VCS Methodology

VM0006

Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects

Version 2.2

17 March 2017

Sectoral Scope 14

Table of Contents

1 SOURCES

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

- CDM Methodology - AR ACM0001 *Afforestation and reforestation of degraded land.* (Version 01).

- CDM Methodology - AR AM0002 *Restoration of degraded lands through afforestation/reforestation.* (Version 03).

- CDM Methodology - AR AM0006 *Afforestation/Reforestation with trees supported by shrubs on degraded land.* (Version 02).

- CDM Methodology – AMS.II.G*. Energy efficiency measures in thermal applications of non-renewable biomass. (*Version 5).

This methodology also refers to the following approved tools and modules, and the latest versions of these must be used:

- CDM A/R Methodological Tool *Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities.*

- CDM A/R Methodological Tool 03 *Calculation of the number of sample plots for measurements within A/R CDM project activities.*

- CDM A/R Methodological Tool 06 *Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected.*

- CDM A/R Methodological Tool 09 *Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity.*

- CDM Tool *Tool for testing significance of GHG emissions in A/R CDM project activities.*

- VCS Tool VT0001 *Tool for the demonstration and assessment of additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) project activities.*

- VCS Tool *Tool for calculating deforestation rates using incomplete remote sensing images[1].*

This methodology also refers to the following approved guidelines and requirements, of which the latest version shall be used:

- CDM Annex 23 *Guidelines on conservative choice and application of default data in estimation of the net anthropogenic GHG removals by sinks.*

- VCS *Jurisdictional and Nested REDD+ (JNR) Requirements.*

---

[1] At issuance of the this methodology, the VCS Tool, *Tool for calculating deforestation rates using incomplete remote sensing images*, is currently in development and is unavailable for use in this methodology until it is approved.

- VCS *Program Definitions.*

- VCS *Standard.*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

This methodology provides procedures for quantifying emission reductions and/or removals from activities aimed at reducing unplanned deforestation and forest degradation of the mosaic configuration. The methodology may be combined with Improved Forest Management (IFM) and Afforestation, Reforestation and Revegetation (ARR) methodologies to implement a landscape-scale Reduced Emissions from Deforestation and Forest Degradation (REDD+) project that addresses land and resource needs of communities in a holistic way. Emission reductions/removals from REDD+ activities are calculated by taking the difference between, on the one hand, *ex-post* monitored changes in carbon stocks in the project areas, and on the other hand *ex-ante* changes in baseline carbon stocks, *ex-post* monitored emissions from leakage, and *ex-post* monitored emission sources. Baseline emissions from unplanned deforestation and degradation in the project area are calculated based on historical deforestation or forest degradation rates in a reference region that is similar to the project area.

Under this methodology, new project activity instances referred to as discrete project parcels can be added after the start of the project as per VCS rules for grouped projects.

The main elements of the methodology are:

- Net emission reductions and removals (NERs) from avoided deforestation and avoided forest degradation are treated separately. When changes in forest biomass cannot be measured with sufficient accuracy, emissions reduction/removals from avoided forest degradation are excluded.

- The quantification of baseline deforestation and degradation rates is based on field-calibrated remote sensing analyses over a historical reference period. More specifically, the baseline rates of deforestation and degradation are quantified by classifying the discrete land cover classes, or forest strata, and analyzing transitions from one class or stratum to a different class or stratum over time.

- Leakage is monitored and quantified using a leakage belt approach for geographically constrained drivers, and a factor approach for geographically unconstrained drivers. Market-effect leakage is accounted for each project according to the discount factors provided in the VCS *AFOLU Requirements.*

- Increases in forest cover through natural regeneration are included in both the baseline and project scenarios. This is achieved by applying the empirically observed baseline regeneration rates in the reference region to the project and baseline scenarios. That is, the baseline scenario includes both projected degradation and deforestation, but also projected regeneration and reforestation in areas that were deforested. Similarly, the project scenario must include all forest class transitions, whether they are positive or negative.

- This methodology allows silvicultural activities and enrichment planting activities within degraded parts of the forests to accelerate the natural regeneration, promote forest regeneration, and provide opportunities for local employment. The accounting of these activities is based on a measured increase in biomass in the area in which such activities were executed.
- Projects with more accurate monitoring and verification are rewarded through a deduction mechanism based on the empirically observed accuracy. The accuracy is quantified based on (1) accuracy of remote sensing classification, and (2) the variance of biomass stock density.
- *Ex-ante,* the relative reduction in deforestation rates inside the project area is calculated by estimating the expected effect of a project activity on each driver. The simple spatial model calibrated previously is then used to divide the total deforestation and forest degradation rates in the project scenario into forest-strata specific rates. Subsequently, emission sources from project activities are calculated.
- Procedures to monitor and account for secondary emissions from increased rice production and intensification of livestock management are included in the methodology.

Note that where projects applying this methodology seek registration under a jurisdictional REDD+ program, the project must follow the requirements specified in the latest version of the VCS *Jurisdictional and Nested REDD+ (JNR) Requirements.*

Additionality and Crediting Method	
Additionality	Project Method
Crediting Baseline	Project Method

3 DEFINITIONS AND ACRONYMS

The following definitions and acronyms apply in the methodology.

3.1 Definitions Regarding Project Boundary

Baseline Validation Period
The period during which the *ex-ante* calculation of net GHG emissions under the baseline scenario is valid. As per VCS *AFOLU Requirements*, baselines are fixed for 10 years in all projects after which a new *ex-ante* baseline needs to be calculated and validated as per VCS rules.

Discrete Project Area Parcels
A project area that is contiguous or consists of multiple smaller adjacent and non-adjacent project areas that are equivalent to project activity instances when grouping procedures are applied.

Historical Reference Period

A fixed time period during which historical deforestation and forest degradation is analyzed in the reference region to set the forward-looking baseline. At validation, the historical reference period ends at the start of the crediting period. Once the project has started, and a baseline update is calculated, the historical reference period ends at the time at which the baseline is updated.

JNR Area

The geographic area registered under the jurisdictional REDD+ program.

Leakage Area

The sum of individual leakage belts which do not have to be contiguous.

Leakage Belt

The geographical area where leakage is expected around individual discrete project area parcels. Since leakage can occur on both forest land and non-forest land, such as woodland or grassland, the leakage belt may include any of these land types.

Project Area

The geographical area where the project participants will implement activities to reduce deforestation and forest degradation.

Reference Region

The region from which historical and current deforestation and forest degradation quantities and trends are obtained to predict future deforestation and degradation quantities in the absence of project activities (i.e., baseline scenario).

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

Forest Regeneration

The persistent increase of canopy cover and/or carbon stocks in an existing forest due to natural succession or human intervention, and falls under the IPCC GPG-LULCF 2003 land category of forest remaining forest.

Forest Strata

A division of forest land use and land cover (LULC) class determined by carbon stock density, native forest type, past and future management, landscape position, biophysical properties, and the degree of past disturbance.

Forest Stratification

The sub-division of the LULC class into narrower forest strata.[2]

---

[2] The minimum mapping unit established for LULC class is also applied to forest strata.

Increased Forest Cover

The transition of non-forest land into forest land, and encompasses both reforestation and natural succession.

Land Transition

A change from one LULC class or forest stratum into another within one geographical area. This methodology considers six main categories of transitions defined as deforestation, forest degradation, forest regeneration, increased forest cover, natural succession and reforestation.

Land Use and Land Cover (**LULC**) **Classes**

A land classification system that is hierarchical in nature. Specific definitions for cropland, grassland, settlement, wetland, and other land are provided in the IPCC Change's Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003 report (IPCC GPG-LULCF 2003).

Minimum Mapping Unit

The minimum unit used for remote sensing and classification procedures. In this methodology, a minimum mapping unit of 1 hectare (ha) applies.

Natural Succession

The natural increase in forest covers without any human intervention.

3.3   Other Definitions

Agents of Deforestation or Forest Degradation (**Agent**, **Agent of Deforestation**, or **Agent of Degradation**)

The social group, community or other entity involved in deforestation or forest degradation.

Assisted Natural Regeneration (ANR).

Human-induced forest regeneration through silvicultural activities that induce or accelerate increase in forest biomass, as compared to natural regeneration. ANR silvicultural activities include thinning to stimulate tree growth, removal of invasive species, coppicing, and enrichment planting.

Commercial Timber Harvesting.

The extraction of timber wood for further sale on regional or global timber markets outside of the project area.

Cook Stove and Fuel Efficiency (CFE) Activities.

Activities that result in efficiency improvements in the thermal application of non-renewable biomass. Example of such activities include the introduction of high efficiency biomass fired cook-stoves, ovens, dryers and/or improvement of energy efficiency of existing biomass fired cookstoves, ovens, or dryers.

Driver of Deforestation and Forest Degradation (Driver, Driver of Deforestation, Driver of Forest Degradation)

The immediate activity executed by agents of deforestation or degradation that leads to

deforestation/ degradation.

Subsistence Farming
A system of farming where all or almost all of the produce is used to meet the consumption needs of the farm family without any significant surplus for commercial sale.

3.4   Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use
ARR	Afforestation, Reforestation, and Revegetation
CDM	Clean Development Mechanism
CP	Conference of the Parties
CV	Coefficient of Variation
DBH	Diameter at Breast Height (1.3 m)
DF	Deforestation
DG	Forest Degradation
DM	Dry Matter
DNA	Designated National Authority
EF	Emission Factor
GHG	Greenhouse Gas
GIS	Geographic Information System
GPG-LULUCF	Good Practice Guide for Land Use, Land Use Change and Forestry
GPS	Global Positioning System
GWP	Global Warming Potential
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
LCL	Lower Confidence Limit
Mg	Mega gram = 1 metric tons
MMU	Minimum Mapping Unit
tCO2e	Metric Tons of Carbon Dioxide Equivalents
NER	Net Greenhouse Gas Emission Reduction
PD	Project Document
QA/QC	Quality Assurance / Quality Control
RED	Reduced Emissions from Deforestation
REDD	Reduced Emissions from Deforestation and Forest Degradation
SOC	Soil Organic Carbon
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit

4 APPLICABILITY CONDITIONS

4.1 General Applicability Conditions

The following applicability conditions apply. Note that in case the project area consists of multiple discrete project area parcels, each discrete project area parcel must also meet all applicability conditions below.

4.1.1   Conditions Related to Eligible Land Conditions

This methodology is applicable to areas where land prior to project implementation meets the following conditions:

- Land in the project area consists of either one contiguous area or multiple discrete project area parcels, and must meet an internationally accepted definition of forest, such as those based on UNFCCC host-country thresholds or FAO definitions, and must qualify as forest for a minimum of 10 years before the project start date.

- The project area must be deforested or degraded in absence of the REDD project activity and the deforestation and degradation must be mosaic in nature as described in the VCS *AFOLU Requirements.*

- Drivers of deforestation and forest degradation must fall into one or more of the following categories):

    - Conversion of forest land to cropland for subsistence farming.

    - Conversion of forest land to settlements.

    - Conversion of forest land to infrastructure, including new roads.

    - Logging of timber for commercial sale (eg, wood planks or poles for commercial sale).

    - Logging of timber for local enterprises and domestic uses.

    - Wood collection for commercial sale of fuelwood and charcoal.

    - Fuelwood collection for domestic and local industrial energy needs (eg, cooking, home heating, tobacco curing, brick making).

    - Cattle grazing in forests.

    - Extraction of understory vegetation (eg, thatch grass collection for roof and livestock bedding materials, shrubs and small trees for straw fences).

    - Forest fires to the extent that they are not part of natural ecosystem dynamics (eg, forest fires related to hunting, honey collection, intentional land clearing on land with a high fuel-load).

None of the drivers listed above must be planned in nature. If deforestation from a specific driver is occurring as a result of planned forest conversion activities, then such a driver must be excluded from analysis.

- This methodology is not applicable to organic soils or peatland.

4.1.2   Conditions Related to Eligible Project Activities

This methodology is applicable to projects that implement one or more of the following activities:

- Strengthening of land-tenure status and forest governance.

- Supporting the development and implementation of sustainable forest and land use management plans.

- Demarcating forest, tenure and ownership boundaries; promoting forest protection through patrolling of forests and forest boundaries; promoting social inclusion and stewardship in local communities; facilitating social fencing through capacity building; and creating mechanisms to alert law enforcement authorities of forest trespassing.

- Fire prevention and suppression activities including the construction of fire breaks, reduction of fuel loads, prescribed burning, education to minimize intentionally started fires, support for fire brigades, water cisterns, fire lookouts, and communication systems.

- Reducing fuelwood consumption and/or increasing energy efficiency by introducing fuel-efficient woodstoves or brick kilns and curing equipment.

- Creation of alternative sources of fuelwood through agroforestry, farm woodlots management and introduction/intensification of other renewable and non-fossil fuel based energy sources (such as solar).

- Sustainable intensification of agriculture on existing agricultural land.

- Development of local enterprises based on sustainably harvested non-timber forest products (NTFPs) such as honey, medicinal plants, etc.

4.2   Applicability Conditions for Optional Activities

4.2.1   Conditions Related to Optional Assisted Natural Regeneration Activities

Implementing Assisted Natural Regeneration Activities (ANR) activities as described in Section 8.2.5 is optional, but is only eligible under this methodology if all of the following applicability conditions are met:

- ANR activities must take place on degraded land on which no prior ANR activities have taken place. However, areas that were forest at the start of the project, but became deforested during the project crediting period are eligible as per the provisions under Section 9.3.7.

- ANR activities consist of thinning, removal of invasive species, enrichment planting, and coppicing.

- If harvesting takes place or is planned on areas on which ANR activities take place, this area must be considered area under harvest as specified in Section 8.2.7.

- The area on which emission reductions/removals from ANR activities are generated must never exceed the total area that would have been deforested under the baseline scenario . For example, if the baseline scenario includes 500 ha of deforestation per year of which 100 ha becomes forest again due to natural reforestation every year, ANR activities may only be planned for 400 ha in the first year, 800 ha, in the second and 1200 ha in the third..

Note that the total size of the areas on which ANR activities are planned must be specified either in the project description (PD) or the monitoring report depending on when the ANR activities are implemented. For example, if ANR is implemented in a given area between the first and second verification, the total size of the area where ANR is to be implemented must be reported in the second monitoring report and the exact location of the ANR activities must be identified at verification.

4.2.2 Conditions Related to Optional Cookstove and Fuel Efficiency Activities

Implementing cookstove and fuel efficiency (CFE) activities as described in Section 8.2.6 are optional, but are only eligible under this methodology if all of the following applicability conditions are met:

- CFE activities must be implemented by the project proponent managing the project area that is being degraded or deforested, and must be targeted towards households and/or local institutions in the immediate vicinity of the project area,

- Fuelwood use such as collection of fuelwood, and charcoal production must be identified as one of the drivers of deforestation and degradation in the project according to the procedure under this methodology.

- The project forests and leakage belts must be the source for non-renewable biomass in the baseline scenario.

- In the baseline scenario, at least 50% of the households in the reference region must be using traditional cookstoves which can be demonstrated through appropriate local or regional statistics on fuelwood use.

4.2.3 Conditions Related to Optional Harvest Activities in the Project Area

Implementing harvesting in the project area as described in Section 8.2.7 is optional but is only is eligible under this methodology only if the following applicability conditions are met:

- The harvest plan and harvest activities must follow Best Management Practice (BMP) guidance of the country or jurisdiction, if such BMP guidance exists.

- The harvest plan must describe procedures to protect soil, water and residual trees in the harvest area and provide documentation on the presence/absence of any threatened or endangered species on the site, potential impacts on species and mitigation measures that will be employed.

- The harvest plan must describe the biophysical sustainability of the harvesting practices. At minimum, the biophysical sustainability must be demonstrated by ensuring that the net removal of biomass from harvesting is less than the net increment of the biomass in the forest. Where possible, the project proponent should use criteria and indicators such as from International Tropical Timber Organization (ITTO) to assess the sustainability of harvesting practices. In addition, it is recommended to obtain sustainability certification from third parties, such as the Forest Stewardship Council or the Sustainable Forestry Initiative.

4.2.4 Conditions Related to Optional Intensification of Annual Crop Production Systems as a Leakage Prevention Activity

Intensification of annual crop production systems as a leakage prevention activity (see Section 8.3.4.1) is optional, but is only eligible under this methodology if all of the following applicability conditions are met:

- The agricultural intensification measures must be implemented only on land that is located within the leakage belt.

- The agricultural intensification measures must be implemented on land on already under annual crop production systems at the time of validation.

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

4.2.5 Conditions Related to an Optional Increase in Flooded Rice Production Systems as a Leakage Prevention Activity

The introduction of flooded rice production systems as a leakage prevention activity (see 8.3.4.2) is optional, but is only eligible under this methodology only if all of the following applicability conditions are met:

- Flooded rice production systems must be implemented on land that is located within the leakage belt.

- Flooded rice production systems must be implemented on land that is already under annual crop production systems at the time of validation.

- The flooded rice production systems cannot be implemented on organic soils.

- The N_2O emissions from flooded rice production systems must be insignificant.

4.2.6 Conditions Related to an Optional Increase in Livestock Stocking Rates as a Leakage Prevention Activity

Increasing livestock stocking rates as a leakage prevention activity (see 8.3.4.3) is optional, but is only eligible under this methodology if all of the following applicability conditions are met:

- Increased stocking must only occur within the leakage belts of the project area, not within the project boundary.

- If the proposed activity produces forage to feed livestock, all forage must have a similar nutritional value and digestibility, and support only a single livestock group with a single manure management system.

- If the stocking rate is increased for animals that are already in a zero-grazing system or are moved to a zero-grazing system then the grazing activity that is monitored must be the production of fodder.

- Increased stocking rates must only occur on identified forest land, identified cropland, identified grassland, and unidentified land).

- Increased stocking rates must not occur on settlements, wetlands, or other lands as defined by the GPG LULUCF (i.e., bare soil, rock, ice, and all unmanaged land areas that do not fall into category of forest land, cropland, grassland, settlements or wetlands).

5 PROJECT BOUNDARY

5.1 Gases

This methodology requires accounting of all potential emissions of CO_2, N_2O and CH_4 from sources not related to changes in carbon pools, henceforward referred to as emission sources (Table 1). Insignificant emission sources may be excluded according to the VCS rules if insignificance can be demonstrated after using the latest version of CDM *Tool for testing significance of GHG emissions* in EB31 Appendix 16.

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

Source		Gas	Include?	Justification/Explanation
Baseline	Baseline Deforestation and Forest Degradation	CO_2	Optional	Emissions are related to changes in carbon pools. Include only when the degradation has not been included in the estimation of changes in carbon pools and if CFE activities are implemented.
		CH_4	Optional	Conservatively omitted except when CFE activities are implemented.
		N_2O	Optional	N_2O emissions from burning woody biomass are assumed negligible and conservatively excluded except when CFE activities are implemented.
Project	Cookstove and Fuel Efficiency (CFE) activities	CO_2	Optional	Emissions are already included in the changes of carbon pools. Include only when the degradation has not been included in the estimation of changes in carbon pools.
		CH_4	Yes	CH_4 emissions of burning woody biomass in CFE activities are significant.

