	76, 81
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field values to local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$DBH_{tr,ig}$
Data unit:	cm
Description:	DBH of the logged tree
Equations	77
Source of data:	Timber inventories

Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$D_{s,tr,ig}$
Data unit:	cm
Description:	Diameter of the stump of the logged timber tree *tr* in stratum *i*, gap *g*
Equations	77
Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$D_{top,tr,ig}$
Data unit:	cm
Description:	Diameter at the crown end of log extracted from timber tree *tr* in stratum *i*, gap *g*
Equations	77
Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$L_{log,tr,ig}$
Data unit:	m
Description:	Length of log extracted from timber tree *tr* in stratum *i*, gap *g*, measured as the distance from stump to base of crown, less the length of any pieces of bole left on site
Equations	77
Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$H_{s,tr,ig}$
Data unit:	cm
Description:	Stump height of tree *tr* in stratum *i*, gap *g*
Equations	77
Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$B_{AG,tr,ig}$
Data unit:	kg
Description:	Aboveground tree biomass of tree *tr* in stratum *i*, gap *g*
Equations	78

Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$f(DBH_{tr,ig},H_{tr,ig})$
Data unit:	kg $tree^{-1}$
Description:	An allometric equation linking above-ground tree biomass (kg $tree^{-1}$) to diameter at breast height (DBH) and possibly tree height (H)
Equations	78
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$H_{tr,ig}$
Data unit:	m
Description:	Tree height of tree *tr* in stratum *i*, gap *g*
Equations	78
Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{AG,tr,ig}$
Data unit:	t C
Description:	Aboveground biomass carbon of tree *tr* in stratum *i*, gap *g*
Equations	79
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{pieces,tr,ig}$
Data unit:	t C
Description:	Biomass carbon of remaining log pieces left in the logging gap from timber tree *tr* in stratum *i*, gap *g*
Equations	80, 81, 82
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$D_{pce\text{-}b,tr,ig}$
Data unit:	cm
Description:	Diameter of bottom end of piece *pce* left from timber tree *tr* in stratum *i*, gap *g*

Equations	80
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$D_{pce\text{-}t,tr,ig}$
Data unit:	cm
Description:	Diameter of top end of piece *pce* left from timber tree *tr* in stratum *i*, gap *g*
Equations	80
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1

Comments:	N/A

Data / Parameter:	$L_{pce,tr,ig}$
Data unit:	cm
Description:	Length of piece *pce* left from timber tree *tr* in stratum *i*, gap *g*
Equations	80
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	ϕ_i
Data unit:	t d.m.m^{-3}
Description:	Wood density of piece *pce* left from timber tree *tr* in stratum *i*, gap *g*
Equations	80
Source of data:	Timber inventories
Description of measurement methods and procedures to be applied:	See section 8.2.1.1

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	Pce
Data unit:	Pieces
Description:	Individual enumerated log pieces left in the logging gap from timber trees, i.e. 1, 2, 3, …, *PCE*; pieces.
Equations	80
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{c+s,tr,ig}$
Data unit:	t C
Description:	Biomass carbon in crown and stump of logged tree *tr* in stratum *i*, gap *g*

Equations	82, 83
Source of data:	Timber inventories or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{AG,tr,ig}$
Data unit:	t C
Description:	Aboveground biomass carbon in tree *tr* in stratum *i*, gap *g*
Equations	82
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1

Comments:	N/A

Data / Parameter:	$C_{log,tr,ig}$
Data unit:	t C
Description:	Biomass carbon of log extracted from tree *tr* in stratum *i*, gap *g*
Equations	82
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{c+s,ig}$
Data unit:	t C
Description:	Biomass carbon in crown and stump of all logged trees in stratum *i*, gap *g*
Equations	83
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	tr
Data unit:	Tree
Description:	1, 2, 3, …, *TR* timber trees in stratum *i*, gap *g*; dimensionless
Equations	83
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{incdam,ig}$
Data unit:	t C

Description:	Incidental carbon damage in stratum *i*, gap *g* due to logged tree
Equations	84
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$C_{AG,tr\_d,ig}$
Data unit:	t C
Description:	Aboveground tree biomass carbon of damaged tree *tr_d* in stratum *i*, gap *g*
Equations	84, 85
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions

Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$B_{AG,tr\_d,ig}$
Data unit:	kg
Description:	Aboveground tree biomass of damaged tree *tr_d* in stratum *i*, gap *g*
Equations	85, 86
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	f(DBH,H)
Data unit:	kg $tree^{-1}$
Description:	An allometric equation linking above-ground tree biomass (kg $tree^{-1}$) to diameter at breast height (DBH) and possibly tree height (H)
Equations	86
Source of data:	Carbon accounting calculations
Description of measurement methods	See section 8.2.1.1

and procedures to be applied:	
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Tree proportional assessments
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.1.1
Comments:	N/A

Data / Parameter:	$A_{P,burn,it}$
Data unit:	ha
Description:	Area burned in stratum *i*, monitoring year *t* within in the project area
Equations	87
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,it}$

Data unit:	t CO_2-e ha^{-1} burnt
Description:	Average fire emission factor for stratum *i*, monitoring year *t*
Equations	87
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$A_{P,burn,kt}$
Data unit:	ha
Description:	Peat area burned in stratum *k*, time *t* in the project area
Equations	87
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,PeatBurn,kt}$
Data unit:	t CO_2-e ha^{-1} burnt
Description:	Average peat fire emission factor for stratum *k*, monitoring year *t*
Equations	87
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,it}$
Data unit:	t CO_2-e ha^{-1} burnt
Description:	Total increase in CO2-e emissions as a result of aboveground biomass burning in the project case in stratum *i*, monitoring year *t*
Equations	88
Source of data:	Field surveys, local literature, or satellite imagery

Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,CO2,it}$
Data unit:	t CO_2-e ha^{-1} burnt
Description:	CO_2 emission from biomass burning under the project case in stratum *i*, monitoring year *t*
Equations	88, 89
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,N2O,it}$
Data unit:	t CO_2-e ha^{-1} burnt
Description:	N_2O emission from biomass burning under the project case in stratum *i*, monitoring year *t*
Equations	88
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,CH4,it}$
Data unit:	t CO_2-e ha^{-1} burnt
Description:	CH_4 emission from biomass burning under the project case in stratum *i*, monitoring year *t*
Equations	88
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$MC_{B,BB,AG,it}$
Data unit:	t C ha^{-1}
Description:	Average above-ground biomass carbon stock in the baseline scenario for stratum *i*, monitoring year *t*
Equations	89, 90
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$PBB_{P,it}$
Data unit:	Dimensionless
Description:	Average proportion of $MC_{B,BB,AG,it}$ burnt under the project case for stratum *i*, time *t*
Equations	89, 90

Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	CE
Data unit:	Dimensionless
Description:	Average biomass combustion efficiency (IPCC default=0.5)
Equations	16, 56, 89
Source of data:	IPCC Guidelines or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports, IPCC values, and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$MC^{burned}_{P,AG,it}$
Data unit:	$t\ C\ ha^{-1}$
Description:	Estimated aboveground carbon stock after burning under the project case for stratum *i*, time *t*
Equations	90
Source of data:	Field surveys, local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and satellite imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,CO2,it}$
Data unit:	t CO_2-e
Description:	CO_2 emissions factor for biomass burning under the project case in stratum *i*, monitoring year *t*
Equations	91
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,CO2,it}$
Data unit:	t CO_2-e ha^{-1}
Description:	CO_2 emission from aboveground biomass burning under the project case in stratum *i*, monitoring year
Equations	92, 93
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,N2O,it}$
Data unit:	t CO_2-e ha^{-1}
Description:	N_2O emission from aboveground biomass burning under the project case in stratum *i*, monitoring year *t*
Equations	92

Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,BiomassBurn,CH4,it}$
Data unit:	tCO_2-e ha^{-1}
Description:	CH_4 emission from aboveground biomass burning under the project case in stratum *i*, monitoring year *t*
Equations	93
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2

Comments:	N/A

Data / Parameter:	N / Cratio
Data unit:	Dimensionless
Description:	Nitrogen-carbon ratio (IPCC default = 0.01);
Equations	92
Source of data:	IPCC Guidelines or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of literature and IPCC values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	ER_{N2O}
Data unit:	t CO_2-e (t C)$^{-1}$
Description:	Emission ratio for N_2O (IPCC default value = 0.007)
Equations	92
Source of data:	IPCC Guidelines or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of local literature and IPCC values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	ER_{CH4}
Data unit:	$t\ CO_2\text{-}e\ (t\ C)^{-1}$
Description:	Emission ratio for CH_4 (IPCC default value = 0.012)
Equations	93
Source of data:	IPCC Guidelines, field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,PeatBurn,kt}$
Data unit:	$t\ CO_2e\ ha^{-1}$

Description:	Total increase in CO_2-e emissions as a result of peat burning under the project scenario in stratum *k*, time *t*
Equations	94
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,PeatBurn,CO2,kt}$
Data unit:	t CO_2e ha^{-1}
Description:	Total CO_2 emissions from peat burning under the project scenario in stratum *k*, time *t*
Equations	94, 95
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$EF_{P,PeatBurn,CH4,kt}$
Data unit:	t CO_2e ha^{-1}
Description:	Total CH_4 emissions from peat burning under the project scenario in stratum *k* time *t*
Equations	94, 96
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$M_{P,peat,kt}$
Data unit:	Tons ha^{-1}
Description:	Mass of peat burned under the project scenario in stratum *k* time *t*
Equations	95, 96, 97
Source of data:	Section 8.2.2

Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	EF_{CO2}
Data unit:	g CO_2/ton peat
Description:	CO_2 emissions from the combustion of peat,
Equations	95
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	EF_{CH4}
Data unit:	g CO_2/ton peat
Description:	CH_4 emissions from the combustion of peat
Equations	96
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$D_{P,burn,kt}$
Data unit:	meters
Description:	Depth of peat burned under the project scenario in stratum *k* at time *t*;
Equations	97
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	BD_k
Data unit:	($g\ cm^{-3} = t\ m^{-3}$)
Description:	Bulk density of peat in stratum *k*
Equations	97
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.2
Comments:	N/A

Data / Parameter:	$E_{P,it}^{LCC}$
Data unit:	t CO_2-e
Description:	GHG emissions from biomass due to land cover change in the project area
Equations	98

Source of data:	Section 8.2.3
Description of measurement methods and procedures to be applied:	See section 8.2.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.3
Comments:	N/A

Data / Parameter:	$A_{P,LCC,it}$
Data unit:	ha
Description:	area that underwent land cover change in stratum *i*, monitoring year *t*
Equations	98
Source of data:	Field surveys or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.3
Comments:	N/A

Data / Parameter:	$EF_{P,LCC,AG,it}$
Data unit:	$t\ CO_2\text{-}e\ ha^{-1}$
Description:	Average deforestation emission factor for stratum *i*, monitoring year *t*
Equations	98
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature values
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.3
Comments:	N/A

Data / Parameter:	$EF_{P,LCC,AG,it}$
Data unit:	$t\ CO_2\text{-}e$
Description:	GHG emissions in the project scenario due to land cover change in the above-ground living biomass
Equations	99
Source of data:	Field surveys or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.3

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and imagery
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.3
Comments:	N/A

Data / Parameter:	$E_{P,drainage,t}$
Data unit:	t CO_2-e
Description:	Annual monitored GHG emissions from drained peat under the project scenario in stratum *k* at time *t*
Equations	100
Source of data:	Plot measurements
Description of measurement methods and procedures to be applied:	See section 8.2.4
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review of plot measurements
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4
Comments:	N/A

Data / Parameter:	$E_{P,drainage,CO_2,t}$
Data unit:	t CO_2-e

Description:	Annual monitored CO_2 emissions from drained peat under the project scenario in monitoring year *t*
Equations	100, 101
Source of data:	Plot measurements
Description of measurement methods and procedures to be applied:	See section 8.2.4 and 8.2.4.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review of plot measurements
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4 and 8.2.4.1
Comments:	N/A

Data / Parameter:	$E_{P,drainage,CH_4,t}$
Data unit:	t CO_2-e
Description:	Annual monitored CH_4 emissions from drained peat under the project scenario in monitoring year *t*
Equations	100,104
Source of data:	Plot measurements
Description of measurement methods and procedures to be applied:	See section 8.2.4.1 and 8.2.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review of plot measurements
Purpose of data:	Calculation of project emissions