		N₂O	Yes	N$_2$O emissions of burning woody biomass in CFE activities are significant.
	Biomass burning from unplanned large and small scale fires	CO$_2$	No	Emissions are already included in the changes of carbon pools
		CH$_4$	No	CH$_4$ emissions of burning woody biomass from unplanned fires are insignificant. If the fires are catastrophic, CH$_4$ emissions must be estimated and demonstrated negligible or otherwise accounted for.
		N$_2$O	No	N$_2$O emissions of burning woody biomass from unplanned fires are insignificant, unless fires are catastrophic, N$_2$O emissions must be estimated and demonstrated negligible, or otherwise accounted for.
	Fossil fuel used during harvesting	CO$_2$	No	Emissions from fossil fuel combustion is considered de-minimis for REDD.
		CH$_4$	No	Insignificant
		N$_2$O	No	Insignificant
	Removal of woody biomass for fire prevention and suppression activities	CO$_2$	Yes	Emissions related to changes in carbon pools are taken into account
		CH$_4$	Yes	CH$_4$ emissions from removal of woody biomass are significant when prescribed burning is used to clear the land.
		N$_2$O	No	N$_2$O emissions from burning woody biomass are assumed negligible and conservatively excluded.
	Removal of woody biomass during assisted natural regeneration (ANR) activities	CO$_2$	Yes	Emissions related to changes in carbon pools are taken into account
		CH$_4$	Yes	CH$_4$ emissions from removal of woody biomass are significant when fire is used in preparing the land for ANR activities
		N$_2$O	No	N$_2$O emissions from burning woody biomass during ANR activities are assumed negligible and conservatively excluded.
	Fertilizer used during enrichment planting for assisting natural regeneration	CO$_2$	No	Assumed negligible
		CH$_4$	No	Assumed negligible
		N$_2$O	No	Assumed negligible per VCS guidance
	Increased area of	CO$_2$	No	Assumed negligible

rice production systems	CH$_4$	Yes	CH$_4$ emissions from rice cropping systems are significant
	N$_2$O	No	Assumed negligible per VCS guidance
Increased fertilizer use	CO$_2$	No	Not applicable
	CH$_4$	No	Not applicable
	N$_2$O	No	N$_2$O emissions related to increased fertilizer use are de minimis
Increased livestock stocking rates	CO$_2$	No	Not applicable
	CH$_4$	Yes	CH$_4$ emissions related to increases in livestock stocking rates are significant
	N$_2$O	Yes	N$_2$O emissions related to increases in livestock stocking rates are significant

5.2 Carbon Pools

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

Table 2: Selected Carbon Pools

Carbon Pool	Included?	Justification/ Explanation of Choice
Aboveground tree biomass	Yes	Major carbon pool affected by project activities
Aboveground non-tree biomass	Yes / Optional	Expected to increase from project activities. Must be included when the land cover under the baseline scenario is perennial tree crop. May be excluded when baseline land cover is annual crop or pasture grass.
Belowground biomass	Optional	Major carbon pool affected by project activities. May be conservatively excluded.
Dead wood	Optional	Major carbon pool affected by project activities. May be conservatively excluded. If included either or both of standing or lying deadwood may be included.
Litter	No	Excluded as per VCS *AFOLU Requirements*.
Soil organic carbon	Optional	Conservative to exclude since this pool is expected to decrease under the baseline scenario. However, may be only included per VCS *AFOLU Requirements* on the condition that the land cover under the baseline scenario is comprised of annual cropping systems.
Wood products	Yes	Major carbon pool affected by project activities

5.3   Spatial Boundaries

The spatial boundaries of (1) the project area, (2) the leakage area and (3) the reference region or the JNR Area if a project is nested within a jurisdictional REDD+ program. The spatial boundary must be unambiguously defined in the PD. Project proponent must provide digital (vector-based) files of the discrete project area parcels in Keyhole Markup Language (KML) file format or any other format required by *VCS Standard*. The project area may be contiguous or consist of multiple adjacent or non-adjacent parcels i.e., discrete project area parcel. A leakage belt for each discrete project area parcel must be defined, if applicable. The leakage area is the sum of the individual leakage belts. The reference region excludes the project and leakage areas. Therefore, as new project and leakage areas are defined over the course of the project crediting period as new project activity instances (i.e., discrete project area parcels) are added, project and leakage areas must be excluded from the reference region polygon.

6   PROCEDURE FOR DETERMINING THE BASELINE SCENARIO

Under this methodology, the most plausible baseline scenario for a project is the existing or historical changes in carbon stocks in the carbon pools within the project boundary. This baseline scenario is consistent with scenario identified in the CDM Modalities and Procedures for afforestation and reforestation, project activities (Decision 5/CMP.1), paragraph 22, option (a):

Existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary.

This option was selected because under the mosaic typology of deforestation, the historical changes in land-use are representative for the most likely future changes in land-use. The most appropriate future scenario is that historical rates, change in rate, and dynamics of deforestation and forest degradation will continue in the future.

The net GHG sources and sinks under the baseline scenario must be estimated *ex-ante* for each year of the crediting period. Once validated, the baseline is to be used for the calculation of actual NERs. Baseline calculations remain valid only for a limited period of time and must be updated in accordance with the VCS rules on renewal of baselines. The procedure for updating the baseline is specified in Section 9.3.9.

7   PROCEDURE FOR DEMONSTRATING ADDITIONALITY

Projects must apply 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* to demonstrate additionality.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions for Projects

8.1.1 Select Spatial Boundaries

This step includes the demarcation of the project area and the reference region. Note that the demarcation of the leakage area is included in Section 8.3.2.2.

8.1.1.1 Describe Spatial Boundaries of the Discrete Project Area Parcels

The project proponent must provide digital (vector-based) files of the discrete project area parcels in Keyhole Markup Language (KML) file format as required by *VCS Standard*. A clear description must accompany each file, and the metadata must contain all necessary projection reference data. In addition, the PD must include a table containing the name of each discrete project area parcel, the centroid coordinate (latitude and longitude using a WGS1984 datum), the total land area in hectares (ha), details of tenure/ownership and the relevant administrative unit it belongs to (county, province, municipality, prefecture, etc.). New discrete project area parcels (referred to as new project instances) may be integrated into an existing project after the project starts and must be verified for crediting.

8.1.1.2 Select a Valid Reference Region

A reference region must be representative of the future trajectory of the project area in absence of the project activities. For a reference region to be fully representative, and selected without any bias, the following necessary conditions must be met:

- The minimum size of the reference region excluding the project area and leakage area must be 250,000 ha or the size of the project area at the start of the crediting period, whichever is greater. If the entire country or autonomous territory is less than this size, then the reference region must be equal to the entire country or that territory. When a project area is located on an island which is smaller than the required reference region, then it is sufficient to have the entire island as the reference region.

- The boundaries of the reference region must be unbiased and coincide with a combination of natural, geopolitical, satellite footprint, and/or watershed boundaries, or boundaries that were created by applying a distance buffer around the discrete project parcels. A natural boundary is a boundary of a naturally occurring phenomenon such as a river, mountain range, lake, ocean, or watershed. Where possible, natural boundaries that coincide with administrative or jurisdictional boundaries so that land-use and land cover related policies are consistent across the reference area must be selected.

- The project proponent must demonstrate that the reference region does not contain areas where agents of deforestation have restricted acces**s**. Include maps where the reference region and the project area have been overlaid with maps of protected areas, including:

  - National parks that are effectively protected.

- Military bases or installations.

- Areas under conservation that are effectively protected.

- Areas under a logging or economic land concession where access is effectively being restricted.

- Large plantations that are effectively protected.

- The reference region must exclude areas where planned deforestation activities took place. It must be demonstrated that planned deforestation areas have been excluded from the reference region or proof of non-existence of such areas within the reference region must be provided.

- The reference region must exclude deforested areas caused by natural (non-anthropogenic) large-scale, extraordinary events (e.g. geological and weather impacts which are infrequent but significant in their impact on the landscape). Such areas are excluded from the reference region since these are not likely to occur within the project area during the crediting period.

- The project proponent must demonstrate that the reference region contains, at minimum, 15% forest cover at the beginning of the crediting period, unless the reference region encompasses a whole country or island[3]. This condition must be explicitly checked using the classification that is developed under Section 8.1.2 of this methodology.

- The project proponent must compare a number of key variables between the reference region and project area according to the procedures outlined in Table 3 below. Areas in the potential reference region where one or more of these variables differ from the project area are not eligible and must be excluded from the reference region.

These conditions are designed as safeguards against biases caused by arbitrary boundary demarcation. However, it is impossible to provide a sufficient set of rules to avoid bias under all project circumstances. Therefore, at validation, the validation/verification body must determine that the selection of the reference region is truly unbiased.

The reference region may include project area and leakage belts initially, but the project area and leakage belts are excluded from the reference region after the start of the crediting period. Additionally, whenever new instances of project areas and leakage areas that were previously included in the reference region are added into the existing project area, the new added instances must be removed from the reference region.

---

[3] Given historical deforestation, the reference region is likely to have a significantly higher percentage of forest cover at the beginning of the historical reference period.

Table 3: Comparison variables to demonstrate similarity between project area and reference region.

Category	Variable	Comparison procedure	Explanation
Drivers of deforestation	Drivers of deforestation	All drivers that were identified in the project area must also be present in the reference region. A comparison of the existence of every driver between the project area and the reference region must be carried out. The similarity between the project area and the reference region drivers must be documented and justified with relevant evidence.	Since the reference region will be used to determine baseline deforestation and degradation rates in the project area, the drivers of deforestation must be similar in the reference area and the project area.
Landscape configuration	Distribution of native forest types	The proportion of each forest type within the reference region (see Section 8.1.2.2) at the beginning of the historical reference period must be within 10% of forest type proportions within the project area. Percentages must be calculated relative to the total area of forests, not the total land area.	Deforestation and land-use change dynamics are highly dependent on geographical conditions. For example, if the project is to protect montane forest at the top of a watershed then lowland and valley forests should not be used as a reference region.
	Elevation	The proportion of area contained within 500-m elevation classes of the reference region must be within 10% of these elevation class proportions in the project area.	
	Slope	The proportion of area contained within 5% slope classes of the reference region must be within 10% of these slope class proportions in the project area.	
Socio-economic and	Land-tenure status	The land-tenure system prevalent in the reference	The specific land tenure system impacts the rate of

cultural conditions		region must be demonstrated to be similar to the land-tenure system in the project area with reference to peer-reviewed literature, reports, or expert opinion. Any differences in land tenure systems between the project area and reference region must not affect the drivers of deforestation and degradation or the operation of the agents of deforestation and degradation	land use changes, and must therefore be similar between the project area and reference region, especially in terms of how the land tenure system may impact access and mobility of the agents or influence the drivers of deforestation and degradation.
	Policies and regulations	The reference region must be governed by an administrative unit that has comparable enforced policies, regulations and capacities as the administrative unit of the project area.	Different governing bodies may have a different legislative framework or capacity for enforcement. It has to be demonstrated that the forest is similar in the reference region and project area.
	Degree of urbanization	Proportion of urbanized and agriculture-based population within the reference region must be within 10% of this proportion in the project area.	People living in urban areas have a significantly different relation to forest land compared to people that are agriculture-based.

8.1.2 Analyze Historical Deforestation and Forest Degradation in the Reference Region

8.1.2.1 Describe Data Sources

The quantification of deforestation and forest degradation rates under this methodology is based in part on remote sensing and other spatial data. The selection of data sources must follow Chapter 3A.2.4 of the IPCC 2006 GL AFOLU. Table 4 below lists the data that are required. This table also outlines the information about these data that must be documented in the PD. At least three images of forest cover are required during the historical reference period, (1) at minimum one image from 0-3 year before project start date, (2) at minimum one image from 4-9 years before project start date, and (3) at minimum one image from 10-15 years before project start date. No images older than 15 years may be used for the historical reference period.

Table 4: Information to be reported with respect to remote sensing and other spatial data employed for assessing deforestation and forest degradation.

Data Source	Main Use for Data	Information Needed about the Data Collected
High to medium resolution (≤ 30 m) remote sensing data are required for at least three time points: (1) at least one image from 0-3 years before project start date, (2) at least one image from 4-9 years before project start date, and (3) at least one image from 10-15 years before project start date. No images older than 15 years may be used for the historical reference period.	Historical analysis of deforestation and forest degradation	Source Type Resolution (spatial and spectral) Acquisition date Coordinate system and pre-processing If different sources of remote sensing data are used, a formal comparison of the sensors should be added to the monitoring report to ensure consistency.
Readily available LULC maps which are already processed are complementary	Training of classification procedures Independent verification of the analysis of historical images	Minimum Mapping Unit (ha) Description of method used to produce these data Descriptions of the LULC classes and/or LULC-change categories Information on how these classes may match with IPCC classes and categories
Recent (< 5 yr) high resolution (< 5 m) remote sensing data is required for at least part of the reference region at a time point coinciding with one of the	Training of classification procedures. Ground-truthing and check of accuracy	Source Type Resolution (spatial, spectral) Acquisition date Coordinate system and pre-

medium-resolution remote sensing images.		processing
Direct field observations or visually interpreted locations from remote sensing images are required for calibration of the classification and stratification procedures and validation of the calibration and classification accuracy.	Training of classification procedures. Ground-truthing and check of accuracy	Acquisition date Type of data coordinate system Location of coordinates

8.1.2.2 Define LULC Classes and Forest Strata

The ultimate goal of a classification and stratification system is to partition an analysis area, into LULC classes or forest strata that are homogeneous in carbon stock density, in a cost-effective and practically-feasible way. The exact number and type of LULC classes and forest strata used is project-specific and dependent on local conditions. A number of iterations between the remote sensing image analysis and LULC class and forest strata definitions may be necessary before an optimal classification is attained. The same LULC classification and forest stratification must be developed for and applied to all analysis areas (i.e. reference region, project area and leakage area) and crediting periods in order to avoid any spatial or temporal bias in carbon accounting.

The result of forest stratification reflects the current condition or state, and not the process of change or future evolution of a specific forest stratum. A degraded forest stratum will regenerate if drivers of deforestation are restricted. In contrast, a low-density, open forest may stay in a low-carbon state due to persistent biophysical conditions and constraints. Although their future evolution will be different, these two forest systems may share similar carbon stock densities for a time.

A sound definition of LULC classes and forest strata is crucial for accurate and conservative carbon accounting. The project proponent must demonstrate that the LULC classes and forest strata identified will not lead to systematic overestimation of carbon losses in the baseline and therefore overall emission reductions/removals attributed to the project. This assessment must be done after biomass density values are available for each LULC class or forest stratum, as described in Section 8.1.4.4.

LULC classification and forest stratification must be conducted for the whole analysis area, which is the union of the reference region, leakage area and project area, as follows:

- Include, at minimum, the six IPCC LULC classes (Forest Land, Crop Land, Grassland, Wetlands, Settlements, and Other Land) in the LULC class definitions. The definition of these classes must be consistent with Chapter 2 of the IPCC GPG-LULUCF 2003. In cases where the country has defined more specific LULC classes than the IPCC classes, these definitions must be used if they are accurate enough for project-specific classification.

- The minimum mapping unit for LULC classes must be less than 1 ha.

- To achieve the goal of defining classes that are homogeneous in carbon stock density, the forest LULC class must be sub-divided into forest strata. Forest land is usually heterogeneous in terms of local climate, soil condition, forest canopy cover, and forest type. Forest stratification can help define homogeneous units with reduced variance in terms of carbon stock density, and thereby increase the measurement precision without increasing cost, or reduce the measurement cost without reducing precision.

- If emissions from avoided degradation are included, appropriate forest strata representing regeneration stages must be included as well. Because emission reductions are discounted based on the uncertainty of the biomass inventory, stratifying forest may lead to increased emission reductions.

- It is recommended that forest stratification be based on an assessment of the key factors that influence carbon stocks in the included carbon pools such as soil features, local climate, landform (e.g., elevation, slope, and aspect), forest type, dominant tree species, soil erosion intensity, forest management, regeneration stage and human degradation intensity using a GIS analysis augmented with forest surveys.

- Managed forests must be divided into different forest strata according to the forest management regimes, unless the differences in management among regimes do not lead to significant differences in carbon density during the baseline validation period.

- The accuracy of stratification maps must be determined using the procedures described in Section 8.1.2.7

- All areas that will be subject to ANR activities within the project area[4] must be further divided into forest strata according to the specific silvicultural management activities that will be employed on these areas. The project proponent must present maps of the stratified project areas in the PD.

- All areas that will be subject to harvest activities within the project area must be further divided into forest strata according to the harvest plan. The project proponent must present maps of the stratified project areas in the PD.

8.1.2.3 Define Land Transitions between LULC Classes/Forest Strata

A list of the expected land transitions must be included in the PD in the form of a LULC and forest strata transition matrix.

Land that only temporarily transitions from forest to non-forest and transitions back to forest after a short while is considered temporarily unstocked forest and may not be counted towards the total deforestation and increased forest cover rates. For every deforestation transition, select the maximal period that the "from" forest stratum can be out of forest cover and is temporarily unstocked. Use a default value of two years, unless project-specific

---

[4] ANR activities are carried out only in areas that would otherwise be deforested in the baseline scenario which is different from Afforestation and Reforestation activities.

conditions demand a different period.

By definition, degradation is a process that must have persisted for at least 3 years. In other words, forest land that transitions from a stratum with a larger carbon density stock to a stratum with smaller carbon density stock can only be considered degradation if it has persisted for 3 years.

8.1.2.4 Analyze Historical LULC Class and Forest Strata Transitions

The historical rates of all LULC classes and forest strata transitions must be calculated on the union of the reference region, leakage area, and project area, based on a remote sensing analysis executed by the project proponent. However, existing classification or stratification maps can be used if (1) the classes or strata in these maps can be matched to the LULC class and forest strata definitions developed according to this methodology and (2) the accuracy of these maps is quantified using the procedures in Section 8.1.2.7.

A wide range of remote sensing products exist for LULC classification and forest stratification based on optical, multispectral, RADAR or LiDAR sources, and acquired from airborne or satellite platforms. The most appropriate data product is dependent on project conditions and requirements. The analysis of land cover change must be performed by processing and analyzing remote sensing data in three steps described in the following sections:

- Pre-processing of remote sensing data.

- LULC classification and forest stratification.

- Accuracy assessment and discounting factor determination.

8.1.2.5 Pre-processing of Remote Sensing Data

Pre-processing includes geometric correction and handling image data loss due to cloud cover.

- Geometric correction ensures that images in a time series overlay properly to each other and to other GIS maps used in the analysis (i.e. for post-classification stratification). The average location error between two images (RMSE) must be less than or equal to one pixel.

- Clouds or cloud shadows must be masked out and excluded from the calculation of deforestation rates. The maximum allowable cloud cover is ≤ 20% for a single image or ≤ 20% on average across image pairs used in the transition rate analysis.

- A forest benchmark map must be generated to show forest cover status in the project and leakage areas. The final LULC map in the historic series can be used as the forest benchmark map, however missing values within the project and leakage areas due to cloud and cloud shadow must be filled with RS data acquired within three years before the start of the crediting period to be eligible. Geographic areas for which no cloud-free or cloud-shadow-free imagery is available within three years of the project start must be excluded from the project area. These may only be added back to the project area at verification following the rules of

"Additions of New Project Area" set out in Section 9.3.

- Calculation of GHG benefits in the project and leakage areas after the project start must include only cloud-free imagery. When clouds and cloud shadows are present, calculation of the GHG benefits from these areas must be postponed until cloud-free remote sensing data is available in a subsequent monitoring period. These temporarily halted NERs may be added to the NERs generated in the subsequent monitoring period. This is only allowed on areas for which the forest status was unambiguously demonstrated at the beginning of the crediting period (see previous point).

Consult experts and literature for further advice on pre-processing techniques. Duly record all pre-processing steps for later reporting.

8.1.2.6 LULC Classification and Forest Stratification

LULC classification and forest stratification may be (sub-) pixel based or segment-based. Attribution of classes to pixels or segments must be done using widely accepted methods such as maximum likelihood, decision trees, or support vector machines. Ancillary data may be included to improve classification accuracy. Typical ancillary data includes climate, soil, elevation, slope, proximity to certain built or natural features (e.g. roads, settlements, or water bodies), and land tenure status (e.g. protected forest, logging concession, indigenous reserve, etc.). The minimum mapping unit for LULC classification and forest stratification must be set according to the forest definition employed for the project, but must be less than 1 ha (see Section 3.2).

If emission reductions from avoided degradation are included, a forest stratification model must be unambiguously defined at validation. The forest stratification model may use input data that includes a combination of optical remote sensing, radar and LiDAR measurements, as well as ancillary data such as topography or LULC classes. The model itself may be rule-based, regression-based, or machine-learning based. However, the parameters of the model may not be changed after validation (ie, the forest stratification model itself is fixed until the next baseline update). In addition, if biomass plot or biomass carbon stock density is used during the development of a forest stratification model, either to develop a regression model or to verify the stratification model, these data may not be used for calculating the biomass stock densities and emission factors of the strata.

8.1.2.7 Map Accuracy Assessment and Discounting Factor Determination

Different procedures to determine discounting factors for the broad classification into forest types or forest/non-forest land and the stratification of forest land into different carbon density classes are imposed.

Discounting factor for LULC classification, $u_{classification}$: The accuracy by which broad LULC classes can be discerned is used to discount emission reductions and/or removals from avoiding deforestation. The discounting factors for LULC classification are fixed until the next baseline update.

The accuracy assessment of LULC classification must be conducted for all LULC maps

across the whole analysis area, i.e., the union of the project and leakage areas and the reference region. The accuracy must be assessed by comparing predicted LULC classes for a number of reference locations with independently determined LULC classes. Reference locations must be located throughout the reference region, leakage area, and project area. The LULC classes for these reference locations must be identified using field observations, in-situ maps, remote sensing data, and/or other ground-truthing data. At minimum 50 reference locations per LULC class must be used. If the area of the class exceeds 500 km[2] or the number of classes is more than 12, then, at minimum,75-reference locations per class must be used.[5] The reference locations within each LULC class must be systematically distributed to represent varying topography, parcels and other geographic features.

The accuracy of historic images may be assessed using historic medium to high-resolution images, aerial photographs or local topographic maps existing at the time when the historic image was acquired. At validation, the historic period is relative to the start of the crediting period. However, when a baseline update occurs, the historic period is relative to the current project year, and more historical data may become available to conduct an accuracy assessment at that time. See monitoring Section 9.3.2 for procedures to apply after the project start.

The discounting factor for the LULC classification is determined in three steps:

- **Step 1**: Determine the accuracy of LULC classification for each map by creating a confusion matrix. Report the overall accuracy, and the commission and omission errors (see Congalton 1991 and Pontius 2002 for an in-depth explanation of these concepts).

- **Step 2**: Multiply the accuracy of LULC classification from step 1 with a factor based on the smallest accuracy of all maps (see Table 5 below). If the accuracy of broad LULC classification is less than 70%, the project is not eligible under this methodology.

Table 5. Uncertainty deduction factors for LULC classification as a function of accuracy attained.

Accuracy attained	STEP 2 factor
≥85%	1.00
≥80 to <85%	0.80
≥75 to <80%	0.75
≥70 to <75%	0.70
<70%	Project is not eligible

---

[5] The specification of the number of reference locations is based on recommendations by Congalton (1991), Hay (1979) and Fenstermaker (1991).

- **Step 3**: Multiply the factor from Step 2 with a factor based on the number of images in the historical reference period to get $u_{classification}$, the total discounting factor for avoiding deforestation as indicated in Table 6, An absolute minimum of three images is required to quantify the historical deforestation rate.[6]

Table 6. Uncertainty deduction factors for LULC classification as a function of number of images in historical reference period.

Number of images in historical reference period	STEP 3 factor
1-2	Project is not eligible
3	0.90
>3	1.00

The classification accuracy of every map used for verification must be greater than the smallest accuracy obtained during the historical reference period. The $u_{classification}$ factor must be fixed at validation until the next baseline update, even when the classification accuracy improves after the start of the project.

Discounting factor for forest stratification, $u_{stratification}$: As forest strata are determined by their carbon content, the full uncertainty of stratification can be assessed in an unbiased way through the discounting factor for the carbon stock density of the stratum, as explained in Section 8.1.4.4. However, there are two important conditions for this statement to be true:

- The plots used in calculating the uncertainty of the carbon stock density were not used to develop the forest stratification model; and

- The plots used in calculating the uncertainty are randomly selected and represent all time points that are covered.

While the first is covered by the requirement that different plots must be used for creating the forest stratification model and determining the carbon stock density and its uncertainty, the second can only be fulfilled if biomass plot densities measured and assessed at multiple times are used in the calculation of the carbon stock density and the associated uncertainty following Section 8.1.4.4. Since it is unlikely that a project will have historical biomass inventories available, the methodology allows using biomass inventories collected at different time points after the project start date to estimate $u_{stratification}$, the discounting factor for forest stratification. Further, to incentivize a sound monitoring effort by the project proponent, the discounting factor for forest stratification is dependent on the number of time points available in biomass inventories. Note that there must be at least one year in between time points for biomass inventories. Finally, it is allowed to only use biomass inventories that are located within the project area on conditions that these plots do not cause any bias and that these plots are representative of the stratum and/or LULC of the reference region.

---

[6]   Note that when baselines are updated during the crediting period, a similar procedure must be used to update baseline deforestation rates. The historical reference period always ends at the time of the baseline update. Therefore, gradually more data points will become available during the crediting period, and eventually eliminate this discounting.

Table 7. The discounting factor for forest stratification as a function of the number of time points available in biomass inventories.

Number of time points available in biomass inventories	$u_{stratification}$
1	0.75 for ex-ante; not eligible for ex-post
2	0.75
3	0.90
>3	1.00

For example, if validation is done separate from verification, only 1 set of biomass inventories is available at validation, therefore $u_{stratification}$ must be set to 0.75 for ex-ante calculations. At first verification, the project proponent is required to measure an additional set of biomass plots so that at least 2 time points of biomass inventories are available. Section 8.1.4.4 explains how to update the average carbon stock density values and the uncertainty associated with them when plot measurements from multiple times are available. Therefore, at first verification, $u_{stratification}$ remains 0.75 according to the table above. At second verification, the project proponent has a choice to either not measure additional plots and keep $u_{stratification}$ at 0.75, or measure a third set of biomass inventories and use 0.9 as $u_{stratification}$.

In contrast to $u_{classification}$, $u_{stratification}$ is not fixed at validation and may be updated at verification

8.1.2.8 Summarize all Historical Land Transitions

For every pair of subsequent images in the historical reference period, calculate the area of each land transition and report in a LULC and forest strata transition matrix. Note that for deforestation, lands should have been without forest cover for longer than the period defined as temporarily un-stocked. Likewise, for degradation, lands must have been in the smaller carbon stock density stratum for at least 3 years. Apply an appropriate temporal filter to ensure that only land that meets the three-year condition is designated as degradation. In addition, the PD must contain a table which contains the overall areas (ha) of deforestation, increased forest cover, forest degradation, and regeneration for each sub-period. These data will be used to project future land use change (Section 8.1.5.1).

8.1.3 Analyze the Agents and Drivers of Deforestation and Degradation

Deforestation can be the result of a short-term process (e.g., forest clear-cutting) or a gradual progressive process referred to as forest degradation (see definitions). Therefore, it is often challenging to distinguish agents/drivers of deforestation from agents/drivers of forest degradation. As a consequence, throughout this document, the term agents/drivers of deforestation is used for agents/drivers of deforestation and forest degradation. The drivers of deforestation and/or forest degradation must be those set out under the applicability conditions.

The PD must contain an analysis of the agents of deforestation and drivers similar to the analysis in Angelsen and Kaimowitz (1999) and Chomitz et al. (2006) by performing four

steps, as described below.

8.1.3.1 Identify Agents and Drivers of Deforestation and Forest Degradation

For each of the ten included categories of drivers covered by this methodology that are present in the reference region, the main agents must be identified. Agents of deforestation may include small-scale farmers, encroachers, hunters, ranchers and loggers. In some cases, one or more of the listed categories of drivers need to be sub-divided into separate individual drivers based on main agents acting on particular drivers. A qualitative analysis of the broader underlying forces determining the agents' motivations for deforestation and forest degradation must be included. Where relevant to a driver, the following aspects must be considered in this analysis:

- Population pressure.

- Poverty.

- War and other types of conflicts and their effects.

- Changes in policies related to subsidies or payments for environmental services

- Property and land tenure regime.

- Market forces influencing land and commodity prices.

8.1.3.2 Assess the Relative Importance of the Drivers of deforestation

The relative contribution of each of the drivers of deforestation to the total historical deforestation and forest degradation is estimated in two steps: (1) estimating the absolute annual carbon loss per driver, and (2) estimate the relative contribution of each driver to the total carbon loss from deforestation and degradation.
Sub-Step 1: Estimating the absolute annual carbon loss per driver using the formulas in Table 8, which are based on GPG-LULUCF.

Table 8. Formulas to calculate the absolute annual carbon loss per deforestation or forest degradation driver category

No.	Driver category	Annual carbon loss
1	Conversion of forest land to cropland for subsistence farming	$$L(1) = CF \cdot \sum_{i=1}^{nrStrata} \Big(\Delta area_{cropland,baseline}(i) \cdot \big(OM(i) - OM(cropland)\big)\Big) \quad \text{[EQ1]}$$ (Equation 3.3.8 from GPG LULUCF)
2	Conversion of forest land to settlements	$$L(2) = CF \cdot \sum_{i=1}^{nrStrata} \Big(\Delta area_{settlement,baseline}(i) \cdot \big(OM(i) - OM(settlement)\big)\Big) \quad \text{[EQ2]}$$ (Equation 3.3.8 from GPG LULUCF)
3	Conversion of forest land to infrastructure such as roads, cell phone tower, power lines	$$L(3) = CF \cdot \sum_{i=1}^{nrStrata} \Big(\Delta area_{infrastructure,baseline}(i) \cdot \big(OM(i) - OM(infrastructure)\big)\Big) \quad \text{[EQ3]}$$ (Analogous to Equation [EQ2])
4	Logging of timber for commercial sale	$$L(4) = CT_{baseline} \cdot \rho_{wood} \cdot BEF_2 \cdot CF \quad \text{[EQ4]}$$ (Equation 3.2.7 from GPG-LULUCF)
5	Logging of timber for local enterprises, and domestic uses	$$L(5) = DT_{baseline} \cdot \rho_{wood} \cdot BEF_2 \cdot CF \quad \text{[EQ5]}$$ (Equation 3.2.7 from GPG-LULUCF)
6	Wood collection for commercial on-sale of fuelwood and charcoal	$$L(6) = CFW_{baseline} \cdot \rho_{wood} \cdot BEF_2 \cdot CF \quad \text{[EQ6]}$$ (Equation 3.2.8 from GPG-LULUCF)
7	Fuelwood collection for domestic and local industrial energy needs	$$L(7) = DFW_{baseline} \cdot \rho_{wood} \cdot BEF_2 \cdot CF \quad \text{[EQ7]}$$ (Equation 3.2.8 from GPG-LULUCF)
8	Grazing	$$L(8) = CF . GR_{baseline} \quad \text{[EQ8]}$$ (Adaption of Equation 1 of CDM A/R Methodological Tool *Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity*)
9	Understory vegetation collection	$$L(9) = CF \cdot VG_{baseline} \quad \text{[EQ9]}$$

		(Analogous to Equation [EQ9])	
10	Forest fires	$L(10) = CF . \sum_{i=1}^{nrStrata} \Delta area_{fire,baseline}(i) \cdot E \cdot P \cdot OM(i)$ (Equation 3.2.9 from GPG-LULUCF)	[EQ10]

where:

$L(d)$	Annual carbon loss associated with driver d. [Mg C yr^{-1}]
ρ_{wood}	Basic wood density, estimated using Table GPG-LULUCF 3A.1.9. [Mg DM m^{-3}]
BEF_2	Biomass expansion factor for converting volumes of extracted round wood to total aboveground biomass (including bark), estimated using GPG-LULUCF Table 3A.1.10. [-]
CF	Carbon fraction of dry matter (default = 0.5). [Mg C (Mg DM)$^{-1}$]
$nrStrata$	Number of deforestation and forest degradation strata. [-]
$\Delta area_{fire,baseline}(i)$	Annual forest areas in the project area affected by disturbances from forest fires. [ha yr^{-1}]
E	Average combustion efficiency of the aboveground tree biomass. [-]
P	Average proportion of mass burnt from the aboveground tree biomass; estimate from GPG-LULUCF Table 3A.1.13 relative to C_{class1} . [-]
$OM(i)$	Average organic matter for forest stratum i. [Mg DM ha^{-1}]
$\Delta area_{cropland,baseline}(i)$	Forest area converted from forest stratum i to cropland at the beginning of the crediting period. [ha yr^{-1}]
$OM(cropland)$ $OM(settlement)$ and $OM(infrastructure)$	Average organic matter of cropland, settlement, developed infrastructure respectively; [Mg DM ha^{-1}]
$\Delta area_{settlement,baseline}(i)$	Average forest area converted from forest stratum i to settlement land. [ha yr^{-1}]
$\Delta area_{infrastructure,baseline}(i)$	= Average forest area converted from forest stratum i to developed infrastructures such as, but not limited to, roads, power transmission lines, phone lines, towers etc. [ha yr^{-1}]
$CT_{baseline}$	Annually extracted volume of harvested timber, round wood for commercial on-sale. [m^3 yr^{-1}]
$DT_{baseline}$	Annually extracted volume of timber for domestic and local use, round wood. [m^3 yr^{-1}]
$CFW_{baseline}$	Annual volume of fuelwood gathered for commercial sale and charcoal production in the baseline scenario. [m^3 yr^{-1}]
$DFW_{baseline}$	Annual volume of fuelwood gathered for domestic as well as local energy needs in the baseline scenario. [m^3 yr^{-1}]

$GR_{baseline}$ Total dry matter intake by grazing animals under the baseline scenario. Calculate by multiplying the number of animals taking into account different types of grazing animals [Mg DM yr^{-1}]

$VG_{baseline}$ Biomass (dry matter) of understory vegetation extraction by project participants under the baseline scenario. Calculate by multiplying the number of households involved in extraction of vegetation with the average annual extraction rate by household for different vegetation types [Mg DM yr^{-1}]

Sub-Step 2: Estimating the relative contribution of each driver to the total carbon loss from degradation and deforestation. Carbon losses must be separated into losses from deforestation and losses from degradation. In case of conversion of forestland to cropland and settlements, all of the carbon loss is related to deforestation. However, drivers that have a more gradual carbon decrease (fuelwood collection, wildfires, and logging) will first lead to forest degradation, and eventually deforestation when biomass density becomes smaller than the arbitrary threshold implied under the forest definition. For example, a loss of 25 Mg biomass per hectare on a well-stocked forest of 200 Mg biomass per hectare may, according to the forest definition, be categorized as forest degradation, while the same loss on a poorly-stocked forest of 50 Mg standing biomass per hectare could be deforestation, because the final tree cover has become smaller than the forest cover threshold in the forest definition. The default proportion of the carbon loss from fuelwood collection, wildfires, and logging that leads to deforestation versus forest degradation is estimated depending on specific conditions outlined in Table 9. The default proportion can be modified when justification for such changes can be provided. Such justifications must be based on locally observed scientific publications.

Table 9. Proportion of carbon loss leading to deforestation vs. forest degradation for different drivers.

Driver	$proportion_{DF}(i)$	$proportion_{DG}(i)$
1. Conversion of forest land to cropland	100%	0%
2. Conversion of forest land to settlements	100%	0%
3. Conversion of forest land to infrastructure	100%	0%
4a. Logging for commercial sale by clear cutting[7].	100%	0%
4b. Logging for commercial sale by selection cutting (i.e. by employing either individual tree selection method and/or group selection).	0%	100%
5a. Logging for domestic use as clear cutting.	100%	0%
5b. Logging for domestic use by selection cutting (i.e. by employing either individual tree selection method and/or group selection).	0%	100%
6. Wood collection for commercial on-sale of fuelwood and charcoal.	5%	95%
7. Fuelwood collection for domestic and local industrial energy needs	5%	95%
8. Cattle grazing (i.e., in-forest grazing)	5 %	95%
9. Understory vegetation extraction (i.e., thatch grass collection for roof and livestock bedding materials, shrubs and small trees for straw fences)	50%	50%
10a. Small forest fires to the extent that they are not part of natural ecosystem dynamics	0%	100%
10b. Large crown fires to the extent that they are not part of natural ecosystem dynamics.	100%	0%

The total carbon loss due to deforestation versus forest degradation can be calculated as following:

$$\Delta C_{DF} = \sum_{d=1}^{nrDrivers} proportion_{DF}(d) \cdot L(d)$$

---

[7]   Clear-cutting is defined as removing more than 75% of the trees on an area that is considered as forest in the forest definition used.

$$\Delta C_{DG} = \sum_{d=1}^{nrDrivers} proportion_{DG}(d) \cdot L(d)$$

where:

ΔC_{DF}	=	Total carbon loss due to deforestation. [Mg C yr^{-1}]
ΔC_{DF}	=	Total carbon loss due to degradation. [Mg C yr^{-1}]
$nrDrivers$	=	Number of drivers of deforestation or forest degradation. [-]
$proportion_{DF}(d)$ and $proportion_{DG}(d)$	=	Proportion of the gradual carbon loss that leads to deforestation or forest degradation, respectively, due to driver d. Estimate using the procedure detailed in Table 9.
$L(d)$	=	Annual carbon loss associated with driver d. [Mg C yr^{-1}]

The relative importance of the deforestation and forest degradation drivers can be calculated by combining the absolute carbon losses from Table 8 with the contributions from Table 9 using the following formula (as an example for the first driver):

$$contribution_{DF}(i) = \frac{proportion_{DF}(d) \cdot L(d)}{\Delta C_{DF}}$$

$$contribution_{DG}(i) = \frac{proportion_{DG}(i) \cdot L(d)}{\Delta C_{DG}}$$

where:

$contribution_{DF}(d)$	=	Relative contribution of driver i to the total deforestation. [-]
$contribution_{DG}(d)$	=	Relative contribution of driver i to the total forest degradation. [-]
$proportion_{DF}(d)$	=	Proportion of the gradual carbon loss that leads to deforestation. [-]
$proportion_{DG}(d)$	=	Proportion of the gradual carbon loss that leads to degradation. [-]
ΔC_{DF}	=	Total carbon loss due to deforestation. [Mg C yr^{-1}]
ΔC_{DG}	=	Total carbon loss due to degradation. [Mg C yr^{-1}]
$L(d)$	=	Annual carbon loss associated with driver d. [Mg C yr^{-1}]

8.1.3.3 Analyze of the Mobility of Each Deforestation and Forest Degradation Driver

The geographical extent of leakage is, in part, dependent on the mobility of each agent of deforestation. It must be determined how far each agent of deforestation is willing to go to acquire the forest resource or clear the land for cropland, grassland or settlement.

- For every driver of deforestation, report the main mode of transportation used by the main agent of deforestation of that driver: on foot, bike, scooter, motorcycle, car, or truck. Substantiate the choice with data from (lower-ranked options may only be used if higher-ranked options are not available) (1) social appraisals, (2) recent (preferably less than 10 years old) peer-reviewed scientific literature conducted among groups similar to the agents of deforestation of the project, (3) consultations with local socio-cultural and anthropological experts.

- Present a table of the average speed by which each identified mode of transportation can cross each of the LULC classes and forest strata and road categories, such as tracks, seasonally accessible small roads, and year-round accessible two-lane roads. Note the average speed on land with restricted access, such as national parks, as 0. Substantiate the choice with data from (lower-ranked options may only be used if higher-ranked options are not available) (1) social appraisals, (2) recent (preferably less than 10-year old) peer-reviewed scientific literature conducted among groups similar to the agents of deforestation of the project, (3) consultations with local socio-cultural and anthropological experts.

- Drivers that are less geographically constrained will still be confined to a "sphere of influence". For example, illegal timber logging activities may shift outside of project boundary, possibly to outside of provincial boundary, upon inception of REDD project activity. In this case, the sphere of influence of the driver is national. However, for the purpose of this methodology, planned timber concessions, must not be considered within "sphere of influence".

8.1.3.4 Identify the Quantitative Driving Variables of Deforestation and Forest Degradation

For each identified driver, provide potential spatial driving variables that explain the location of land cover change are also called "predisposing factors" (De Jong, 2007) (to be used in Section 8.1.5.2). The project proponent must select one or more of the following variables that potentially explain the location of deforestation and forest degradation.

- Access to forests (such as vicinity to existing roads, railroads, navigable rivers and coastal lines).

- Slope.

- Aspect.

- Proximity to markets.

- Proximity to industrial facilities (e.g., sawmills, agricultural products processing facilities, etc.).

- Proximity to forest edges.

- Proximity to settlements.

- Soil fertility and rainfall.

- Management category of the land (e.g., national park, logging concession.indigenous reserve, etc.).

Once the agents and drivers of deforestation have been identified, the project proponent must re-assess the similarity between the project area and the reference region, according to the procedure in Section 8.1.1.2. If necessary, adjust the area and location of the reference region to ensure that the same drivers of deforestation are present in both the reference region and the project area.

8.1.4   Determine Emission Factors for All Included Transitions

The project proponent must develop the emission factors following the requirements below.

For each LULC class or forest stratum that could be subject to a transition as identified in Section 8.1.2.3, it is necessary to determine the average carbon stock density, based on sampling plots. Plots may be either permanent or temporary, but the location of the plots must be known and available at the time of verification. Alternatively, on non-forest land, conservative defaults gathered from scientific literature may be used to quantify the carbon stock density. The applicability of these default values must be confirmed by the validator. The number of plots and their location must be determined in a stratified sampling design. The following steps are to be followed:

- Identify the LULC classes and forest strata for which carbon stocks are to be quantified.