Calculation method:	See section 8.2.4.1 and 8.2.4.2
Comments:	N/A

Data / Parameter:	$E_{P,drainage,N_2O,t}$
Data unit:	t CO_2-e
Description:	Annual monitored N_2O emissions from drained peat under the project scenario in monitoring year *t*
Equations	100,105
Source of data:	Plot measurements
Description of measurement methods and procedures to be applied:	See section 8.2.4.1 and 8.2.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review of plot measurements
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.1 and 8.2.4.3
Comments:	N/A

Data / Parameter:	$A_{P,drain,k}$
Data unit:	ha
Description:	Land area of drained organic soils under the project scenario in stratum *k*
Equations	101, 104, 105
Source of data:	Stratum area measurements
Description of measurement methods	See section 8.2.4.1

and procedures to be applied:	
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Stratum comparisons
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.1
Comments:	N/A

Data / Parameter:	$EF_{P,drainage,kt,CO_2}$
Data unit:	$t\ CO_2\ ha^{-1}$
Description:	Emissions factor for drained organic soils in stratum *k*, time *t*
Equations	101
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.4.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison with similar EFs
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.1
Comments:	N/A

Data / Parameter:	$EF_{peat,drainage,kt}$

Data unit:	t CO_2-e ha^{-1}
Description:	Average deforestation emission factor for peat drainage in stratum *k*;, monitoring year *t*
Equations	102
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.4.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of literature and surveys
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.1.1
Comments:	N/A

Data / Parameter:	$ME_{dd,kt}$
Data unit:	t CO2-e ha^{-1}
Description:	Average peat CO2 emissions under the project scenario in stratum k and monitoring year t due to land cover change in the project area
Equations	102
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.2.4.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of literature and surveys

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.1.1
Comments:	N/A

Data / Parameter:	$D_{drain,kt}$
Data unit:	cm
Description:	Average depth of peat drainage or average depth to water table in the deforested area under the project scenario in stratum *k*, time *t*
Equations	103
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.2.4.1.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of literature and surveys
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.1.1
Comments:	N/A

Data / Parameter:	$EF_{CH4, land, kt}$
Data unit:	t CH_4 ha^{1} yr^{-1}
Description:	Emission factors for direct CH4 emissions from drained organic soils in stratum *k* in monitoring year *t*
Equations	104
Source of data:	Current, relevant, and local literature or field surveys

Description of measurement methods and procedures to be applied:	See section 8.2.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of literature and surveys
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.2
Comments:	N/A

Data / Parameter:	$EF_{CH4,\ ditch\ kt}$
Data unit:	t CH_4 ha^{1} yr^{-1}
Description:	Emission factors for CH4 emissions from drainage ditches in stratum *k* in monitoring year *t*
Equations	104
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of literature and surveys
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.2
Comments:	N/A

Data / Parameter:	$Frac_{ditch}$
Data unit:	Unitless
Description:	Fraction of the total area of drained organic soil which is occupied by ditches
Equations	104
Source of data:	Field surveys and satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.2.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.2
Comments:	N/A

Data / Parameter:	GWP_{CH4}
Data unit:	t CO_2-e (t CH_4)$^{-1}$
Description:	Global Warming Potential (GWP) for CH_4
Equations	93, 96, 104
Source of data:	Current, relevant, and local literature or field surveys and IPCC Guidelines
Description of measurement methods and procedures to be applied:	See sections 8.2.2 and 8.2.4.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparisons between field measurements and IPCC Guidelines
Purpose of data:	Calculation of project emissions
Calculation method:	See IPCC Guidelines
Comments:	Must be updated based on latest guidance from IPCC.

Data / Parameter:	GWP_{N2O}
Data unit:	t CO_2-e (t N_2O)$^{-1}$
Description:	Global Warming Potential (GWP) for N_2O
Equations	92, 105
Source of data:	Current, relevant, and local literature or field surveys as well as IPCC Guidelines
Description of measurement methods and procedures to be applied:	See sections 8.2.2 and 8.2.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparisons between field measurements and IPCC Guidelines
Purpose of data:	Calculation of project emissions
Calculation method:	See IPCC Guidelines
Comments:	Must be updated based on latest guidance from IPCC.

Data / Parameter:	$EF_{N_2O,\,kt}$
Data unit:	t N_2O ha^{-1}
Description:	Emissions factor for annual N_2O emissions per hectare within drained peat in stratum *k* at time *t*
Equations	105

Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.2.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.2.4.3
Comments:	N/A

Data / Parameter:	$C_{BSL,t}$
Data unit:	t CO_2-e
Description:	Baseline greenhouse gas emissions
Equations	123, 124, 125
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4 and 8.4.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4 and 8.4.1
Comments:	N/A

Data / Parameter:	NER_t
Data unit:	t CO_2-e
Description:	Net Emissions Reductions (NERs) calculated for year *t*
Equations	123
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4
Comments:	N/A

Data / Parameter:	LK_t
Data unit:	t CO_2-e
Description:	Leakage emissions at time t
Equations	123, 124, 126
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4, 8.4.1, and 8.4.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.4, 8.4.1 and 8.4.2
Comments:	N/A

Data / Parameter:	$C_{ACTUAL,t}$
Data unit:	t CO_2-e
Description:	Actual net greenhouse gas emissions avoided
Equations	125, 126
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.1 and 8.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.1 and 8.4.2
Comments:	N/A

Data / Parameter:	C_{BSL}
Data unit:	t CO_2-e
Description:	Sum of peat emissions and carbon stock changes in aboveground biomass under the baseline scenario
Equations	125

Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.1
Comments:	N/A

Data / Parameter:	$C_{PRJ,t}$
Data unit:	t CO_2-e
Description:	Sum of emissions that occur within the project boundary
Equations	125
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.1
Comments:	N/A

Data / Parameter:	$C_{REDD,t}$
Data unit:	t CO_2-e
Description:	Net reduced emissions from deforestation at year *t*
Equations	126, 127
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.2
Comments:	N/A

Data / Parameter:	$VCUs_t$
Data unit:	VCUs
Description:	Number of Voluntary Carbon Units at time t
Equations	127
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.2
Comments:	N/A

Data / Parameter:	BRR_t
Data unit:	Dimensionless
Description:	Portion of carbon credits to be withheld as a buffer reserve
Equations	127
Source of data:	Carbon accounting calculations, project risk calculations
Description of measurement methods and procedures to be applied:	See section 8.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.2
Comments:	N/A

Data / Parameter:	$\Delta C_{PS,BS,t=100}$
Data unit:	t CO_2e
Description:	Net difference between baseline and project soil carbon stocks at year 100 of the project, the maximum crediting allowed for the project
Equations	128

Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.3
Comments:	N/A

Data / Parameter:	$C_{PS,t=100}$
Data unit:	t CO_2-e
Description:	Soil organic carbon stock in project scenario at *t*=100
Equations	128
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.3
Comments:	N/A

Data / Parameter:	$C_{BS,t=100}$
Data unit:	t CO_2-e
Description:	Soil organic carbon stock in baseline scenario at *t*=100
Equations	128
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.3
Comments:	N/A

Data / Parameter:	$U_{P,SS,t}$
Data unit:	%
Description:	Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions in the with-project case at time *t* (1,2...n represent different carbon pools and/or GHG sources)
Equations	129
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2
Comments:	N/A

Data / Parameter:	$E_{P,SS,t}$
Data unit:	t CO_2-e
Description:	Carbon stock, GHG sources or leakage emission type (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning, emission from leakage due to activity shifting etc.) at time t (1,2…n represent different carbon pools and/or GHG sources) in the with-project case
Equations	129
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2
Comments:	N/A

Data / Parameter:	$E_{P,it}$

Data unit:	t CO_2-e
Description:	Sum of carbon stock, GHG sources and leakage emission types in stratum i at time t
Equations	130, 131
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

Data / Parameter:	$C_{REDD\_ERROR,t}$
Data unit:	%
Description:	Total uncertainty for REDD project activity
Equations	139, 140
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.5 and 8.4.4.6
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature

Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.5 and 8.4.4.6
Comments:	N/A

Data / Parameter:	$Uncertainty_{BSL,t}$
Data unit:	%
Description:	Total uncertainty in baseline scenario at time t
Equations	133, 139
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.3
Comments:	N/A

Data / Parameter:	$Uncertainty_{P,t}$
Data unit:	%
Description:	Total uncertainty in project scenario at time *t*
Equations	138, 139
Source of data:	Carbon accounting calculations

Description of measurement methods and procedures to be applied:	See section 8.4.4.2 and 8.4.4.2.6
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2 and 8.4.4.2.6
Comments:	N/A

Data / Parameter:	$C_{REDD,t}$
Data unit:	t CO_2-e
Description:	Net anthropogenic greenhouse emission reductions at time *t*
Equations	124, 126, 127, 140
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.2
Comments:	N/A

Data / Parameter:	$Adjusted\_C_{REDD,t}$
Data unit:	t CO_2-e
Description:	Adjusted value for $C_{REDD,t}$ to account for uncertainty
Equations	140
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.6
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.6
Comments:	N/A

Data / Parameter:	U_s
Data unit:	%
Description:	Percentage uncertainty on the estimate of the mean parameter value
Equations	129
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2
Comments:	N/A

Data / Parameter:	μ
Data unit:	Unit of the parameter
Description:	Sample mean value of the parameter
Equations	129
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2
Comments:	N/A

Data / Parameter:	U_i
Data unit:	Dimensionless
Description:	Percentage uncertainties associated with each term of the product (parameters and activity data)
Equations	130

Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2.6
Comments:	N/A

Data / Parameter:	$Uncertainty_{B,it}$
Data unit:	%
Description:	Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case of stratum i at time t; %
Equations	131, 133
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3

Comments:	N/A

Data / Parameter:	$U_{B,SSn,it}$
Data unit:	%
Description:	Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case i at time t (1,2…n represent different carbon pools and/or GHG sources)
Equations	131
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

Data / Parameter:	$U_{B,SSn,jt}$
Data unit:	%
Description:	Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case j at time t (1,2…n represent different carbon pools and/or GHG sources)
Equations	130, 132
Source of data:	Carbon accounting calculations

Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

Data / Parameter:	$E_{B,SSn,it}$
Data unit:	t CO_2-e
Description:	Carbon stock, GHG sources or leakage emissions from aboveground biomass in stratum i at time t (1,2…n represent different carbon pools and/or GHG sources) in the baseline scenario
Equations	130, 131
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

Data / Parameter:	$E_{B,SSn,jt}$
Data unit:	t CO_2-e
Description:	Carbon stock, GHG sources or leakage emissions from peat in stratum j at time t (1,2…n represent different carbon pools and/or GHG sources) in the baseline scenario
Equations	130, 132
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

Data / Parameter:	$Uncertainty_{B,t}$
Data unit:	%
Description:	Total uncertainty in baseline scenario at time t
Equations	133
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.3

Frequency of monitoring/recording:	Once per baseline update
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.3
Comments:	N/A

Data / Parameter:	$Uncertainty_{P,it}$
Data unit:	%
Description:	Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the project case of stratum i at time t; %
Equations	134, 136
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.4
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.4
Comments:	N/A

Data / Parameter:	$U_{P,SSn,it}$
Data unit:	%

Description:	Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the project case i at time t (1,2…n represent different carbon pools and/or GHG sources)
Equations	134
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.4
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.4
Comments:	N/A

Data / Parameter:	$U_{P,SSn,kt}$
Data unit:	%
Description:	Percentage uncertainty (expressed as 90% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the project case of stratum k at time t (1,2…n represent different carbon pools and/or GHG sources)
Equations	135
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.4
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.4
Comments:	N/A

Data / Parameter:	$E_{P,SSn,it}$
Data unit:	t CO_2-e
Description:	Carbon stock, GHG sources or leakage emissions from aboveground biomass in stratum i at time t (1,2…n represent different carbon pools and/or GHG sources) in the project scenario
Equations	134
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of baseline emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

Data / Parameter:	$E_{P,SSn,kt}$
Data unit:	t CO_2-e
Description:	Carbon stock, GHG sources or leakage emissions from peat in stratum k at time t (1,2…n represent different carbon pools and/or GHG sources) in the project scenario

Equations	135
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.4.4.2.6 and 8.4.4.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of project emissions
Calculation method:	See section 8.4.4.2.6 and 8.4.4.3
Comments:	N/A