- Review existing biomass stock density and biomass increment data for comparison with field measurements.

- Determine the sample size per LULC class or forest stratum.

- Measure carbon density stocks of each LULC class or forest stratum.

- Calculate emission factors for each land transition category.

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

Present a table of the LULC classes and forest strata that are likely to be subject to transitions within the project area or anticipated leakage area based on the land transition matrix.

8.1.4.2 Review Existing Data of Biomass Stock Densities and Biomass Net Annual Increments

Review existing data on biomass stock densities: For the purpose of sampling design and quality assurance of the measured values, all existing data on biomass stock densities must be reviewed. Sources that must be consulted include (lower-ranked options may only be used if higher-ranked options are not available): (1) peer-reviewed scientific literature conducted within the reference region, (2) peer-reviewed scientific literature from an area ecologically similar to the reference region, (3) non peer-reviewed reports or studies from the reference region or similar areas. Sources that contain a measure of the variation of the

values (range, standard deviations, standard errors, or coefficients of variation) are specifically useful, since these can be used for preliminary determination of the number of sampling plots required during field sampling. For every data source used, note the following items:

- Methodology (field inventory, extrapolation from satellite imagery, ecosystem model, or GIS analysis).

- Number of measurement plots used.

- Whether all species are included in the sampling.

- The minimum DBH of measured trees in the biomass inventory or any other relevant threshold.

- Region in which the samples were taken.

The carbon stock density on non-forest land may be quantified using conservative defaults gathered from scientific literature. The applicability of these default values must be confirmed by the validator.

For project areas registered within a JNR area and where biomass stock data has been registered under the jurisdictional REDD+ program for the same LULC class and forest strata as in the project area, the most accurate estimates will be used, subject to any requirements specified within the jurisdictional REDD+ program.

Review existing data on net annual increments of biomass: Whereas the GHG benefits from avoided deforestation and avoided forest degradation are based on observed transitions between LULC classes and forest strata, the GHG benefits from ANR activities are based directly on the empirically observed increases in biomass stock densities. Therefore, for accurate ex-ante estimates, all existing data on net annual increments of biomass carbon stocks must be reviewed. Sources that must be consulted include (lower-ranked options may only be used if higher-ranked options are not available): (1) values measured by the project proponent in the project area using the methods used for forest inventories discussed in this methodology, (2) national or local growth curves and tables that are usually used in national or local forest inventories, (3) values from peer-reviewed literature, and (4) values from IPCC GPG-LULUCF (2003) Table 3A.1.5.

8.1.4.3 Determine the Sampling Design, i.e., Number, Location, and Layout of Plots

The determination of the sample size (number of sampling plots) required per LULC class and forest strata that are identified in 8.1.4.1 is dependent on (1) the required precision of at least 15% at a confidence level of 95% and (2) the anticipated variance in the specific LULC class and forest strata. Extra measurement plots must be installed within the ANR and harvest areas to reliably estimate the increase in carbon density. The CDM tool AR-AM Tool 03 *Calculation of the number of sample plots for measurements within A/R CDM project activities* may be used to determine the number of biomass sample plots required.

Further explanation on how to select the layout of sampling plots (form, nesting, etc.) can be found in textbooks such as Hoover (2008). For measuring and monitoring carbon density

in the forest strata, a network of permanent or temporary forest sampling plots must be established. Due to the significant anthropogenic influence on non-forest land, it is not deemed feasible to install permanent sampling plots. Therefore, the average carbon stock density on non-forest LULC classes must be assessed using non-permanent sampling plots. Alternatively, conservative defaults gathered from scientific literature may be used to quantify the carbon stock density on non-forest land. The applicability of these default values must be confirmed by the validator.

Within a LULC class or forest stratum, the location of sample plots should be selected as random as practically feasible. However, in cases where access to the forest land is challenging, biomass plots located along a forest transects may be used instead of a stratified random sampling design on the condition that all forest classes and strata are represented in an unbiased way along the transect.. The randomization must be done *ex-ante* by a computer program. This is required to avoid subjective choice of plot locations. For each sample plot, record the observed LULC class, forest type, and estimated forest canopy closure. Note that stratification is usually an iterative process in which the stratification model – as defined in Section 8.1.2.6 - is adjusted based on biomass inventories and the stratum of a biomass inventory is guided by the stratification model. To avoid bias in the calculation of the uncertainty of stratification, the plots used to develop the forest stratification model must not be used to calculate the uncertainty of the carbon stock density of a specific stratum, as stipulated in Section 8.1.2.7.

This methodology allows implementing ANR and harvesting activities under certain conditions (see Section 8.2.5). The sample plots used to calculate the plant emission factors must not be located within areas in which ANR or harvest activities are planned. This requirement is necessary to prevent bias in the calculation of increases in forest biomass from natural regeneration and decreases in forest biomass due to harvesting.

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

8.1.4.4 Measure and Calculate Carbon Stock Density

Plot-based measurements must be aggregated within the LULC class or forest stratum they belong to.

- If degradation is not included, the LULC class of a specific biomass plot must be determined based on the LULC map that is closest in time to the time of measurement of the biomass plot. In case multiple measurements are available for one permanent biomass inventory plot, only the most recent value of the carbon stock density must be used.
- If degradation is included, the aggregations of non-forest LULC classes follow the procedures outlined above "if degradation is not included". However, biomass inventory plots located in forest area must be assigned the appropriate forest stratum using the forest stratification model developed in Section 8.1.2.6. In case multiple measurements are available for one permanent biomass inventory plot, all values in time of the carbon stock density must be used in the aggregation and used to calculate the average and uncertainty metrics.

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

$$OM_{AGD,plot\text{-}wise}(i,p) = OM_{LDW,plot\text{-}wise}(i,p) + OM_{SDW,plot\text{-}wise}(i,p) \qquad \text{[EQ15]}$$

$$OM_{AGL,plot\text{-}wise}(i,p) = OM_{AGT,plot\text{-}wise}(i,p) + OM_{AGNT,plot\text{-}wise}(i,p) \qquad \text{[EQ16]}$$

where:

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

In addition, the following symbols are used in subsequent equations, calculations as well as monitoring tables:

$OM_{BG,plot\text{-}wise}(i,p)$	=	Belowground tree organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]
$OM_{SOM,plot\text{-}wise}(i,p)$	=	Soil organic matter of plot p within LULC class or forest stratum i. [Mg DM ha^{-1}]

For the aboveground live (AGL), aboveground dead (AGD), belowground (BG), and soil organic matter (SOM) pools, the average stock densities of stratum i and associated statistics are calculated using the equations below. The "o" subscript indicates a pool out of the possible pools (AGL, AGD, BG, or SOM carbon).

$$OM_o(i) = average\left(OM_{o,plot\text{-}wise}(i,p)\right) \qquad \text{[EQ17]}$$

$$stdev\left(OM_o(i)\right) = stdev\left(OM_{o,plot\text{-}wise}(i,p)\right) \qquad \text{[EQ18]}$$

$$stderr\left(OM_o(i)\right) = \frac{stdev\left(OM_o(i)\right)}{\sqrt{n_i}} \qquad \text{[EQ19]}$$

$$HCWI\big(OM_o(i)\big) = t_{0.95,n-1} \cdot stderr\big(OM_o(i)\big) \qquad \text{[EQ20]}$$

$$CE_{inventory}(i) = \frac{\sqrt{\sum_o HWCI\big(OM_o(i)\big)^2}}{\sum_o OM_o(i)} \qquad \text{[EQ21]}$$

$$u_{inventory}(i) = \begin{cases} 1 & \text{if } CE(i) \le 0.15, \\ 1 - CE(i) & \text{if } 0.15 < CE_{inventory}(i) < 1, \\ 0 & \text{if } CE(i) \ge 1 \end{cases} \qquad \text{[EQ22]}$$

where:

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

[EQ21] and [EQ22] are used in estimating the combined error, $CE_{inventory}(i)$, and the uncertainty, of the biomass stock density, $u_{inventory}(i)$, respectively. Note that procedures to calculate the uncertainty of the *difference* of two biomass stock densities due to a land transition are explained in the Section8.1.4.5. Estimation of combined error of the inventory, $CE_{inventory}(i)$ is prerequisite to estimation of uncertainty, $u_{inventory}(i)$. These two equations must be treated as generic and can be applied in estimating uncertainty for some specific project area when needed. For example, when uncertainty in estimated carbon stock density in harvest areas are needed, then inventory data from areas under harvest alone must be used in these two equations to estimate inventory uncertainty in harvest areas i.e., $u_{inventory,harvest}(i)$.

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

$$OM(i) = \sum_{o} OM_o(i) \qquad \text{[EQ23]}$$

$$C_o(i) = CF \cdot OM_o(i) \qquad \text{[EQ24]}$$

$$C(i) = \sum_{o} C_o(i) \qquad \text{[EQ25]}$$

where:

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

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

Aboveground organic matter, $OM_{AGT}(i, p)$. The aboveground organic matter must be determined by measuring the appropriate tree metric (e.g. DBH) of all trees using the appropriate cutoff DBH specified in the allometric equation (e.g., DBH ≥ 5 cm) within the sampling plot. The applicability of the allometric equation $f_{allometric}$ used must be specifically verified using the procedures Section. The allometric equation(s) must remain fixed during a baseline validation period. During a baseline update, the project proponent may replace previously used allometric equations, and BEF values by more accurate ones, if these would become available.

Aboveground non tree organic matter, $OM_{AGNT}(i, p)$. The above ground non-tree vegetation must be measured by destructive harvesting techniques. Alternatively, the

aboveground organic matter can also be estimated using default values IPCC default values by following appropriate tool as the latest version of CDM Tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in AR CDM project activities*.

Belowground organic matter, $OM_{BG}(i, p)$. The below organic matter pool is estimated from the aboveground organic matter using a relationship $f_{belowground}$ between aboveground and belowground organic matter, such as a root-to-shoot ratio. Similar to the constants used for the aboveground organic matter, $f_{belowground}$ must be fixed during a baseline validation period. During baseline validation, the project proponent may replace a previously used $f_{belowground}$ by a more accurate one, if this would become available.

Lying deadwood organic matter, $OM_{LDW}(i, p)$. Lying deadwood must be sampled with the line intersect method (Harmon and Sexton, 1996) using the equation by Warren and Olsen (1964) as modified by Van Wagener (1968). Each piece of dead wood is assigned to one of three decay classes as (a) Sound, (b) Intermediate, or (c) Rotten, on the basis of a machete test . The estimated biomass for each dead wood piece is subject to density reduction factor. While the project proponent may use most applicable density reduction factor, the default density reduction factors are 1, 0.80, and 0.45 respectively for decay classes- sound, intermediate and rotten.

Standing deadwood organic matter, $OM_{SDW}(i, p)$. Standing dead trees must be measured using the same procedures used for measuring live trees with the addition of a decomposition class and the addition of an appropriate biomass reduction factor. Specifically, all the standing dead trees must be assigned with one of the two conditions (a) Dead trees which have lost only leaves and twigs, and (b) Dead trees which have lost leaves, twigs, and small branches (diameter < 10cm) and use an appropriate biomass reduction factor for each of the two conditions. The project proponent may use biomass reduction factors based on local or national data/study or use a default factor of 0.975 for trees in condition (a) and 0.80 for trees in condition (b). If the tree has lost all the branches, such a tree must be considered a Dead Tree Stump.

Dead tree stump organic matter, $OM_{DTS}(i, p)$. If the stump height is greater than the mid-point diameter of a stump or dead tree without branches, then the biomass must be estimated using the method found in Ormerod (1973). First, the volume of the dead tree stump must be estimated using Huber's formula in which the cross-sectional area is estimated using the mid-point diameter of tree or tree stump multiplied with height of the stump. The estimated volume is subsequently multiplied by wood density. A density reduction factor is assigned to each of the decay classes, which is to be multiplied by the basic wood density of the species of the stump to obtain its estimated wood density. The following default values of the density reduction factors for the three decay classes must be used, unless project specific data is available for the decay class: (i) 1.0 for sound organic matter, (ii) 0.8 for organic matter in an intermediate decay class and (iii) 0.45 for rotten organic matter.

Soil organic matter, $OM_{SOM}(i, p)$. Soil organic carbon pool must be estimated using soil samples taken at different soil horizons. The depth to which the soil samples are taken and analyzed must be at least 30 cm as per the recommendation of the IPCC GPG-LULUCF (2003). In these samples, depth, bulk density and concentration of organic dry matter must

be recorded.

Stratum-specific average organic matter density, $OM(i)$ and its associated uncertainty, $u_{inventory}(i)$ may also be (partially) estimated using other sampling approaches such as double sampling, regression estimators e.g. LiDAR on the condition that (1) it can be demonstrated that the use of such approach is conservative, and (2) valid and unbiased uncertainty estimators are provided for the biomass stock density that are equivalent to the uncertainty estimators used for plot-based measurements described in this methodology.

8.1.4.5 Calculate Emission Factors

Emission factors only include the carbon pool-related sources due to changes in carbon stock densities between the LULC classes and forest strata. Since N_2O and CH_4 emissions from forest fires increase emissions, they can be conservatively omitted for baseline calculations[8]. Once the carbon stock densities are calculated, biomass carbon emission factors and their uncertainties for each LULC class or forest stratum transition are calculated. A positive emission factor (i.e. EF_o) indicates a net sequestration of carbon, or an increase in the carbon stock, while a negative emission factor sign indications emission. The emission factor for aboveground live biomass is calculated as:

$$EF_{AGL}(CS1 \rightarrow CS2) = \frac{44}{12} \cdot \left(C_{AGL}(CS2) - C_{AGL}(CS1) \right) \qquad \text{[EQ26]}$$

where:

$EF_{AGL}(CS1 \rightarrow CS2)$	=	Emission factor for change in aboveground live plant organic matter from an LULC Class or forest Stratum (CS) 1 to 2. [tCO$_2$e ha^{-1}]
$CS1 \rightarrow CS2$	=	Land transition from LULC class or forest stratum 1 to 2.
$C_{AGL}(i)$	=	Carbon density of aboveground plant organic matter of classes or forest stratum i. [MT C ha^{-1}]

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

For $t \leq 10$:

$$EF_{AGD}(CS1 \rightarrow CS2, t) = \frac{44}{12} \cdot \frac{\left(C_{AGD}(CS2) - C_{AGD}(CS1) \right)}{10} \qquad \text{[EQ27]}$$

For $t > 10$:

$$EF_{AGD}(CS1 \rightarrow CS2, t) = 0 \qquad \text{[EQ28]}$$

---

[8] Note that under the project scenario, N$_2$O emissions from prescribed burning must be included in the carbon accounting.

where:

$EF_{AGD}(CS1 \rightarrow CS2, t)$	=	Emission factor from change in above ground dead wood from an LULC Class or forest Stratum (CS) 1 to 2 at t years after transition. [tCO₂e ha^{-1}]
$CS1 \rightarrow CS2$	=	Land transition from LULC class or forest stratum 1 to 2.
$C_{AGD}(i)$	=	Carbon density of aboveground dead plant organic matter of classes or forest stratum i. [MT C ha^{-1}]

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

For $t \leq 10$:

$$EF_{BG}(CS1 \rightarrow CS2, t) = \frac{44}{12} \cdot \frac{\left(C_{BG}(CS2) - C_{BG}(CS1)\right)}{10} \qquad \text{[EQ29]}$$

For $t > 10$:

$$EF_{BG}(CS1 \rightarrow CS2, t) = 0 \qquad \text{[EQ30]}$$

where:

$EF_{BG}(CS1 \rightarrow CS2, t)$	=	Emission factor for change in belowground plant organic matter from an LULC Class or forest Stratum (CS) 1 to 2 at t years after transition. [tCO₂e ha^{-1}]
$CS1 \rightarrow CS2$	=	Land transition from LULC class or forest stratum 1 to 2.
$C_{BG}(i)$	=	Carbon density of belowground plant organic matter of classes or forest stratum i. [MT C ha^{-1}]

The total soil emission factor must be gradually spread over time. The project proponent may propose their own temporal component (e.g., an exponential equation) if the conservative nature of the temporal component can be demonstrated using peer-reviewed literature or measurements conducted by the project proponent. If no temporal component is proposed by the project proponent, the temporal component from the IPCC GPG-LULUCF 2003 and used in following formula for the soil emission factor must be used:

For $t \leq 20$:

$$EF_{SOM}(CS1 \rightarrow CS2, t) = \frac{44}{12} \cdot \frac{\left(C_{SOM}(CS2) - C_{SOM}(CS1)\right)}{20} \qquad \text{[EQ31]}$$

For $t > 20$:

$$EF_{BG}(CS1 \rightarrow CS2, t) = 0 \qquad \text{[EQ32]}$$

where:

$EF_{SOM}(CS1 \rightarrow CS2, t)$ = Emission factor for change in soil organic matter from LULC Class or forest Stratum (CS) 1 to 2 at t years after transition. [tCO₂e ha⁻¹]

$cs1 \rightarrow cs2$ = Land transition from LULC class or forest stratum 1 to 2.

$C_{SOM}(i)$ = Carbon density of soil organic matter plant of LULC class or forest stratum i. [MT C ha⁻¹]

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

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

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

$$u_{transition}(CS1 \rightarrow CS2) = \begin{cases} 1 & \text{if } CE_{transition}(CS1 \rightarrow CS2) \leq 0.15, \\ 1 - CE_{transition}(CS1 \rightarrow CS2) & \text{if } 0.15 < CE_{transition}(CS1 \rightarrow CS2) < 1, \\ 0 & \text{if } CE_{transition}(CS1 \rightarrow CS2) \geq 1 \end{cases} \qquad \text{[EQ34]}$$

where:

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

$HWCI(OM_o(i))$ = Half-width of the 95% confidence interval around the mean plant organic matter density of LULC class or forest stratum i in pool o. [tCO₂e ha⁻¹]

$CE_{transition}(CS1 \rightarrow CS2)$ = Combined error in estimated biomass stock density change for a transition from one stratum to another. [-]

List the estimated emission factors, the associated uncertainties, and the lower confidence limit per LULC class and forest strata category in a table in the PD. The inventory must be iteratively expanded until for every transition, $u_{transition}(CS1 \rightarrow CS2)$ is greater than 0.75. This threshold serves to ensure a minimal accuracy of biomass inventories. Finally, it must

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

8.1.5 Estimate Ex-ante Land Transition Rates under the Baseline Scenario

The goal of this step is to calculate all land transitions, including deforestation and increased forest cover, and forest degradation and regeneration under the baseline scenario. The procedure below calculates first the total deforestation and forest degradation rates, and also the relative regeneration and increased forest cover change rates per forest stratum and LULC class. Subsequently, the total rates of deforestation and forest degradation are split into LULC class and forest stratum specific rates using a geographical modeling approach, similar to the GEOMOD model[9]. Note that the exact location of future deforestation predicted by the model is not used as such for carbon accounting. Location-specific data on deforestation, forest degradation, and other LULC transitions are aggregated again into a land-use change transition matrix, which is the activity data on which the carbon accounting is based.

8.1.5.1 Calculate Total Rates of Deforestation and Forest Degradation in the Project Area

The total future deforestation and degradation rates are interpolated from past trends. However, scarcity of land may decrease rates to values below the maximal rates interpolated on past trends. This is accounted for in Section 8.1.5.4.

Create a graph of the historical deforestation rates in the reference region (hectares per year) versus time (years) for each consecutive pair of images in the historical reference period. Create a similar graph of the historical degradation rates versus time. From these graphs, calculate the future deforestation and degradation rates using two beta regression[10] equations, one for deforestation and one for forest degradation:

$$D_{referemceRegion,baselineScenario,DF}(t) = BetaReg_{DF}(t) \qquad \text{[EQ35]}$$

$$D_{referenceRegion,baselineScenario,DG}(t) = BetaReg_{DG}(t) \qquad \text{[EQ36]}$$

where:

---

[9] This approach is conservative since upon exhaustion of one forest stratum, the deforestation will be displaced to the stratum with the greatest likelihood of being deforested. In case stratum-specific deforestation rates were calculated up front, the displacement of deforestation to other forest strata would have been more challenging.

[10] Beta regression is commonly used to model variables that assume values in the standard unit interval (0; 1). Beta regression assumes that the dependent variable is beta-distributed and that its mean is related to a set of regressors through a linear predictor with unknown coefficients and a link function. Parameter estimation is performed by maximum likelihood.

$D_{referenceRegion,baselineScenario,DF}(t),$

$D_{referenceRegion,baselineScenario,DG}(t)$

= Rate of deforestation/degradation within the reference region for during year t. [ha yr^{-1}]

$BetaReg_{DF}(t)$

and

$BetaReg_{DG}(t)$

= Beta regression model describing the relationship between time and deforestation/degradation rate in the reference region during the historical reference period. [ha yr^{-1}]

t

= Time since project start (negative before project start). [yr]

However, if only three images were included in the historical analysis, and, therefore, only two deforestation/degradation rates are available, the average of the two rates must be used instead of the extrapolation using the Beta regression.

The future deforestation and forest degradation must be calculated as follows:

If the area of deforestation/degradation is constant (i.e. if the slope of the relation between deforestation/degradation quantities and time is not significantly different from 0 at the 95% confidence level), a constant future deforestation/degradation quantity is set as the mean of the observed deforestation/degradation amounts in the reference region.

Time since project start or last baseline update (yr)
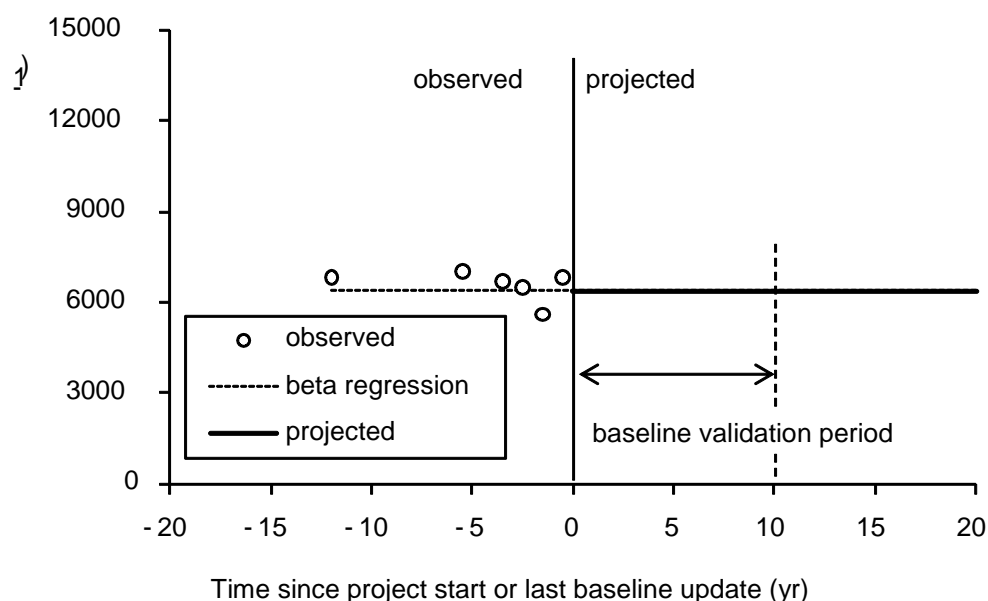
If the deforestation/degradation quantity increases (i.e. if the slope of the relation between deforestation/degradation quantities and time is significantly larger than 0 at the 95% confidence level), the lower 95% confidence interval of the beta regression model must be used.
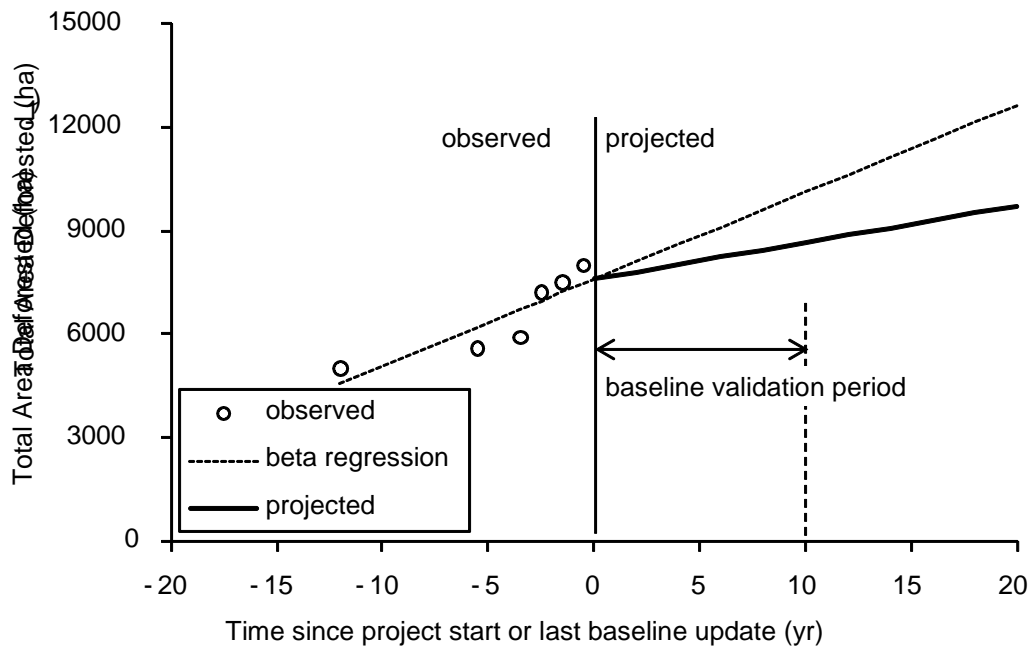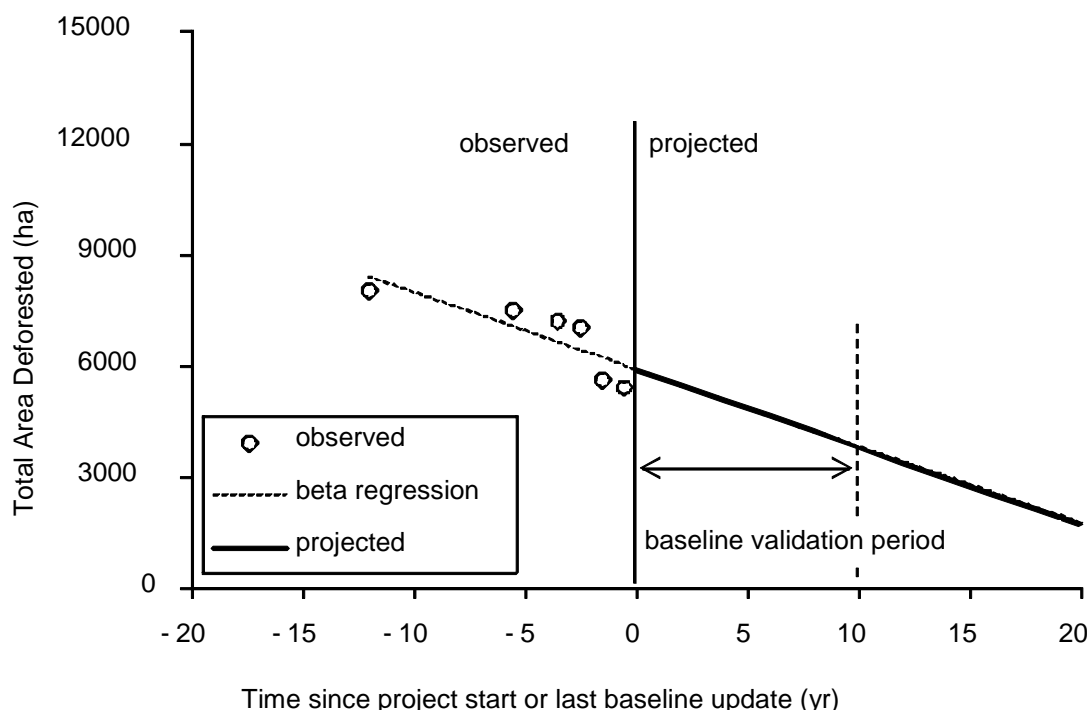
If the deforestation/degradation quantity decreases (i.e. if the slope of the relation between deforestation/degradation quantities and time is significantly smaller from 0 at the 95% confidence level), the original beta regression model must be used.

When there is a clear break in the historical trend, it is required to examine when the anomaly occurred, why it occurred, and whether the change is likely to be stable to determine whether to adjust the data points used in the beta regression. A break in the historical trend must only be considered when at least six points in time are available[11]. A break in the historical trend usually indicates a technological breakthrough, a policy reform, or change in land use practice. If it is demonstrated that the reasons for a break in the trend continued into the future, omit the observations occurring before the break to project the future deforestation quantity. The projected deforestation rate must be determined from the period that goes back no farther than the appearance of the breakpoint (Sataye and Andrasko, 2007). Use one of the approaches above depending on the trend observed after the break.

---

[11] Even though, often, only 3 or 4 data points will be available upon validation, increasingly more data points will become available during the crediting period. Therefore, when the baseline is updated, sufficient points may be available to detect a break.
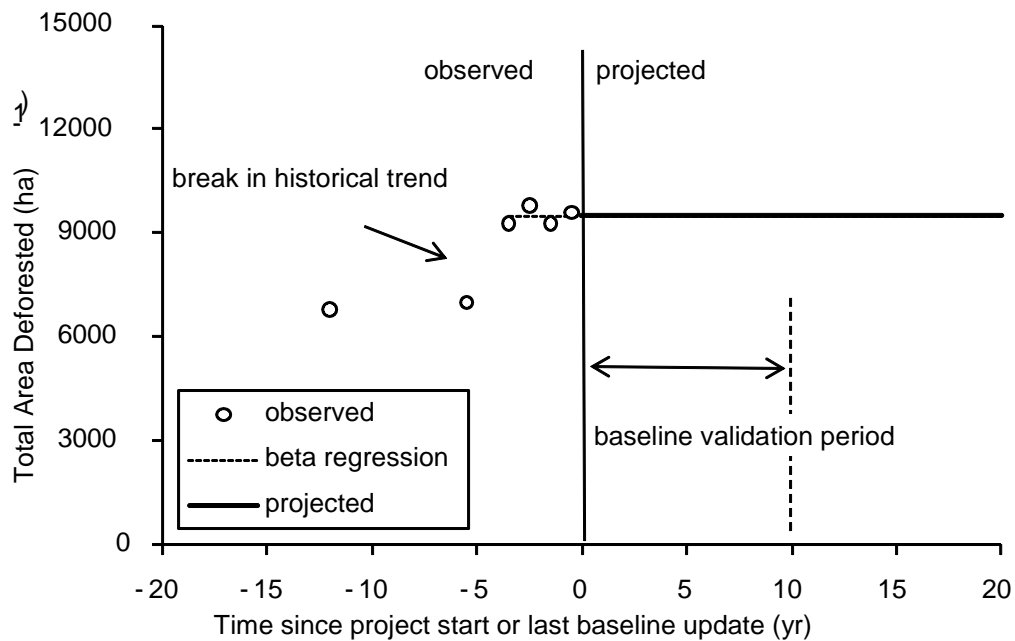
Single outliers are most likely due to once-only anomalies (e.g., loss of forest land due to fire, hurricane or other natural disturbance). It is required that the cause of this single outlier be examined to determine if it may be removed. They may only be removed from the other points in the historical reference period if it is demonstrated that the occurrence of the outlier is due to specific conditions that are not present anymore (as would be the case for a natural disturbance). Use one of the approaches above depending on the trend observed after removing the outlier.
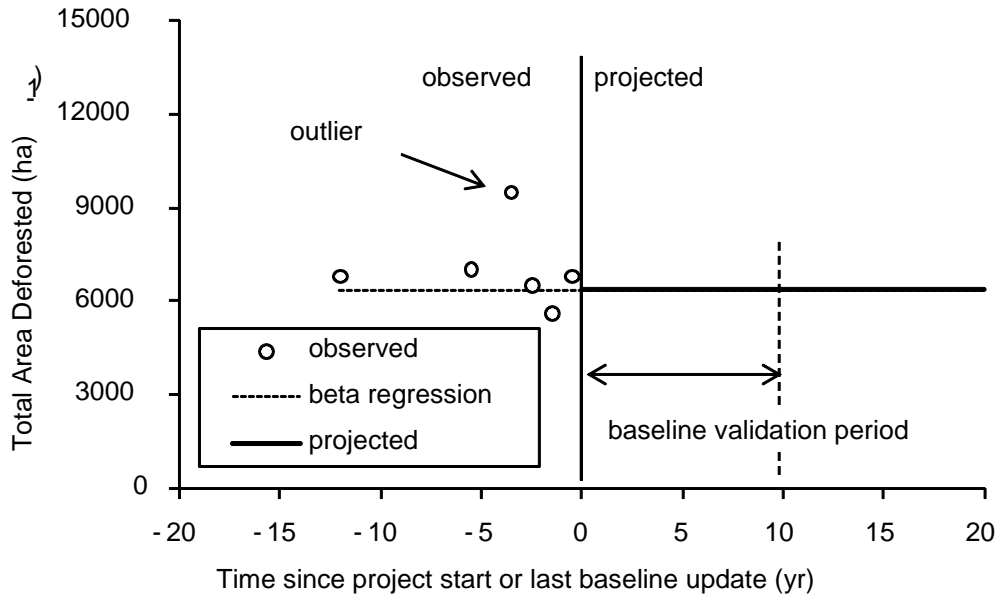
Once the coefficients from the beta regressions are determined, calculate the baseline total deforestation and degradation rates in the project area as:

$$D_{projectArea,baselineScenario,DF}(t) = BetaReg_{DF}(t) \cdot \frac{size_{projectArea}}{size_{referenceForest}}$$ [EQ37]

$$D_{projectArea,baselineScenario,DG}(t) = BetaReg_{DG}(t) \cdot \frac{size_{projectArea}}{size_{referenceForest}}$$ [EQ38]

where:

$D_{projectArea,baselineScenario,DF}(t)$, and $D_{projectArea,baselineScenario,DG}(t)$	=	Baseline rate of deforestation/degradation within the project area during year t. [ha yr⁻¹]
$BetaReg_{DF}(t)$ and $BetaReg_{DG}(t)$	=	Beta regression model describing the relationship between time and deforestation/degradation rate in the reference region during the historical reference period. [ha yr⁻¹]
t	=	Time since project start (negative before project start). [yr]
$size_{projectArea}$	=	Total size of the project area. [ha]
$size_{referenceForest}$	=	Total size of the forest area in the reference region. [ha]

The deforestation rate or degradation rate calculated from this procedure represents the gross deforestation rate, but not net deforestation or degradation rate. Therefore, all non-forest to forest transitions need to be explicitly included in the baseline to achieve a correct representation of the forest cover dynamics.

8.1.5.2 Calculate LULC Class or Forest Stratum-Specific Relative forest cover increase and Regeneration Rates

Although reforestation is not allowed as a project activity, the baseline scenario must include potential increases in forest cover or forest biomass that would have happened without project activities. There must be a full symmetry in carbon accounting: degradation in the baseline scenario may only be included if regeneration under the baseline is included as well. Likewise, both transitions from forest to non-forest and non-forest to forest (and that were forest at the start of the crediting period, per applicability condition 1) must be included in the baseline. Note that the quantification of transitions of non-forest to forest areas must not be based on areas on which large-scale reforestation has occurred as such areas should have been excluded from the reference region.

The extent of increase in forest cover or forest regeneration that would have happened under the baseline scenario is quantified based on historical observations in the reference region during the historical reference scenario. For every land class or forest stratum that transitions into a different class with higher biomass, calculate the relative regeneration or forest cover increase rate by dividing the area of the transition by the area of the "from" class:

for every transition for which $C(CS_2) > C(CS_1)$:

[EQ39]

$$RFRGrate(CS_1 \rightarrow CS_2) = \frac{\Delta area_{historical}(CS_1 \rightarrow CS_2, t_1 \rightarrow t_2)}{area_{historical}(CS_1, t_1) \cdot (t_2 - t_1)}$$

where:

CS_1 and CS_2	=	Class or Stratum 1 and 2, respectively
$C(CS_1)$ and $C(CS_2)$	=	Average carbon stock density of LULC class or forest stratum 1 and 2, respectively. [Mg C ha^{-1}]
$RFRGrate(CS_1 \rightarrow CS_2)$	=	Relative annual forest cover increase and regeneration factor for the transition from class or stratum 1 to 2. [yr^{-1}]. Multiply with 100 to obtain a forest cover increase and regeneration rate in percentage per year.
$\Delta area_{historical}(CS_1 \rightarrow CS_2, t_1 \rightarrow t_2)$	=	Area of transition from class or stratum 1 to 2 from time 1 to 2 during the historical reference period. [ha]
$area_{historical}(CS_1, t_1)$	=	Total area of class or stratum 1 at time 1. [ha]
t_1 and t_2	=	Time 1 and time 2, respectively. [years]

Calculate the LULC class or forest stratum-specific regeneration or forest cover increase rates for every pair of subsequent images in the historical reference period, and report the averages in a table in the PD.

8.1.5.3 *Calibrate and Validate a Spatial Model to Predict the Suitability for Deforestation and Degradation*

Deforestation and degradation do not occur randomly within the forest area, but occur preferentially at specific locations where predisposing factors are present (De Jong 2007). These factors are referred to as *spatial driver variables* and were identified in Section 8.1.3.4. By examining the impact of spatial driver variables on historical land use change, the likelihood of land-use change can be quantified; this likelihood relation can be extrapolated into the future to predict the location of future land use change. This Section focuses on examining the relation between spatial drivers and historical land use change, while Section 8.1.5.4 focuses on extrapolating this relation into the future. Spatial driver variables may be constant, meaning that they will never change during model execution, such as slope or elevation, or dynamic, meaning that they may change during project runs, such as distance to the nearest road, or forest density. In addition, they may be continuous, such as distance to the closest market, or categorical, such as soil type. Logistic regression models are one class of models that have been used successfully to quantify the suitability of deforestation and degradation (Lambin 1997, Verburg et al. 2004 and Boer et al. 2006). However, this methodology does not prescribe an exact form of a statistical model. The following steps are to be followed once to calibrate the deforestation model and once to calibrate the degradation model. For brevity, the steps below assume a deforestation model.

For each pair of two subsequent LULC classification maps developed as per Section**,** randomly select a large number (>10,000) of forested grid-cells/pixels from the first image. Use the second image of the pair to determine whether these grid-cells/pixels were deforested, degraded, or showed no change during the period in between the two images. Since grid-cells are selected randomly from the baseline LULC maps, pixels will be selected from degrading, deforested, and no-change areas in an unbiased way.

Calculate the value of each spatial driver variable based on the first LULC map of the image pair for each of the points selected in the previous step. Create a list containing the location, land transition category, and all values of each of the spatial driver variable identified in Section 8.1.3.4. In case of dynamic spatial driver variables, use a spatial driver at the time the first image was recorded. Deforestation and degradation usually occur in a clustered fashion. Therefore, include the distance to the forest edge, or forest fragmentation as spatial driver variables (Lambin et al., 1997).

Split this list randomly into a calibration dataset and a (statistical) validation dataset. The calibration data will be used to fit the deforestation and degradation statistical models and the validation data will be used to independently assess the quality of the model. 2/3 of the points should be used for calibration and 1/3 for validation.

Calibrate a statistical model for deforestation based on the values of spatial driver variables at the calibration point dataset. The statistical model must predict the suitability for deforestation for every location in the project area, and must therefore be bound by the interval [0,1]. A logistic regression model is an example of an appropriate statistical model. If necessary, apply mathematical transformations to make the effect of the spatial driver variables linear. For instance, the influence of a road on deforestation will decrease exponentially with distance to the road, and a log-transformation should be applied.

Calibrate a statistical model for degradation based on the values of spatial driver variables at the calibration point dataset.

Calibrate a statistical model to predict the LULC class of the new land use on cells selected for deforestation. In case that there are more than two potential new LULC classes, use multinomial logit model, which predicts a multilevel categorical variable bases on the spatial driver variables. Quality assurance: significance and goodness-of-fit. As a quality assurance step, report the significance of the statistical model. In case of a regression, report the results of a likelihood ratio test, and the significance of individual drivers of deforestation (t-tests). Both the full model and all individual drivers must be significant at the 95% confidence level. In addition, perform a goodness-of-fit test by predicting the new LULC classes and forest strata for the independent statistical validation data, and comparing the results with the measured data. Present a table of the empirically observed land-use change rates vs. the land-use change rate predicted using the statistical model. The difference in aggregated deforestation and forest degradation rates as well as forest stratum and LULC-class transition rates averaged over all the time periods (in between images of the reference period) between empirically observed and modeled rates may not be more than 15%. The capability of the model to adequately estimate likelihoods of deforestation and forest degradation must be confirmed by the validation/verification body.