9.2.2 Data to be Collected and Archived for Leakage

Data / Parameter:	LK_t
Data unit:	t CO_2-e
Description:	Leakage emissions resulting from displacement of economic activities, market effects, and ecological effects at time t
Equations	106, 124
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3 and 8.4.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature

Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3 and 8.4.1
Comments:	N/A

Data / Parameter:	$LK_{MarketEffects,t}$
Data unit:	t CO_2-e
Description:	Total GHG emissions due to market effects leakage through decreased timber harvest;
Equations	106, 107
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3 and 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3 and 8.3.1
Comments:	N/A

Data / Parameter:	$LK_{ActivityDisplacement,t}$
Data unit:	t CO_2-e
Description:	Total GHG emissions due to activity shifting leakage for projects preventing planned deforestation at time t
Equations	106, 110
Source of data:	Carbon accounting calculations

Description of measurement methods and procedures to be applied:	See section 8.3 and 8.3.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3 and 8.3.2
Comments:	N/A

Data / Parameter:	$LK_{Ecological,t}$
Data unit:	t CO_2e
Description:	Total GHG emissions due to ecological leakage at time t
Equations	106
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3
Comments:	N/A

Data / Parameter:	$LK_{ME,it}$
Data unit:	t CO_2-e
Description:	Total GHG emissions due to market effects leakage through decreased harvest in stratum i at time t
Equations	107
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	$LK_{ME,i}$
Data unit:	Dimensionless
Description:	Leakage factor for market effects calculations
Equations	108
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	$C_{B,XBT,it}$
Data unit:	t CO_2-e
Description:	Carbon emission due to displaced timber harvests in the baseline scenario in stratum i at time t
Equations	108
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	PMP_i
Data unit:	Dimensionless
Description:	Merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundaries
Equations	N/A

Source of data:	Field inventories or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	PML_{FT}
Data unit:	Dimensionless
Description:	Mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type
Equations	N/A
Source of data:	Field inventories or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	$LF_{ME,i}$
Data unit:	Dimensionless
Description:	Leakage factor for stratum i market-effects calculations
Equations	N/A
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	$C_{B,XBT,it}$
Data unit:	t CO_2-e
Description:	Carbon emission due to displaced timber harvests in the baseline scenario in stratum i at time t
Equations	109
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	$V_{B,it}$
Data unit:	m^3
Description:	Volume to be extracted under the baseline scenario in stratum i at time t
Equations	109
Source of data:	Field inventories or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	ϕ_i
Data unit:	t d.m. m^{-3} merchantable volume
Description:	Volume-weighted average wood density
Equations	109

Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	CF
Data unit:	Dimensionless
Description:	Carbon fraction of dry matter (0.5 t C / t biomass)
Equations	80, 81, 87, 109, 116
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See sections 8.2.1.1, 8.3.1 and 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison between field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See sections 8.2.1.1, 8.3.1 and 8.3.2.2.1
Comments:	N/A

Data / Parameter:	LDF
Data unit:	$t\ C\ m^{-3}$ (default 0.37 $t\ C\ m^{-3}$)
Description:	Logging damage factor
Equations	109
Source of data:	Current, relevant, and local literature or field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1
Comments:	N/A

Data / Parameter:	t
Data unit:	Years
Description:	Time elapsed since the projected start of the REDD project activity
Equations	109, 110, 113, 114
Source of data:	Project start date
Description of measurement methods and procedures to be applied:	See section 8.3.1 and 8.3.2

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.1 and 8.3.2
Comments:	N/A

Data / Parameter:	$LK_{AD,it}$
Data unit:	t CO_2-e
Description:	Total GHG emissions due to activity shifting leakage in stratum i at time t for projects preventing planned deforestation
Equations	110
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2
Comments:	N/A

Data / Parameter:	$LKA_{planned,it}$
Data unit:	ha
Description:	The area of activity shifting leakage in stratum i at time t

Equations	110, 114, 117, 118
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2 and 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2 and 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$LKA_{planned,kt}$
Data unit:	ha
Description:	The area of activity shifting leakage in stratum k at time t
Equations	110
Source of data:	Field surveys or satellite imagery.
Description of measurement methods and procedures to be applied:	See section 8.3.2 and 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2 and 8.3.2.1

Comments:	N/A

Data / Parameter:	ΔC_{it_init}
Data unit:	t CO_2-e ha^{-1}.
Description:	Average initial carbon stock changes and greenhouse gas emissions in stratum i at time t (excluding timber emissions where applicable)
Equations	110, 115, 117
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2 and 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Comparison of field reports and local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2 and 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$\Delta C_{kt\_continued}$
Data unit:	t CO_2-e ha^{-1}
Description:	Average carbon stock changes and greenhouse gas emissions in stratum k at time t as a result of continued emissions
Equations	110, 121, 122
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.2

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review carbon stock calculations
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.2
Comments:	N/A

Data / Parameter:	$WoPA_{it}$
Data unit:	ha
Description:	Total (cumulative) area of forest cleared by the baseline agent of planned deforestation in stratum i at time t
Equations	111
Source of data:	Field surveys, relevant local literature, or satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare satellite imagery and field reports
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1
Comments:	N/A

Data / Parameter:	a
Data unit:	ha
Description:	Estimated intercept of the regression line

Equations	111
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review carbon calculations
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1
Comments:	N/A

Data / Parameter:	$WoPR_{it}$
Data unit:	ha cleared at time *t*
Description:	Slope of the linear regression, i.e., rate of deforestation by the baseline agent in the absence of the project in stratum *i*
Equations	111, 112, 113
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Review carbon calculations
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1

Comments:	N/A

Data / Parameter:	$HistHa_i$
Data unit:	ha
Description:	Total number of hectares of forest cleared by the baseline agent of the planned deforestation in the n years prior to project implementation in stratum i
Equations	112
Source of data:	Carbon accounting calculations, relevant local literature, satellite imagery of reference area, or field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare satellite imagery and field reports
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1
Comments:	N/A

Data / Parameter:	n_{yrs}
Data unit:	Dimensionless
Description:	Number of years included in the analysis of deforestation
Equations	112
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.1

Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with relevant local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1
Comments:	N/A