8.1.5.4 Calculate All Class or Stratum-Specific Transition Rates.

Once the statistical models for deforestation and forest degradation, and the carbon density map are prepared, a simple cellular automata type model can be used to predict the future land use and land cover in each grid-cell and for each year of the crediting period. Even though the spatial model produces maps of the exact location of future deforestation, these maps are not used outside of the modeling step. The main output of the modeling step is a land-use change transition matrix. This matrix is calculated by aggregating the LULC class and forest stratum maps that are produced by the spatial model. In addition to the principles of neighborhood constraint and land suitability, as explained in Pontius (2002), the land-use change model incorporates the forest scarcity principle, the notion that deforestation rates decrease upon the gradual depletion of the native forest resources. Without forest scarcity, it is assumed that deforestation occurs linearly until all forest is gone, which will be incorrect in most circumstances and lead to an overestimate of net emission reductions. It is well documented that deforestation rates decrease when forest areas are gradually disappearing. The "forest transition" theory (Mather and Needle, 1998) explains how areas with vast forest areas which are initially characterized by rapid deforestation rates, stabilize their forest area after some time. To incorporate a decrease in deforestation rate upon a gradual depletion of forest resources, initial deforestation rates are multiplied with a "forest scarcity" factor, which is initially 1, but gradually decreases as the proportion of remaining

forest decreases (Figure 1). This "scarcity factor" must be calibrated using scientific literature in an area close to the project area that has followed a more advanced deforestation route. Examples are neighboring countries, states or provinces that have undergone a more rapid deforestation course than the area where the project is located. Typically, deforestation rates start to decrease when around 50% of the original forest cover has disappeared. In addition, deforestation usually halts when around 80% of the forest area has disappeared. This pattern has been observed by Meyfroidt and Lambin (2008) in Vietnam. Deforestation rates started decreasing when 50% of forest cover remained, and halted in 1991-1993 at around 25% forest cover. However, the specific values of the forest cover when deforestation will decrease are dependent on project conditions and should be analyzed and substantiated within the project document at validation.
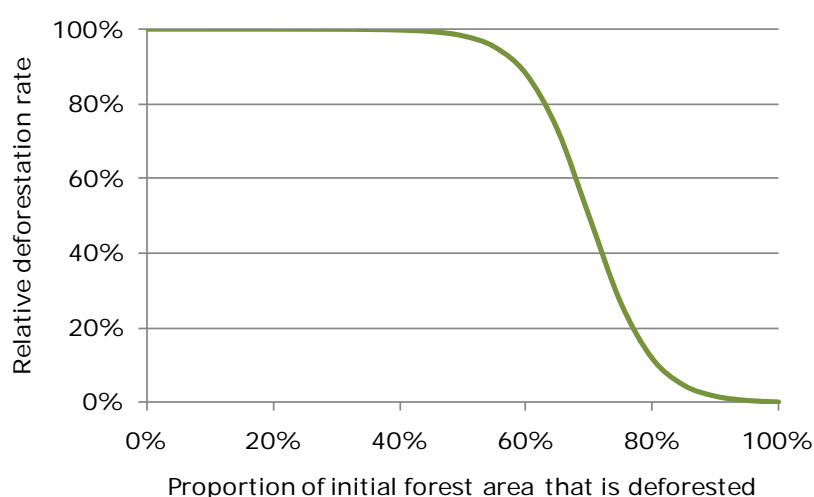
Figure 1. Example of "forest scarcity factor": the relative Deforestation Rate as a Function of Proportion of Initial Forest Area that is Deforested.

The following equation must be used to model the scarcity factor:

$$f_{scarcity}(t) = \frac{1}{1 + e^{sc_1\left(sc_2 - \frac{area(t,nonForest)}{size_{projectArea}}\right)}}$$

[EQ40]

Where:

$f_{scarcity}(t)$	=	Forest scarcity factor used to reduce the historical deforestation rate at time t. [-]
sc_1	=	First shape factor for the forest scarcity equation; steepness of the decrease in deforestation rate (greater is steeper). [-]
sc_2	=	Second shape factor for the forest scarcity equation; relative deforested area at which the deforestation rate will be 50% of the initial deforestation rate. [-]

| $area(t, nonForest)$ | = | Total area that is not forest within the project area at time t after project start. [ha] |
| $size_{projectArea}$ | = | Total size of the project area. [ha] |

The two shape factors sc_1 and sc_2 within this equation must be fitted using historical information in areas similar to the project area or data from peer-reviewed literature. Data sources that must be used are remotely sensed forest cover data in heavily deforested areas close to the project area such as neighboring provinces, states or countries. Values of sc_1 and sc_2 should be selected so that the carbon accounting is conservative. Lower values of sc_1 and higher values of sc_2 will result in lower deforestation, and are therefore more conservative. The project proponent must demonstrate that the source data used to fit this equation is appropriate. The following steps must be followed:

- Calculate the deforestation suitability for all forest cells using the logistic regression model.

- Sort the forest cells according to their deforestation suitability from highest suitability to lowest suitability.

- During a given year, the area that is effectively deforested is dependent on (1) the total rate of deforestation $D_{projectArea,baselineScenario,DF}(t)$, and (2) the remaining total forest cover. More specifically, the area that is effectively deforested equals the total rate of deforestation $D_{projectArea,baselineScenario,DF}(t)$ multiplied with the forest scarcity factor, which is a function of the remaining forest cover. Since deforestation is dependent on the remaining forest cover and the remaining forest cover changes as deforestation occurs, an iterative loop is necessary in which the remaining forest cover is updated as more and more forest is deforested. To begin the iterative loop, set $D_{projectArea,baselineScenario,DF,remaining}(t)$ to $D_{projectArea,baselineScenario,DF}(t)$ multiplied with the forest scarcity factor based on the remaining forest cover at the end of the previous year. Start deforesting cells (in order of highest to lowest deforestation probability). Every time a cell is deforested, update the remaining forest cover and the scarcity factor and re-calculate $D_{projectArea,baselineScenario,DF,remaining}(t)$ as $D_{projectArea,baselineScenario,DF}(t)$ minus the total amount of deforested cells and multiplied with the updated forest scarcity factor as a function of the remaining forest cover. Continue the loop until $D_{projectArea,baselineScenario,DF,remaining}(t) = 0$.

- Calculate the suitability for a new non-forest LULC class on the cells that were selected for deforestation. Assign the LULC class with the highest suitability, according to the calibrated models in previous step.

- Repeat steps 1-4 for forest degradation on the forest cells that were not assigned for deforestation, and that are not in the forest strata or LULC class with the lowest carbon density. Degrade the cells selected for degradation by assigning them to the next-lower forest strata. The scarcity factor calculated based on remaining forest cover must be used for forest degradation. Note that degradation must be applied on the result of the deforestation, so that cells that were deforested that year cannot be subject to forest degradation as well.

- Using the maps developed in the previous steps, sum the areas for each transition

separately for (1) the project area excluding ANR and harvest ($\Delta area_{projectAreaEAH,baselineScenario}(t,i)$), (2) the areas with ANR ($\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$) and (3) the areas with harvesting ($\Delta area_{projectAreaWithHarvest,baselineScenario}(t,i)$). This step will yield three transition matrices.

- For each of the three areas and three transition matrixes, calculate the regeneration transitions from one class or stratum ("CS1" in the equation below) to another class or stratum ("CS2" in the equation below) by multiplying the total area of the first class or stratum with the relative regeneration rate for transitions from one class or stratum to another, in the following formula noted as class or stratum 1 to 2. As explained in the summary, the baseline scenario includes not only projected degradation and deforestation, but also projected regeneration and reforestation in areas that were deforested. The equation below describes the carbon accounting for projected regeneration and reforestation under the baseline scenario.

$$\Delta area(t, CS1 \rightarrow CS2) = RFRGrate(CS1 \rightarrow CS2) \cdot area(t, CS1) \qquad \text{[EQ41]}$$

where:

$\Delta area(t, CS1 \rightarrow CS2)$	=	Area of transition from class or stratum 1 to 2 from time t to $t + 1$. [ha]
$RFRGrate(CS1 \rightarrow CS2)$	=	Relative annual regeneration rate for the transition from a class or stratum 1 to another, 2, from time t to $t + 1$. [yr^{-1}]
$area(t, CS1)$	=	Total area of class or stratum 1 for time t of the crediting period. [ha]

Apply the regeneration area $\Delta area(t, CS1 \rightarrow CS2)$ to the appropriate LULC classes and forest strata obtained after step 5 (degradation) so that the areas of all LULC classes are updated. The resulting areas of LULC classes and forest strata represent all land use dynamics for year t for one of the three areas considered. Report the final areas of all LULC classes and forest strata for year t separately for each of the three areas introduced in step 7.

8.2   Project Emissions

One or more of the drivers of deforestation described in Section 8.1.3 must be mitigated through specific project activities. Some activities may focus on increasing the livelihood options of local communities or preventing leakage through, for example, increasing the land use intensity of already deforested land. Success of the implementation and on-going maintenance of these activities is critically dependent on the active involvement of all stakeholders in the planning and execution of these project activities. In particular, the local communities must be actively involved. Therefore, project management, advisory, oversight, and consultative structures must be developed to ensure the active involvement of all stakeholders.

A holistic approach should be taken to meet the various resource needs of local communities. For example, rather than excluding local communities from using any forest

resources at all (and therefore necessarily forcing them to acquire these resources outside of the project area or purchase these in local or provincial markets, leading to leakage), a sustainable land management plan including key components of agriculture and forestry practices should be put in place to meet local wood and agricultural needs.

The *ex-ante* estimation of the deforestation and forest degradation rates is based on a breakdown of the effectiveness of every project activity (a) in decreasing any driver of deforestation (d) relative to that driver's contribution to deforestation and forest degradation, i.e. $effectiveness(a, d)$. For example, assume that the collection of fuelwood leads to a degradation of 200 Mg C per year, and the introduction of fuel-efficient woodstoves decreases emissions equivalent to 50 Mg C per year. Furthermore, assume that the development of biogas plants reduce emissions equivalent to 100 Mg C per year. The effectiveness of fuel-efficient woodstoves to decrease degradation from fuelwood collection, i.e. $effectiveness(fuel\text{-}efficient\ stoves, fuel\text{-}wood\ collection)$, is 25%, whereas the effectiveness of biogas plants to decrease degradation from fuelwood collection, i.e. $effectiveness(fuel\text{-}efficient\ stoves, fuel\text{-}wood\ collection)$, is 50%. Values of effectiveness factors must be estimated for every combination of project activity and driver of deforestation and forest degradation. Note that effectiveness values are only meant for *ex-ante* estimates of emission reductions/removals. E*x-post* emission reduction/removals are not quantified based on these values. The effectiveness values are often challenging to quantify, and depend on local conditions and the experience of the project proponent. However, estimation of the volume of emission reductions/removals that a project will generate depends on the ability of the project proponent to estimate the effectiveness values and refine these estimations throughout project monitoring.

The $effectiveness(a, d)$ factor represents the maximal effectiveness during the crediting period. This maximal effectiveness is adjusted over time using a rate factor, i.e., $rate(a, t)$, to reflect changes in the effectiveness due to gained experience, changes in funding levels, or on-going capacity building.

8.2.1 Identify Project Activities and Estimate the Effectiveness in Reducing Deforestation and Degradation Rates under the Project Scenario

A description of the REDD project activities that are included in this methodology, together with procedures to quantify the effectiveness for each project activity and each targeted driver follows.

8.2.1.1 *Strengthening of Land-Tenure Status and Forest Governance*

Legal agreements between the participating communities, landowners, project developers, and relevant government administrative levels are a necessary first step to secure land tenure and carbon rights. These agreements are particularly important when participating communities do not legally own the forest land, and the land-tenure status is unclear or obscured by a complex administrative hierarchy. The project proponent can assist local communities in securing their land tenure status. This can include developing legally binding community forestry agreements, purchasing or securing long-term conservation easements, or the revision of spatial plans and zoning laws. The expenses related to the establishment of these agreements can be covered by the revenue from REDD credit sales.

Strengthening the land-tenure status is essential for protecting land from encroachment by people other than participating communities and provide clarity on the allowed land use by the participating communities. However, legal tenure is insufficient for an effective protection of the forest resources. It must be complemented with on-the-ground protection measures such as social fencing or a patrolling system.

Table 10. Procedures to quantify the maximal effectiveness of strengthening land-tenure for target drivers.

Target driver	Maximal effectiveness quantification
Logging of timber for commercial on-sale	$$effectiveness < 5\% \hspace{2cm} [EQ42]$$ Legal recognition of the land-tenure status will eliminate overlapping authority from different administrations and reduce the potential that logging concessions are granted without explicit permission of participating communities. In addition, it is a necessary (but insufficient) step to reduce illegal logging of timber for commercial on-sale. Note that strengthening land-tenure alone usually does not directly lead to a reduction in deforestation.
Conversion of forest land to cropland (by people other than participating communities)	$$effectiveness < 5\% \hspace{2cm} [EQ43]$$ Legal recognition of the land tenure status will reduce the potential of conversion of forest land to cropland within the project area because it will provide clarity on the legal land uses. However, on-the-ground patrolling is necessary to effectively avoid conversion to cropland.
Conversion of forest land to settlements (by people other than participating communities)	$$effectiveness < 5\% \hspace{2cm} [EQ44]$$ See previous driver
Conversion of forest land to infrastructure	$$effectiveness < 5\% \hspace{2cm} [EQ45]$$ See previous driver

8.2.1.2 *Support with the Development and Implementation of Sustainable Forest and Land Use Management Plans*

Forest and land use management plans should be established in a participatory and democratic way. These plans can include the volumes of timber, fuelwood or NTFP each community can sustainably harvest, the areas for livestock grazing, or the area of forest land that can be converted into settlements or cropland and where the conversion must take place. The management plans must be based on the current and future need for forest products and land. Such plans will increase the efficiency of the current land use and avoid unplanned conversion of forest patches that can accelerate forest degradation. Plans must

be integrated and compatible with the land tenure and usage rights and be long-term or permanent (where possible) in nature.

The management plan is only binding for participating communities and will not affect the drivers of deforestation for which the agents are not participating in the project. The following table outlines the procedure to quantify the maximal effectiveness for this driver.

Table 11. Procedure to quantify the maximal effectiveness of forest and land use plans for target drivers.

Target driver	Maximal effectiveness quantification
Conversion of forest land to cropland by participating communities	$$effectiveness = \left(1 - \frac{\Delta area_{cropland,allowed}}{\Delta area_{cropland,baseline}}\right)\%$$ [EQ46] Forest and land-use plans usually explicitly indicate how much land can be converted from forest to cropland. The baseline conversion rates must be estimated based on remote sensing analysis or social assessments when no remote sensing analysis is feasible.
Conversion of forest land to settlements by participating communities	$$effectiveness = \left(1 - \frac{\Delta area_{settlement,allowed}}{\Delta area_{settlement,baseline}}\right)\%$$ [EQ47] See previous driver
Logging of timber for commercial on-sale (commercial timber = CT)	$$effectiveness = \left(1 - \frac{CT_{allowed}}{CT_{baseline}}\right)\%$$ [EQ48] The baseline harvesting rate comes from (1) recent reports and studies within the project area, (2) peer-reviewed literature in regions similar to the reference region, (3) expert opinion.
Logging of timber for local and domestic use by participating communities (domestic timber = DT)	$$effectiveness = \left(1 - \frac{DT_{allowed}}{DT_{baseline}}\right)\%$$ [EQ49] See previous driver
Fuelwood collection for domestic and local energy needs (domestic fuelwood = DFW)	$$effectiveness = \left(1 - \frac{DFW_{allowed}}{DFW_{baseline}}\right)\%$$ [EQ50] See previous driver
Cattle grazing in forests (grazing = GR)	$$effectiveness = \left(1 - \frac{GR_{allowed}}{GR_{baseline}}\right)\%$$ [EQ51] See previous driver

Extraction of understory vegetation (vegetation = VG)	$effectiveness = \left(1 - \dfrac{VG_{allowed}}{VG_{baseline}}\right)\%$ [EQ52] See previous driver

Any variable with the subscript "allowed" represents the allowed quantity or amount under the project scenario within the project boundary. Analogously, variables with the subscript "baseline" refer to the quantity in the baseline scenario. At the start of the project, information on parameters for the baseline must come from the project area itself. During a baseline update, these values must come from the reference region and/or leakage belts.

8.2.1.3 Demarcating Forest, Tenure and Ownership Boundaries, and Areas of Forest Protection

The installation of fences, gates, boundary poles, and signage provides local communities a transparent, recognizable and fixed boundary of the project area. Because legal protection alone (project action 1, "Strengthening the land-tenure status") may be insufficient to prevent deforestation, often a physical boundary or signage is required to avoid deforestation and to support social fencing and patrolling. Once the boundaries are demarcated, they must be protected and patrolled. Often, the capacity of the law enforcing authorities is too limited to do this task, so communities commit to defend their own land-tenure and land use rights by engaging in regular patrolling of the forest area. It must be clarified with the local administration which types of actions can be undertaken in the case of illegal trespassing (e.g., confiscating chainsaws, alerting local law enforcers, etc.). This often results in improved synergies amongst local communities, law enforcement and other relevant agencies to support boundary protection. Other project actions can include the creation of logistical plans to protect boundaries, social fencing, and the acquisition of equipment (e.g., small motorized vehicles) for patrolling and enforcement. The following table outlines the procedure to quantify the maximal effectiveness for this driver.

Table 12. Procedures to quantify the maximal effectiveness of demarcating boundaries for target drivers.

Target driver	Maximal effectiveness quantification
Logging of timber for commercial on-sale	$50\% < effectiveness < 100\%$ [EQ53] Since legally sanctioned logging is already regulated under forest management plans, the main driver affected here is illegal logging for commercial on-sale. With a sound forest patrolling plan in place, it is assumed that illegal logging for commercial on-sale can be at least halved.
Conversion of forest land to cropland by people other than participating communities	$effectiveness = 100\%$ [EQ54] Boundary demarcation and forest protection can eliminate conversion of forest land to crop land in most instances.
Conversion of forest land to settlements by people other than	$effectiveness = 100\%$ [EQ55] See previous driver

participating communities	

8.2.1.4 Fire Prevention

If forest fires threaten the project's forest resources, specific fire prevention measures could be taken. These include (1) installation of fire breaks, (2) clearing the forest of dead wood that can act as fuel for fires, especially around regenerating and young secondary forests, (3) discouraging or eliminating (if possible) fire-based hunting techniques, and (4) social inclusion activities to ward off revenge related fires. Saplings and small trees are particularly vulnerable to forest fires. If fire prevention activities require cutting down trees, or removing dead wood, this loss of carbon should be accounted for. The following table outlines the procedure to quantify the maximal effectiveness for this driver.

Table 13. Procedures to quantify the maximal effectiveness of fire prevention for target drivers.

Target driver	Maximal effectiveness quantification
Forest fires	$$40\% < effectiveness < 60\% \qquad \text{[EQ56]}$$ Fire prevention measures such as fire breaks, together with education, can effectively reduce fire-related deforestation and forest degradation by 50%. Set the value of effectiveness between the thresholds above based on (1) pilot experiments in the project area, (2) peer-reviewed studies in an area similar to the project area or (3) advice from experts.

8.2.1.5 Reduce the Fuelwood Consumption by Increasing Energy Efficiency
The collection of fuelwood only leads to forest degradation if it is collected from live trees. A low-intensity collection of fuelwood from downed dead wood may, in fact, have a positive effect on forest regeneration by decreasing the potential for forest fires. In cases where the collection of fuelwood leads to forest degradation, the introduction of fuel-efficient woodstoves will decrease the need for local consumption of fuelwood (Top et al. 2004). Adoption rates of these alternatives need to be monitored, together with the potential on-sale of fuelwood on local markets, which can potentially annul the GHG benefits generated by the alternative stoves. Only fuelwood gathering for domestic use is allowed in project areas. No fuelwood gathering is allowed for commercial purposes. The carbon accounting related to a decrease in consumption of fuelwood is done by monitoring the changes in carbon stocks; the following table outlines the procedure to quantify the maximal effectiveness for this driver.