Data / Parameter:	$NewR_{it}$
Data unit:	ha
Description:	New calculated area of forest clearance in stratum i and time t by the baseline agent of planned deforestation where no leakage is occurring
Equations	113, 114
Source of data:	Carbon accounting calculations, field surveys, and satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare satellite imagery and field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1
Comments:	N/A

Data / Parameter:	$A_{defLK,it}$
Data unit:	ha

Description:	The total observed area of deforestation by the baseline agent in stratum i at time t
Equations	114
Source of data:	Field surveys and satellite imagery
Description of measurement methods and procedures to be applied:	See section 8.3.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare satellite imagery and field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.1
Comments:	N/A

Data / Parameter:	$C_{ML,it}$
Data unit:	t C ha^{-1}
Description:	Average carbon stocks accounted for as timber emissions under market leakage
Equations	115, 116, 117
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions

Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$B_{B,it}^{logged}$
Data unit:	t d.m. ha-1
Description:	Timber biomass logged under the baseline scenario for stratum i at time t
Equations	116
Source of data:	Carbon accounting calculations based off of field surveys, satellite imagery in the reference region, and relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$E_{B,p,t}$
Data unit:	t CO2-e
Description:	Total baseline GHG emissions from peat under the baseline scenario at time t
Equations	115, 117
Source of data:	Carbon accounting calculations and relevant local literature
Description of measurement methods	See section 8.3.2.2.1

and procedures to be applied:	
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$MV_{B,AG\_tree,it}$
Data unit:	m^3 ha^{-1}
Description:	Mean merchantable volume under the baseline scenario in stratum i at time t
Equations	116
Source of data:	Carbon accounting calculations and field surveys/local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$LKP_{unaccounted,it}$

Data unit:	Dimensionless
Description:	Unaccounted proportion of timber emissions not accounted for under market leakage
Equations	118
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$MC_{LK,AG,it}$
Data unit:	t C ha^{-1}
Description:	Mean carbon stocks in aboveground biomass in leakage stratum i at time t
Equations	119
Source of data:	Carbon accounting calculations
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature

Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	ΔSOC_{jt}
Data unit:	t CO_2-e ha^{-1}
Description:	Mean change in soil carbon stocks in stratum i at time t after conversion to annual cropland
Equations	119, 120, 122
Source of data:	Carbon accounting calculations based off of relevant local literature and field surveys
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$C_{soil,kt}$
Data unit:	t C ha^{-1}
Description:	Average soil carbon stocks to 30 cm depth in stratum k at time t before conversion to annual cropland
Equations	120
Source of data:	Relevant local literature and field surveys

Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	F_{LU}
Data unit:	Dimensionless
Description:	Land-use factor for calculating relative soil carbon stock changes
Equations	120
Source of data:	Carbon accounting calculations and relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.1
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare with field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.1
Comments:	N/A

Data / Parameter:	$\Delta C_{kt\_continued}$
Data unit:	t CO_2-e ha^{-1}
Description:	Average greenhouse gas emissions resulting from continued peat drainage or soil emissions in stratum k
Equations	121, 122
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.2
Comments:	N/A

Data / Parameter:	$ME_{B,dd,kt}$
Data unit:	t CO_2 ha^{-1}
Description:	Mean CO_2 emissions from drained peat in stratum k, time t
Equations	121
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.2
Frequency of monitoring/recording:	Once per monitoring period

QA/QC procedures to be applied:	Compare field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.2
Comments:	N/A

Data / Parameter:	ΔSOC_{kt}
Data unit:	$t\ CO_2\text{-}e\ ha^{-1}$
Description:	Mean change in soil carbon stocks in stratum k at time t after conversion to annual cropland
Equations	122
Source of data:	Field surveys or relevant local literature
Description of measurement methods and procedures to be applied:	See section 8.3.2.2.2
Frequency of monitoring/recording:	Once per monitoring period
QA/QC procedures to be applied:	Compare field reports/local literature
Purpose of data:	Calculation of leakage emissions
Calculation method:	See section 8.3.2.2.2
Comments:	N/A

9.3 Description of the Monitoring Plan

The methodology outlines the methods for monitoring land use change, forest degradation and carbon pools and forms the basis for implementing the monitoring plan. It facilitates the monitoring of project activities, and serves as reference for monitoring, reporting, and verification required for evaluating project performance, and to support the accurate determination of carbon offsets by project activities.

The methodology was designed so that all necessary field measurements (including measurements of baseline carbon stocks) may be performed up front - prior to project implementation – if desired, thus limiting monitoring activities over the crediting period to monitoring activity data only (area changes).

9.3.1 Monitoring of Project Implementation

The methodology includes methods for monitoring the following elements:

- The proposed project activity including the project boundary, a buffer region surrounding the project boundary to ensure against impacts of outside drainage activities, and all activities that result in increased GHG emissions inside the project boundary;
- Actual net GHG emissions including changes in carbon stocks in above-ground biomass, peat emissions;
- Leakage due to displacement of economic activities; and
- A Quality Assurance/Quality Control plan, including field measurements, data collection verification, data entry and archiving, as an integral part of the monitoring plan of the proposed project activity, to ensure the integrity of data collected.

a. Monitoring of the boundary of the proposed project activity

The project boundary delineates the project activity as a distinct land use in relation to the land uses in the adjoining area. Because this methodology is applicable to avoided emissions projects, the project boundary is fixed throughout the entire crediting period. After initial verification of the project boundary using field-based methods, GPS systems and/or remote sensing methods, the project boundary must be monitored over the crediting period to account for emissions associated with any deforestation, illegal logging, peat drainage, or other events that have occurred within the project boundary.

Monitoring of the project boundary is meant to demonstrate that the actual area where baseline activities were prevented conforms to the area outlined in the project plan. The following monitoring activities are forseen:

- Field (or aerial) surveys concerning the actual project boundary within which baseline activities have been prevented;
- Measuring geographical positions (latitude and longitude of each corner polygon sites) using GPS or remote sensing methods;
- Checking whether the actual boundary is consistent with the description in the PD;
- If the actual boundary falls outside of the project boundary as defined in the PD, these lands must not be accounted as a part of the project activity.
- Input the measured geographical positions into the GIS system and calculate the area of each stratum within the project area.