Table 14. Procedures to quantify the maximal effectiveness of energy efficiency for the target driver.

Target driver	Maximal effectiveness quantification	
Fuelwood collection for domestic and local industrial energy needs	$$effectiveness = \sum \cdot \frac{(maximal\ adoption\ rate)}{(increase\ in\ efficiency\ of\ action)}$$	[EQ57]
	Estimate the maximal adoption rate based on the willingness of project participants to change their practices as quantified (1) in social assessments, or (2) by expert opinion. Estimate the relative increase in efficiency of stoves from (1) field studies, (2) peer-reviewed literature, or (3) local experts.	

8.2.1.6 Creation of Alternative Sources of Fuelwood

While the previous project action focuses on the *demand side* of energy, the set of project actions discussed in this section affects the *supply side* of energy. Activities can focus on creating alternative sources of fuelwood through agroforestry interventions, such as interplanting agricultural fields with trees that benefit agricultural yields, (as does Winterthorn, *Faidherbia albida*), but also provide some fuelwood to local farmers. Other examples include the creation of farm or village woodlots and woodlands on degraded land. Obviously, no forest may be cut to establish a woodlot or woodland. However, emissions related to the removal of biomass as part of a set of silvicultural interventions to maximize biomass growth, such as clearing of shrubs and weeds, are considered de minimis. Finally, renewable and non-fossil fuel based energy sources, such as solar or micro-hydro, can reduce the need for fuelwood by providing an alternative source of energy for cooking, heating or light.

Table 15. Procedures to quantify the maximal effectiveness of alternative fuelwood sources for target drivers.

Target driver	Maximal effectiveness quantification	
Fuelwood collection for domestic and local industrial energy needs	$$effectiveness = \frac{DFW_{baseline} - DFW_{alternative}}{DFW_{baseline}}$$	[EQ58]
	Estimate the production of alternative fuelwood sources that would go to domestic uses. Calculate the fuelwood equivalent of solar and micro-hydro technologies, if applicable.	
Wood collection for commercial on-sale	$$effectiveness = \frac{CFW_{baseline} - CFW_{alternative}}{CFW_{baseline}}$$	[EQ59]
	Estimate the production of alternative wood sources that would go to further on-sale. Calculate the fuelwood equivalent of solar and micro-hydro technologies, if applicable.	

8.2.1.7 Sustainable Intensification of Agriculture on Existing Agricultural Land

Forest land is often deforested to make a place for subsistence farming or extensive grazing. Project activities that will increase productivity and agricultural yields on existing cropland and increase animal stocking rates on grazing lands minimize the need for further forest clearing. Such activities include increases in mechanization, installation of irrigation systems, the introduction of high-yielding crop varieties, increases in livestock stocking rates, conservation agriculture and agroforestry activities, and farm-wood lot management. Intensification of agriculture also provides alternative forest-based biomass resources. Only sustainable farming techniques should be promoted and any increases in GHG emissions due to these activities must be monitored, reported and accounted for. Agriculture can be intensified through (1) sponsoring pilot and demonstration studies on sustainable agriculture and agroforestry, (2) strengthening the relations with local agricultural extension services, colleges and universities and (3) establishing a system of small grants or micro-financing for local farmers to invest into agricultural equipment, infrastructure, seeds, or fertilizer.

Intensification measures must be done on land that was already under agricultural production, or on land that is sanctioned to become agricultural land given the land-use plans. The following table outlines the procedure to quantify the maximal effectiveness for this driver.

Table 16. Procedures to quantify the maximal effectiveness of agricultural intensification for target drivers.

Target driver	Maximal effectiveness quantification
Conversion of forest land to cropland by the project proponent	$effectiveness =$ [EQ60] $(maximal\ adoption\ rate)$ $\cdot (increase\ in\ yield\ per\ hectare)$ Estimate the maximal adoption rate based on the willingness of project participants to change their practices based on (1) quantified in social assessments, or (2) expert opinion. Estimate the relative increase in yield from (1) field studies, (2) peer-reviewed literature or (3) local agricultural extension experts. Latter options may only be used if former options are not available.
Cattle grazing	$0\% \leq effectiveness \leq 100\ \%$ [EQ61] See previous driver
Understory vegetation extraction	$0\% \leq effectiveness \leq 100\ \%$ [EQ62] See previous driver

8.2.1.8 Providing Alternative Livelihoods to the Agents of Deforestation

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

- As much as possible, planned project activities should be carried out by the local communities**.** Engaging communities in forest patrolling, biomass inventory, fire prevention activities, installation of fences and boundary poles, and assisted natural regeneration activities will provide employment and a greater financial return to the communities. In addition, the active involvement of the local communities will strengthen the project goals and decrease the risks of project failure.

- Part of the forest can be made accessible for sustainable eco-tourism, which will create jobs and increase revenue.

- The sustainable extraction of non-timber forest products can be further developed and commercialized. This includes the harvesting of honey, medicinal plants, fungi, and the extraction of resins. Clear harvesting plans need to be developed to ensure the sustainable extraction of these commodities.

It is assumed that people will shift automatically towards a livelihood alternative that has a sufficiently greater return than their current livelihood. Therefore, the total effectiveness is calculated by dividing the income from alternative livelihoods by the total value of forest products that are harvested from the forest and sold on local markets. It is further assumed that alternative livelihood options must be 25% more economically attractive before people will switch to these alternative livelihoods. The total effectiveness thus becomes $0.75 \cdot \frac{\sum income\ through\ alternative\ livelihood}{\sum total\ value\ of\ forest\ products}$. This total effectiveness is then divided into individual values for the effectiveness for each target driver by multiplying the respective relative financial contribution of the target driver with the total value of forest products. The following table outlines the procedure to quantify the maximal effectiveness for this driver.

Table 17. Procedures to quantify the maximal effectiveness of alternative livelihoods for target drivers.

Target driver	Maximal effectiveness quantification
- Conversion of forest land to cropland - Logging of timber for commercial on-sale - Logging of timber for local enterprises and domestic use - Collection of fuelwood and charcoal production for sale on markets - Cattle grazing	$effectiveness =$ [EQ63] $0.75 \cdot \dfrac{\sum income\ through\ alternative\ livelihood}{\sum total\ value\ of\ forest\ products}$

8.2.2   Calculate Effectiveness of Project Activities in Reducing GHG Emissions

The effectiveness of project actions may change during the crediting period, due to the increased experience of project implementers or an increased allocation of funds during the crediting period. This time-dependent project activity rate is accounted for by integrating a factor $rate(a,t)$ for project activity a during year t. As was mentioned before, $effectiveness(a,d)$ represents the maximally attainable effectiveness given project conditions and capacity are optimal. As a consequence, $rate(a,t)$ must be 100% at least once during the crediting period. The relative reduction in deforestation can be estimated *ex-ante* by integrating the relative proportion of each driver of deforestation with the effectiveness coefficients and the estimated adoption rates for each project activity.

$$RelativeDriverImpact_{DF}(t,d)$$
$$= \sum_{a=1}^{nrActivities} \big(rate(a,t) \cdot effectiveness(a,d) \cdot contribution_{DF}(d)\big) \qquad \text{[EQ64]}$$

$$RelativeDriverImpact_{DG}(t,d)$$
$$= \sum_{a=1}^{nrActivities} \big(rate(a,t) \qquad \text{[EQ65]}$$
$$\cdot effectiveness(a,d) \cdot contribution_{DG}(d)\big)$$

$$RelativeProjectImpact_{DF}(t) = \sum_{d=1}^{nrDrivers} RelativeDriverImpact_{DF}(t,d) \qquad \text{[EQ66]}$$

$$RelativeProjectImpact_{DG}(t) = \sum_{d=1}^{nrDrivers} RelativeDriverImpact_{DF}(t,d) \qquad \text{[EQ67]}$$

where:

$RelativeDriverImpact_{DF}(t,d)$ and $RelativeDriverImpact_{DG}(t,d)$	= Relative impact of a driver d on deforestation and forest degradation, respectively for year t of the crediting period.[-]
$RelativeProjectImpact_{DF}(t)$ and $RelativeProjectImpact_{DG}(t)$	= Impact of all project activities on deforestation and forest degradation respectively, relative to the baseline deforestation and forest degradation rates during year t. [-]
$nrActivities$	= Total number of project activities. [-]
$nrDrivers$	= Total number of drivers of deforestation. [-]

$rate(a, t)$	=	Adoption rate or relative degree of activity for activity a during year t. A value of 100% indicates that the activity cannot be more efficient in reducing deforestation or forest degradation. [-]
$effectiveness(a, d)$	=	The effectiveness of project action a to reduce driver of deforestation d. [-]
$contribution_{DF}(d)$ and $contribution_{DG}(d)$	=	The relative importance of driver d in deforestation and degradation to the total deforestation and degradation, respectively. [-]

The absolute rate of deforestation in hectares per year in the project region under the project scenario can be calculated by multiplying the relative project impact with the total deforestation and forest degradation rates in the project region under the baseline scenario.

$$D_{projectArea,projectScenario,DF}(t) \qquad \text{[EQ68]}$$
$$= RelativeProjectImpact_{DF}(t)$$
$$\cdot D_{projectArea,baselineScenario,DF}(t)$$

$$D_{projectArea,projectScenario,DG}(t) \qquad \text{[EQ69]}$$
$$= RelativeProjectImpact_{DG}(t)$$
$$\cdot D_{projectArea,baselineScenario,DG}(t)$$

Where:

$D_{projectArea,projectScenario,DF}(t)$ and $D_{projectArea,projectScenario,DG}(t)$	=	Rate of deforestation/degradation within the project area during year t under the project scenario. [ha yr^{-1}]
$RelativeProjectImpact_{DF}(t)$ and $RelativeProjectImpact_{DG}(t)$	=	Relative impact of all project activities on deforestation and forest degradation respectively during year t. [-]
$D_{projectArea,baselineScenario,DF}(t)$ and $D_{projectArea,baselineScenario,DG}(t)$	=	Baseline rate of deforestation/degradation within the project area during year t. [ha yr^{-1}]

8.2.3   Calculate Forest Strata-Specific Deforestation and Degradation Rates

Use the LULC model calibrated and validated in Section in 8.1.5 to divide the total *ex-ante* deforestation and forest degradation rates under the project scenario into individual rates for every forest stratum transition. The same statistical models may be used for calculating the stratum-specific rates under the project scenario. For every year of the crediting period, present a land transition table for the project areas under the project scenario.

8.2.4   Estimate GHG Emissions Sources from Firebreaks

The only project activity that may lead to an increase in emissions in the project is the clearing of trees to establish fire breaks or other fire prevention measures.[12] Increases in emissions from this activity must be duly accounted for and subtracted from the GHG emission reductions generated by the project activities. In case prescribed burning is used to remove woody biomass, all CH_4 emissions related to the burning must be included. The GHG emissions from fire breaks can be calculated by:

$$
\begin{aligned}
GHG_{fireBreaks} \\
= \frac{44}{12} \cdot \sum_{i=1}^{nrFireClasses} area_{biomassLoss}(i) \cdot \left(C_{AGL}(i) + C_{AGD}(i) + C_{BG}(i)\right) \\
+ \sum_{i=1}^{nrStrata} area_{fireBiomassLoss}(i) \cdot \left(C_{AGL}(i) + C_{AGD}(i) + C_{BG}(i)\right) \cdot \frac{16}{12} \cdot GWP_{CH4} \cdot ER_{CH4}
\end{aligned}
\qquad \text{[EQ70]}
$$

where:

$E_{fireBreaks}$	=	Annual GHG emissions from implementation of fire-preventing actions as REDD project activities. [tCO₂e yr⁻¹]
$nrFireClasses$	=	Number of forest strata in which fire breaks were installed. [-]
$area_{biomassLoss}(i)$	=	Total annual area of forest stratum i that was cleared for creating fire breaks. [ha yr⁻¹]
$C_{AGL}(i), C_{AGD}(i), C_{BG}(i)$	=	Carbon content in the aboveground live, aboveground dead, and belowground pools in forest stratum i. It is conservatively assumed that all biomass is removed. [Mg C ha⁻¹ yr⁻¹].
$area_{fireBiomassLoss}(i)$	=	Annual area of forest stratum i that was cleared by prescribed burning. [ha yr⁻¹]
GWP_{CH4}	=	Global Warming Potential for CH_4 [-]
ER_{CH4}	=	Emission ratio for CH_4 (IPCC default value = 0.012). See Table 3A.1.15 in IPCC GPG-LULUCF (2003). [-]
$nrStrata$	=	Number of forest strata. [-]

---

[12]   Emissions from clearing herbaceous vegetation are insignificant.

Add annual values of $E_{fireBreaks}$ to the summary table of all GHG emissions due to project activities.

8.2.5 Estimate the Net GHG Sequestration from Assisted Natural Regeneration (ANR) Activities

8.2.5.1 Scope and Applicability

This methodology includes procedures to quantify the GHG removals generated from silvicultural activities aimed at restoring degraded forest. These ANR activities serve a triple goal: (1) increase the project area's overall GHG sink strength, (2) reduce activity-shifting, and (3) provide alternative livelihoods to local communities by employing local communities for executing the work.

See Section 4.2.1 for a list of applicability conditions related to ANR activities .Further specific requirements related to ANR activities are provided below.

Assisted natural regeneration must only be done by implementing one or more of the following measures:

- Removal of invasive understory species such as ferns or herbs to promote the growth of tree seedlings.

- Thinning of over-stocked and stagnated forest stands to promote radial growth.

- Removal of exotic and/or invasive tree species to promote the growth of native species.

- Stem removal on trees with multiple shoots to promote the growth of a single stem.

- Enrichment planting with trees of biodiversity or social value.

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

8.2.5.2 General Quantification

Since the general approach to quantify increases in biomass under the project scenario using remote sensing is not very sensitive to gradual changes in forest biomass, regeneration in the areas with ANR are better accounted for using forest biomass inventories only. As a consequence, the changes in carbon stocks in the ANR areas in the project scenario must be accounted for by directly measuring increases in forest biomass using forest biomass inventories. These forest biomass inventory plots must be established, which are re-measured periodically. The calculation of the GHG removals by sinks due to assisted natural regeneration activities follows the latest version of CDM methodology AR-ACM0001 by combining and annualizing equations (11) and (12) (equation numbers from AR-ACM0001). The activity-shifting leakage from ANR activities is already included in the total project's leakage, as explained in Section 8.3. The following equation must be used to calculate sequestration from ANR activities.

$$C_{ANR}(t) = \Delta C_{ANR}(t) - \Delta C_{ANR,BSL}(t) \qquad \text{[EQ71]}$$

where:

$C_{ANR}(t)$ = Net anthropogenic greenhouse gas removals due to biomass increase in assisted natural regeneration during year t. [tCO$_2$e]

$\Delta C_{ANR}(t)$ = Annual change in carbon stocks in all selected carbon pools due to ANR during year t. [tCO$_2$e]

$\Delta C_{ANR,BSL}(t)$ = Baseline GHG gas emissions or sources during year t. [tCO$_2$e]

The procedure for calculating $\Delta C_{ANR}(t)$ is explained in Section 8.2.5.3. The procedure for calculating $\Delta C_{ANR,BSL}(t)$ is explained in Section 8.2.5.4. Section 8.2.5.5 explains how to calculate $GHG_{sources,ANR}(t)$, the increase in CO$_2$ emissions from loss of existing woody biomass due to site-preparation (including burning), and/or to competition from forest (or other vegetation) planted as part of the ANR activities during year t.

8.2.5.3 Estimate Carbon Stock Increase

The procedure to calculate the carbon uptake by biomass in the areas where assisted natural regeneration activities are implemented follows the procedure described in the latest version of CDM-approved methodology AR-ACM0001.

$$\Delta C_{ANR}(t) = \frac{44}{12} \cdot \sum_{i=1}^{nrStrata} \Delta C(t,i) \cdot u_{inventory,ANR}(i) \qquad \text{[EQ72]}$$

$$\Delta C(t,i) = area_{projectAreaWithANR,projectScenario}(t,i) \cdot \frac{C(t_2,i) - C(t_1,i)}{t_2 - t_1} \qquad \text{[EQ73]}$$

where:

$\Delta C_{ANR}(t)$ = Annual change in carbon stocks in all selected carbon pools due to ANR during year t of the crediting period. Corresponds to Equation (12) of AR-ACM0001excluding GHG_E, but converted to CO$_2$ equivalents. [tCO$_2$e]

$nrStrata$ = Number of forest strata. [-]

$\Delta C(t,i)$ = Carbon stock change for ANR stratum i during year t of the crediting period. [Mg C yr^{-1}]

$area_{projectAreaWithANR,projectScenario}(t,i)$ = Amount of land on which ANR activities are planned under the project scenario during year t and in stratum i. [ha]

$C(t_2, i)$ and $C(t_1, i)$ =   Carbon stock density at time t_2 and t_1 respectively and in stratum i. [Mg C ha^{-1}]

$t_2 - t_1$ =   Duration between times 1 and 2. [year]

The larger of the two combined errors of the carbon stock density at time t_1 and t_2 must be used for uncertainty assessment in ANR areas using [EQ74].

$$CE_{inventory,ANR}(i) = max\left(CE_{inventory,ANR}(t_2, i), CE_{inventory,ANR}(t_1, i)\right) \qquad \text{[EQ74]}$$

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

$$u_{inventory,ANR}(i) = \begin{cases} 1 & \text{if } CE_{inventory,ANR}(i) \leq 0.15, \\ 1 - CE_{inventory,ANR}(t, i) & \text{if } 0.15 < CE_{inventory,ANR}(i) < 1, \\ 0 & \text{if } CE_{inventory,ANR}(i) \geq 1 \end{cases} \qquad \text{[EQ75]}$$

Where:

$CE_{inventory,ANR}(t, i)$ =   Combined error in estimated biomass stock density at time period t (i.e., time t_1 or time t_2) within stratum i using equation EQ21. [-]

$CE_{inventory,ANR}(i)$ =   Combined error in estimated biomass stock density within stratum i. [-]

$HWCI\left(C(t_1, i)\right)$ and $HWCI\left(C(t_2, i)\right)$ =   Half-width of the 95% confidence interval around the mean carbon stock density of LULC classes of forest stratum i respectively at time t_1 and t_2. [tCO₂e ha^{-1}]

$u_{inventory,ANR}(i)$ =   Uncertainty discounting factor around biomass stock densities in transition stratum i within ANR areas during time t. [$-$]

$max\left(CE_{inventory,ANR}(t_2, i), CE_{inventory,ANR}(t_1, i)\right)$ =   Maximum of combined error in inventories that were carried out at time t_2 and t_1 in LULC class or forest stratum i.[-]

To ensure that any loss of biomass that occurs as part of ANR activities such as from site preparation is duly accounted for, in the first verification $C(t_1, i)$ are the carbon stocks at the starting date of the crediting period or the starting date of the crediting period of added instance and $C(t_2, i)$ are the carbon stocks at the time of verification in stratum i. In the successive verifications, $C(t_1, i)$ are the carbon stocks at the preceding verificaiton and $C(t_2, i)$ are the carbon stocks at the time of verification in stratum i.

Ex-ante, values for biomass densities in ANR areas must be based on pilot projects or data on biomass increases in regenerating forests from the literature. *Ex-post*, this quantity must be monitored for actual biomass according to a network of sampling plots according to the procedures within this document. Select a sampling design with a confidence level of 95%.