In addition to monitoring the project boundary, if the project boundary does not represent a discrete hydrologic unit (such as a peat dome), then project proponents must monitor a buffer region directly surrounding the project boundary to ensure that no drainage activities have occurred that could potentially impact peat emissions inside the project boundary. The width of this buffer zone must be the distance to the edge of the peat dome or 3 km, whichever is the smaller value.

If the buffer zone is less than 3 km around the project boundary is to be applied, this value must be defended in the PD and methods for monitoring the drainage impacts within the reduced buffer zone must be designed in consultations with experts in peat hydrology.

b. Monitoring of forest protection activities

As part of monitoring forest protection activities, any increases in GHG emissions that occur within the project boundary after the start of the project must be recorded and deducted from the *ex ante* estimate of baseline emissions. The following categories must be recorded in the project database and reported at the time of verification:

- Area where natural or anthropogenic disturbances (including fire, illegal logging and other land use change) occurred within the project boundary by date, location, biomass lost or affected, and the preventative or curative measures, if any implemented
- Number and location of logging gaps by date, location, biomass lost or affected, and the preventative or curative measures, if any implemented
- Area and depth of peat burned within the project area by date, location, estimated peat emissions, and the preventative or curative measures, if any implemented
- Area of peat, if any, that was drained within the project boundary by date, location, estimated peat emissions, and the preventative or curative measures, if any implemented
- Information on forest protection practices

9.3.2 Sampling Design and Stratification

The number and boundaries of the strata defined *ex ante* using the methodology procedure outlined in Section 5.3 may change during the crediting period (*ex post*). For this reason, strata must be monitored periodically. If a change in the number and area of the project strata occurs, the sampling framework must be adjusted accordingly. The methodology procedures for monitoring strata and defining the sampling framework are outlined below.

9.3.2.1 Monitoring of strata

Stratification of the project area into relatively homogeneous units may either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit.

Project participants must present in the PD an *ex ante* stratification of the project area using the methods outlined in Section 5.3 and build a geo-referenced spatial data base in a GIS platform for each parameter used for stratification of the project area under the baseline and project scenario. This geo- referenced spatial data base must be completed at the earliest stages of the implementation of the project activity. The verifier must verify the achievement of this stratification and geo-referenced spatial data base at the first verification. The consistency of the actual boundary of the strata as monitored in the field with the description in the PD must be periodically monitored, as the boundaries may change during the crediting period due to the following:

- Disturbances (e.g. due to fire or deforestation) may occur that are distributed patchily over a landscape, resulting in different effects on different parts of an originally homogeneous stratum;
- Forest management activities (illegal logging, logging concessions) may occur, resulting in different effects on different parts of an originally homogeneous stratum;
- Two different strata may become similar enough to allow their merging into one stratum.

If one or more of the above conditions occur, *ex post* stratification may be required. The possible need for *ex post* stratification must be evaluated at each monitoring event and changes in the strata must be reported to the verifier.

Monitoring of strata must be done using a Geographical Information System (GIS), which allows for the integration of data from different sources (including GPS coordinates and remote sensing data). The monitoring of strata is critical for transparent and verifiable monitoring of the variable A_{it} (area of stratum *i* at time *t*), which is of utmost importance for an accurate and precise calculation of net anthropogenic GHG emissions avoided.

9.3.2.2 Sampling framework

The sampling framework, including sample size, plot size, plot shape and plot location must be specified in the PD. The monitoring methodology was designed so that all sampling may involve temporary plots and may occur at the beginning of the project. Thus, the only monitoring activity necessary over the crediting period is annual monitoring of land cover change within the project boundary. The number of sample plots is estimated based on accuracy and costs.

The number, size and location of sampling plots must be determined using the most current version of the CDM Tool “Calculation of the number of sample plots for measurements within A/R CDM project activities.”[24]

9.3.2.3 Measuring and estimating carbon stock changes and peat emissions over time

If a project chooses to track tree growth over time within the project boundary, then the growth of individual trees on permanent plots may be measured every five years or at each monitoring event depending on the expected GHG stocks and the financial needs of the project activity. The carbon stock changes in the tree pool on each plot are then estimated using the Aerial Imagery Method, the Biomass Expansion Factor method or the Allometric Equations method (as outlined in Section 8.1.1 above).

Although monitoring carbon stock increases over time within the project boundary is optional for avoided emissions projects, monitoring unforeseen carbon stock decreases over time within the project boundary is required. These GHG emissions may be the result of deforestation,

[24] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.pdf

degradation, fire, logging, etc. within the project boundary. Monitoring carbon stock changes over the crediting period will allow a deduction to be made to project benefits, if necessary, to account for the actual GHG emissions that occur within the project boundary over the life of the project as well as outside the project boundary in the form of leakage.

9.3.3 Monitoring biomass accumulation in the project area ($\Delta CO_2e_{P,LB}$)

The carbon emissions that were prevented due to project activities were calculated in the baseline case. The existing carbon stocks in the project area were counted as carbon offsets because in the baseline, trees would have been cut down. However, due to project activities, these trees will continue to grow and accumulate biomass.

It is conservative to ignore this biomass accumulation. Per the applicability condition of this methodology, the biomass of vegetation within the project boundary at the start of the project must be at steady-state, or is increasing due to recovery from past disturbance, and so monitoring project GHG removals by herbaceous vegetation may be conservatively neglected if desired. Monitoring biomass accumulation is recommended only where large accumulations are expected to occur.

If the additional carbon that accumulates in this vegetation over the life of the project (that would have been removed in the baseline case) are to be measured, trees must be monitored using permanent sample plots (field plots or aerial imagery plots) installed at the beginning of the project and biomass accumulation in each stratum must be monitored over time. Methods to estimate changes in the litter and dead wood pool are not included in this methodology and are ignored.

9.3.4 Other Information

9.3.4.1 Quality control (QC) and quality assurance (QA) procedures to be applied to the monitoring process

Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

- Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
- Identify and address errors and omissions;
- Document and archive inventory material and record all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Higher tier QC activities include technical reviews of source or sink categories, activity and emission factor data, and methods.

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, must be performed upon a finalized inventory following the implementation of QC procedures. Reviews verify that data quality objectives were met, ensure that the inventory represents the best possible estimates of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC program.

To ensure the net avoided emissions are measured and monitored precisely, credibly, verifiably and transparently, a quality assurance and quality control (QA/QC) procedure must be implemented, including

(1) collection of reliable field measurement; (2) reliable collection and analysis of aerial imagery (if applicable); (3) verification of methods used to collect field data; (4) verification of data entry and analysis techniques; and (5) data maintenance and archiving. If after implementing the QA/QC plan it is found that the targeted precision level is not met, then additional field measurements need to be conducted until the targeted precision level is achieved.

9.3.4.1.1 Reliable field measurements

Collecting reliable field measurement data is an important step in the quality assurance plan. Persons involved in the field measurement work must be fully trained in the field data collection and data analyses. Standard Operating Procedures (SOPs) for each step of the field measurements must be developed and adhered to at all times. These SOPs must detail all phases of the field measurements and contain provisions for documentation for verification purposes, so that measurements are comparable over time and may be checked and repeated in a consistent fashion. To ensure the collection of reliable field data,

- Field-team members must be fully aware of all procedures and the importance of collecting data as accurately as possible;
- Field teams should install test plots if needed in the field and measure all pertinent components using the SOPs;
- Field measurements must be checked by a qualified person to correct any errors in techniques;
- A document that shows that these steps have been followed must be presented as a part of the project documents. The document will list all names of the field team and the project leader will certify that the team is trained;
- Any new staff is adequately trained.

9.3.4.1.2 Reliable aerial imagery collection and analysis

If collected properly, aerial imagery is a powerful and cost-effective way to estimate carbon stocks remotely.

A systematic sampling design must be used to select plots for analysis.

A subset of image plots must be selected randomly and interpreted independently by at least one different analyst.

Persons involved in the field measurement work must be fully trained in the field data collection and data analyses. Standard Operating Procedures (SOPs) for each step of the imagery collection and analysis must be developed and adhered to at all times. These SOPs must detail all phases of the field measurements and contain provisions for documentation for verification purposes, so that measurements are comparable over time and may be checked and repeated in a consistent fashion.

Field-team members must be fully aware of all procedures and the importance of collecting data as accurately as possible;

Field teams may install test plots if needed in the field and measure all pertinent components using the SOPs;

Virtual measurements shall be checked by a qualified person to correct any errors in techniques;

A document that shows that these steps have been followed must be presented as a part of the project documents. The document will list all names of the field team and the project leader will certify that the team is trained;

Any new staff is adequately trained.

9.3.4.1.3 Verification of field data collection

To verify that plots have been installed and the measurements taken correctly, 10-20% of plots must be randomly selected and re-measured independently. Key re-measurement elements include the location of plots, *DBH* and tree height. The re-measurement data must be compared with the original measurement data. Any deviation between measurement and re-measurement below 5% will be considered tolerable and error above 5%. Any errors found must be corrected and recorded. Any errors discovered must be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

9.3.4.1.4 Verification of data entry and analysis

Reliable estimation of carbon stock in pools requires proper entry of data into the data analyses spreadsheets. To minimize the possible errors in this process, the entry of both field data and laboratory data must be reviewed using expert judgment and, where necessary, comparison with independent data to ensure that the data are realistic. Communication between all personnel involved in measuring and analyzing data should be used to resolve any apparent anomalies before the final analysis of the monitoring data is completed. If there are any problems with the monitoring plot data that may not be resolved, the plot should not be used in the analysis.

9.3.4.1.5 Data maintenance and archiving

Because of the long-term nature of the CDM-AR project activity, data must be archived and maintained safely. Data archiving must take both electronic and paper forms, and copies of all data must be provided to each project participant. All electronic data and reports must also be copied on durable media such as CDs and copies of the CDs are stored in multiple locations. The archives must include:

- Copies of all original field measurement data, laboratory data, data analysis spreadsheet;
- Estimates of the carbon stock changes in all pools and non-CO2 GHG and corresponding calculation spreadsheets;
- GIS products (including all aerial imagery if applicable);
- Copies of the measuring and monitoring reports.

Table 6: Quality control activities and procedures

QC activity	Procedures
Check that assumptions and criteria for the selection of activity data, emission factors and other estimation parameters are documented.	Cross-check descriptions of activity data, emission factors and other estimation parameters with information on source and sink categories and ensure that these are properly recorded and archived.
Check for transcription errors in data input and reference.	Confirm that bibliographical data references are properly cited in the internal documentation Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.
Check that emissions and removals are calculated correctly.	Reproduce a representative sample of emission or removal calculations. Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.
Check that parameter and units are correctly recorded and that appropriate conversion factors are used.	Check that units are properly labeled in calculation sheets. Check that units are correctly carried through from beginning to end of calculations. Check that conversion factors are correct. Check that temporal and spatial adjustment factors are used correctly.
Check the integrity of database files.	Confirm that the appropriate data processing steps are correctly represented in the database. Confirm that data relationships are correctly represented in the database. Ensure that data fields are properly labeled and have the correct design specifications. Ensure that adequate documentation of database and model structure and operation are archived.
Check for consistency in data between categories.	Identify parameters (e.g., activity data, and constants) that are common to multiple categories of sources and sinks, and confirm that there is consistency in the values used for these parameters in the emissions calculations.

Check that the movement of inventory data among processing steps is correct.	Check that emission and removal data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries. Check that emission and removal data are correctly transcribed between different intermediate products.
Check that uncertainties in emissions and removals are estimated or calculated correctly.	Check that qualifications of individuals providing expert judgment for uncertainty estimates are appropriate. Check that qualifications, assumptions and expert judgments are recorded. Check that calculated uncertainties are complete and calculated correctly. If necessary, duplicate error calculations on a small sample of the probability distributions used by Monte Carlo analyses.
Undertake review of internal documentation.	Check that there is detailed internal documentation to support the estimates and enable reproduction of the emission and removal and uncertainty estimates. Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review. Check integrity of any data archiving arrangements of outside organizations involved in inventory preparation.
Check time series consistency.	Check for temporal consistency in time series input data for each category of sources and sinks. Check for consistency in the algorithm/method used for calculations throughout the time series.
Undertake completeness checks.	Confirm that estimates are reported for all categories of sources and sinks and for all years. Check that known data gaps that may result in incomplete emissions estimates are documented and treated in a conservative way.
Compare estimates to previous estimates.	For each category, current inventory estimates may be compared to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain the difference.

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