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

The baseline emissions or sinks on land with ANR are calculated similarly as to the land without ANR using [EQ76].

$$\Delta C_{ANR,BSL}(t) \quad \text{[EQ76]}$$

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

$$- \sum_{i=1}^{nrStrataTransitions} \sum_{tt=1}^{t} \left(\begin{array}{c} u_{stratification} \cdot u_{transition}(i) \\ \cdot \Delta area_{projectAreaWitANR,baselineScenario}(t,i) \\ \cdot \left(EF_{AGL}(i) + EF_{AGD}(i, t-tt) + EF_{BG}(i, t-tt) + EF_{SOM}(i, t-tt) \right) \end{array} \right)$$

where:

$\Delta C_{ANR,BSL}(t)$	=	Baseline GHG gas emissions or sources during year t. [tCO$_2$e]
$u_{classification}$	=	Discounting factor for NERs from avoided deforestation, based on the accuracy of classification, i.e. dividing land into broad land use types. Section 8.1.2.7.
$u_{transition}(i)$	=	Discounting factor for all emission reductions, based on the uncertainty of biomass inventory related to transition i.
$\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$	=	Hectares undergoing transition i within the ANR area under the baseline scenario during year t. [ha yr^{-1}]. Section 8.2.5.3
$EF_{AGL}(i), EF_{AGD}(i, t-tt), EF_{BG}(i, t-tt), EF_{SOM}(i, t-tt)$	=	Aboveground live, aboveground dead, belowground, and soil emission factor for transition i, and time after transition

$t - tt$. Section 8.1.4.5

$u_{stratification}$ = Discounting factor for NERs from avoided degradation, based on the accuracy of stratification, i.e. dividing forest into individual forest biomass classes. Section 8.1.2.7

$nrFNFtransitions$ = Number of forest/non-forest transitions among land classes or forest strata, meaning transitions in which either the "from" or the "to" class are non-forests. Section 8.1.2.3

$nrStrataTransitions$ = Number of transitions among forest strata. Section 8.1.2.38.1.2.3

8.2.5.5 Calculate Emission Sources from Assisted Natural Regeneration

The increase in GHG emissions as a result of the prescribed burning during the implementation of the proposed ANR activity, $GHG_{sources,ANR}(t)$ consists of CH₄ emissions from prescribed burning of woody biomass and is calculated as following:

$$GHG_{sources,ANR}(t)$$
$$= \sum_{i=1}^{nrANRStrata} area_{fireBiomassLoss,ANR}(t,i) \qquad \text{[EQ77]}$$
$$\cdot \left(C_{AGL}(i) + C_{AGD}(i) + C_{BG}(i) \right) \cdot \frac{16}{12} \cdot GWP_{CH4} \cdot ER_{CH4}$$

where:

$GHG_{sources,ANR}(t)$	=	Increase in GHG emissions as a result ANR activity within the project boundary during year t. [tCO₂e]
$nrANRStrata$	=	Number of strata within the project area on which ANR activities are proposed. [-]
$area_{fireBiomassLoss,ANR}(t,i)$	=	Area of biomass removed within ANR stratum i using prescribed burning during year t. [ha]
$C_{AGL}(i), C_{AGD}(i), C_{BG}(i)$	=	Carbon content in aboveground live, aboveground dead and belowground pool in ANR stratum i. [Mg C ha⁻¹]
GWP_{CH4}	=	Global Warming Potential for CH₄ [-]
ER_{CH4}	=	Emission ratio for CH₄ (IPCC default value = 0.012). See Table 3A.1.15 in IPCC GPG-LULUCF (2003). [-]

8.2.6   Estimate the Net GHG Emissions Reductions from Cookstove and Fuel Efficiency Activities

8.2.6.1 Scope and Applicability

Cookstove and Fuel Efficiency (CFE) activities comprise improvements in the thermal application of non-renewable biomass. Examples of such activities include the introduction of high efficiency biomass-fired cookstoves, ovens and dryers, and improvement of energy efficiency of existing biomass-fired cookstoves, ovens and dryers. This methodology anticipates assisting the project proponent in reducing GHG emissions from degradation that can occur due to collection of fuelwood even if forest degradation is not included in the general quantification of GHG emissions reductions benefits. This methodology can be used to quantify GHG emissions reduction generated from reducing consumption of non-renewable biomass based on the procedures below.

See Section 4.2.2 for a list of applicability conditions related to CFE activities. Further specific requirements related to CFE activities are provided below.

8.2.6.2 General Quantification

The quantification approach assumes that, under the baseline scenario, the communities are collecting and consuming biomass fuel from the project area, directly causing deforestation and forest degradation. With the use of appliances with higher efficiency, the consumption of biomass is expected to decrease under the project scenario. The introduction of CFE activities reduces non-CO_2 from burning of fuelwood as well as CO_2 emissions from the loss of carbon stocks in the forest. When the degradation is included in the general quantification of GHG emissions reductions, emissions reductions from CFE activities arising from reducing CO_2 related emissions may have potential to be counted twice. In order to avoid double counting of emissions reductions generated from CFE activities are limited to those arising from non- CO_2 emissions reductions if degradation is included in the REDD project. On the other hand, when the degradation is excluded, GHG emissions emission reductions/removals from CFE activities include the non- CO_2 emissions and CO_2 related emissions. The CO_2 related emissions, however, exclude those related to deforestation activities.

Leakage related to the non-renewable biomass saved by the project activity must be assessed from surveys. Following method AMS.II.G. a leakage discount factor ($DF_{LeakageCFE}$) of 0.95 can be applied to estimated emissions reduction benefits from CFE, in which are surveys are not required.

If the degradation is excluded:

$$ER_{CFE}(t) = DF_{LeakageCFE} \sum_{i=1}^{nrCFE} HH_{non-CFE}(i,t) \cdot U_{CFE}(t) \cdot Fuel(t) \cdot \left(1 - \frac{\eta_{old}}{\eta_{new}}\right)$$
$$\cdot NCVfuel \cdot (EF_{non-CO2,fuel} + proportion_{DG,fuel} \cdot EF_{CO2,fuel}) \qquad \text{[EQ78]}$$

If the degradation is included:

$$ER_{CFE}(t) = DF_{LeakageCFE} \sum_{i=1}^{nrCFE} HH_{non-CFE}(i,t) \cdot U_{CFE}(t) \cdot Fuel(t) \cdot \left(1 - \frac{\eta_{old}}{\eta_{new}}\right)$$
$$\cdot NCVfuel \cdot EF_{non-CO2,fuel}$$

where:

$ER_{CFE}(t)$	=	Emission reduction from CFE activities during year t from cookstoves in the project area. [t CO2e]
$DF_{LeakageCFE}(t)$	=	Leakage discount factor [-]. A default factor from AMS.II.G of 0.95 can be used.
$U_{CFE}(t)$	=	Fraction of cumulative usage rate for technologies in project scenario in year t based on cumulative adoption rate and drop off rate revealed by usage surveys [-].
$Fuel(t)$	=	Average annual volume of biomass fuel consumed by households in the absence of the project activity at time t for cooking purpose. [Mg DM yr^{-1} HH^{-1}]
$HH_{non-CFE}(t,i)$	=	Total number of households in the project area that collect biomass fuel from the project area and use i number of efficient or alternative appliances under the project scenario and do not use CFE under the baseline at time t. [-]
i	=	Number of improved cookstoves and/or fuel efficient appliances from 1 to $nrCFE$ [-]
$nrCFE$	=	Total number of number of improved cookstoves and/or fuel efficient appliances [-]
η_{old}	=	Efficiency of the baseline cookstoves or appliances being replaced. [-]
η_{new}	=	Efficiency of the project CFE appliances deployed. [-]
$proportion_{DG}(fuelwood)$	=	The default proportion of degradation related carbon loss from fuelwood collection activities [-], (See Table 7)
NCV_{fuel}	=	Net calorific value of non-renewable biomass that is substituted. [TJ (Mg DM)$^{-1}$]
$EF_{non-CO2,fuel}$	=	Non--- CO_2 emission factor of the fuel that is reduced. [MgCO2 TJ^{-1}]
$EF_{CO2,fuel}$	=	Emission factor for the substitution of non-renewable biomass by similar consumers. [MgCO2 TJ^{-1}]

8.2.7 Estimate GHG Emissions from Harvesting

This methodology allows (limited) harvesting of timber from the project area. Allowing harvesting activities (1) increases the attractiveness of a REDD project to participating communities by providing employment and/or controlled access to forest resources, (2) reduces activity-shifting and market leakage, and (3) ensures that harvesting occurs legally, controlled and in a sustainable fashion. An integrated forest management plan or a harvest plan must be developed and all harvesting activities must be carried out according to this plan. The plan must include boundary of areas within a REDD project where harvest activities take place, as well as details of the forest inventory, projected forest growth, projected removal and harvest schedules, harvest methods, and location of harvest activities. In addition, forest management as well as silvicultural activities that aim at enhancing the growth and vigor of the forests inside the harvested areas must be described in the plan. The integrated forest management plan must be submitted at validation or during a verification event and may be updated at a verification event. If a specific area on which ANR activities are done or were done in the past but on which harvesting activities are planned at any point in the future, this area must be considered under this section and not in the section on ANR so to avoid overlap in areas. The quantification of the carbon stock density in harvest areas ($C_{harvest}(t,i)$) must be made from sample plots established in the harvest areas.

See Section 4.2.3 for a list of applicability conditions regarding harvesting. Further specific requirements related to harvesting are provided below.

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

- Description of harvest areas in terms of location, size, forest inventory and topography.

- A description of all silvicultural activities that will be applied in the areas where harvesting will be carried out. This description must include number of trees removed and number of trees retained, in case of individual tree selection cut methods. For clear-cut methods or group selection cut methods, maximum opening size must also be described.

- The harvesting methods, i.e. mechanized vs. manual, as well as all processes such as felling, bunching, skidding/ forwarding, loading, and unloading. All machinery and equipment must be described.

- The harvest frequency (years between harvests) and volume of harvest at each time period.

- Regeneration assumptions and description of site indexes for dominant species in the strata. The harvest plan must include the expected tree density that will be maintained in the project area. Additionally, growth estimates for harvest areas in terms of total biomass as well as biomass stock density per unit area must be described and all assumptions and validity of any growth estimates must be justified. If any software based models have been used, proper justification of the suitability of such models used must also be described in the harvest plan.

- Activities that are practiced to protect soil, water, site and residual trees in the

harvest area.

- Documentation on presence/absence of any threatened or endangered species and/or habitat on site, potential impacts on species and mitigation measures, presence/absence of natural heritage areas, and potential impacts on natural heritage areas and mitigation measures.

- A map of the harvest site including the following:

  - Plot locations.

  - Harvest area boundary within the project area boundary.

  - Slope classes.

  - Streams/rivers/roads (if present).

  - Wetlands (if present).

  - Stream side management zones or river buffer (if applicable).

  - Planned skid trails (if applicable).

  - Landing sites/areas (if applicable).

8.2.7.1 Determining Long-term Average Carbon Stock

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

- If the harvest plan concentrates harvest activities in smaller blocks and continuously moves harvesting activities from one block to the next throughout the forest until all the areas are harvested within one harvesting cycle (as practiced in clear-cut or group-selection cut methods), the minimal time period must end at the first year after the end of the crediting period during which all forest blocks have undergone a similar number of harvesting cycles. For example, if the crediting period is 30 years and the duration for all blocks to be harvested once is 12 years, the minimal time period must be 36 years even though project crediting period is only 30 years.

- If the harvest plan intends to target individual trees for harvest throughout the crediting period and the harvest can take place anywhere in a specified are within the forest (as practiced in individual tree selection cut methods), then the established time period over which the long-term average is calculated must be the length of the project crediting period. For example, if the crediting period is 30 years and harvesting of individual trees are carried out throughout the forest during the project crediting period, then the long-term average must be estimated based on the project crediting period.

- After determining the time period for estimating the long-term average, the long-term average carbon stock density must be calculated using [EQ79].

$$LTAC_{harvest} = \frac{\sum_{t=0}^{T} \sum_{i=1}^{nrStrata} C_{harvest}(t,i) \cdot u_{inventory,harvest}(i)}{T} \qquad \text{[EQ79]}$$

where:

$LTAC_{harvest}$	=	Long-term average Carbon stock density contained in harvested areas. [tCO$_{2e}$ ha-1]
$nrStrata$	=	Number of forest strata. [-]
$C_{harvest}(t,i)$	=	Biomass carbon stock density at time t in stratum i in harvested areas. [tCO$_2$ ha^{-1}]
$u_{inventory,harvest}(i)$	=	Discounting factor for the uncertainty in biomass estimation in harvested areas in stratum i in harvest areas. The most recent $u_{inventory,harvest}(t,i)$ value must for used for discounting the estimate for future years. [-]
T	=	Minimal time period for estimating long term average. [yr].

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

- The used models have been prescribed or recommended by designation forest department or related agencies in the country/jurisdiction. For example, growth models or yield project tables listed in forest act/regulations can be used. Alternatively, models that have been found in peer reviewed literature and are from the same region as of the project area can be used. However, such models must be parameterized for the specific conditions of the project area.

- The used models must be clearly documented with respect to the scope of the model, assumptions, known limitations, embedded hypotheses, assessment of uncertainties, and sources for equations, data sets, factors or parameters.

- Simulation software must be based on local data or calibrated for use in the project area. CO2FIX is an example of a simple ready-to-use model that can be easily applied globally. FVS, a different simulation model, has more functionality but requires calibration for use outside of the US (and Canada).

- When no individual simulation model is available, a simple spreadsheet model using IPCC biomass growth estimates or growth estimates based on expert opinion corroborated by local studies and historical practice for the project area can be used. The IPCC biomass tables provide estimate of annual growth and total biomass as a function of different forest types, age-group, and time. When biomass removal is tracked along with the annual growth, biomass remaining in forest can be estimated. Note that this approach gives only linear growth.

8.2.7.2 Calculate Emissions or Sinks on Land on which Harvesting Activities are Implemented

The emissions reductions or removals on the land with harvest activities are calculated using [EQ80].

$$\Delta C_{areaWithHarvest}(t) = \hspace{6cm} \text{[EQ80]}$$

$$\sum_{i=1}^{nrStrata} area_{projectAreaWithHarvest,projectScenario}(t,i) \cdot \left(\frac{C_{harvest}(t_2,i) - C_{harvest}(t_1,i)}{t_2 - t_1} \right)$$

$$\cdot u_{inventory,harvest}(i)$$

$$- \sum_{i=1}^{nrFNFtransitions} \sum_{tt=1}^{t} \left(\begin{array}{c} u_{classification} \cdot u_{transition}(i) \\ \cdot \Delta area_{projectAreaWithHarvet,baselineScenario}(t,i) \\ \cdot \left(EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt) + EF_{SOM}(i,t-tt) \right) \end{array} \right)$$

$$- \sum_{i=1}^{nrStrataTransitions} \sum_{tt=1}^{t} \left(\begin{array}{c} u_{stratification} \cdot u_{transition}(i) \\ \cdot \Delta area_{projectAreaWitHarvest,baselineScenario}(t,i) \\ \cdot \left(EF_{AGL}(i) + EF_{AGD}(i,t-tt) + EF_{BG}(i,t-tt) + EF_{SOM}(i,t-tt) \right) \end{array} \right),$$

In the first verification, $C_{harvest}(t_1,i)$ are the carbon stocks at the starting date of the crediting period and $C_{harvest}(t_2,i)$ are the carbon stocks at the time of verification in stratum i. In the successive verifications, $C_{harvest}(t_1,i)$ are the carbon stocks at the preceding verification event and $C_{harvest}(t_2,i)$ are the carbon stocks at the time of verification in stratum i. Furthermore, when a new instance is included in the project area, in the first verification of the added instance, $C_{harvest}(t_1,i)$ are the carbon stock at the time of that instance addition. $u_{inventory,harvest}(i)$ must be estimated using procedure described in 8.2.5.

where:

$\Delta C_{areaWithHarvest}(t)$	=	Net greenhouse gas emissions or removals in project area with harvest activities during year t. [tCO$_2$e]
$area_{projectAreaWithHarvest,projectScenario}(t,i)$	=	Size of strata i within the project area with harvest activities during year t under the project scenario. [-]
$C_{harvest}(t,i)$	=	Biomass carbon stock density at time t in stratum i in harvested areas. [tCO$_2$ ha^{-1}]

$u_{inventory,harvest}(i)$ = Discounting factor for the uncertainty in biomass estimation in harvested areas in stratum i in harvest areas. The most recent $u_{inventory,harvest}(t,i)$ value must for used for discounting the estimate for future years. [-]

$\Delta area_{projectAreaWithHarvet,baselineScenario}(t,i)$ = Hectares undergoing transition i within the project area in the harvest area, under the baseline scenario during year t. [ha yr^{-1}].

$nrStrataTransitions$ = Number of transitions among forest strata. Section 8.1.2.3

$nrFNFtransitions$ = Number of forest/non-forest transitions among land classes or forest strata, meaning transitions in which either the "from" or the "to" class are non-forests. Section 8.1.2.3

$EF_{AGL}(i), EF_{AGD}(i,t-tt), EF_{BG}(i,t-tt),$ and $EF_{SOM}(i,t-tt)$ = Aboveground live, aboveground dead, belowground, and soil emission factor for transition i, and time after transition $t-tt$. Section 8.1.4.5

$u_{stratification}$ = Discounting factor for NERs from avoided degradation, based on the accuracy of stratification, i.e. dividing forest into individual forest biomass classes. Section 8.1.2.7

$u_{classification}$ = Discounting factor for NERs from avoided deforestation, based on the accuracy of classification, i.e. dividing land into broad land use types. Section 8.1.2.7

$u_{transition}(i)$ = Discounting factor for all emission reductions, based on the uncertainty of biomass inventory related to transition i.

8.2.7.3 Quantification of Emissions from Harvesting

The fossil fuel emissions from forest harvesting activities are likely to be less than 5% of the total GHG emissions reductions benefits generated by the project. Considering that emissions from deforestation and forest degradation will be much higher than those associate to timber harvesting, the emissions from fossil fuel during transport and machinery can be considered *de-minimis.* In addition, according to VCS *AFOLU Requirements* Section 4.3.3.fossil fuel emissions from transport and machinery use in the REDD project activities can be considered *de minimis*. Therefore, emissions from harvesting, $GHG_{sources,harvest}(t)$, are considered "0".

8.3   Leakage

8.3.1   Leakage Categories Included in this Methodology.

Under this methodology, leakage is estimated *ex-ante*, but actual NERs are based on actual leakage calculated with project monitoring data. Leakage does not only occur on forest land outside of the project area, but also on non-forest land, such as woodlands or grassland.

The market leakage assessment only has to be included when illegal logging activities that supply timber to national or international markets as an identified driver. Stopping illegal logging to supply timber products to local communities is going to shift pressures to forested areas close to the project area. As a consequence, emissions due to market-effect leakage will be detected by the monitoring for activity shifting leakage.

However, if the illegal logging activities supply timber products to regional, national or global markets, there is high likelihood of market leakage beyond the detection boundaries of the activity-shifting leakage. Therefore, market leakage $GHG_{marketLeakage}(t)$ from reducing logging activities that supply timber products to regional, national or global markets must be quantified by applying appropriate market leakage discount factor to the total GHG emissions reductions/removals benefits derived from avoiding the deforestation and/or degradation activities that supply timber would otherwise supply timber products to regional, national or global markets in the baseline. The market leakage discount factor must be derived by using procedures for the market leakage discount factors for IFM projects set out in VCS *AFOLU Requirement*.

The procedure to quantify leakage differs between drivers that are geographically constrained and geographically unconstrained drivers (see Table 18).

- *Ex-ante* activity-shifting leakage from the geographically constrained drivers uses a factor-approach based on rural appraisals and expert knowledge; *ex-post* leakage from these drivers is based on the remotely sensed deforestation/degradation rates in the leakage area.

- *Ex-ante* activity-shifting leakage from the geographically unconstrained drivers is based on a factor-approach based on rural appraisals and expert knowledge. *Ex-post* activity shifting leakage is based on a factor-approach using conservative assumptions.

Table 18. Distinction between geographically constrained and geographically unconstrained drivers.

Geographically constrained driver categories	Geographically unconstrained driver categories
• Conversion of forest land to cropland for subsistence farming by local communities • Conversion of forest land to settlements	• Conversion of forest land to cropland for subsistence farming by migrants • Conversion of forest land to

by local communities • Logging of timber for local enterprises and domestic use • Fuelwood collection or domestic and local industrial energy needs • Cattle grazing in forests • Extraction of understory vegetation • Forest fires not part of natural ecosystem dynamics[13]	settlements by migrants • Logging of timber for commercial on-sale • Wood collection for commercial on-sale of fuelwood and charcoal production

8.3.2 Estimate Leakage from Geographically Constrained Drivers

Leakage from geographically constrained drivers is estimated *ex-ante* by calculating deforestation and forest degradation rates in the area adjacent to the project area subject to leakage, i.e. the leakage belts.

- First, calculate the leakage induced increase in deforestation/degradation due to project activities.

- Subsequently, demarcate the location and the size of the leakage belts using a GIS analysis.

- Next, estimate forest strata-specific deforestation and forest degradation rates in the leakage belts. Calculate first the total deforestation and degradation rates in the leakage belts by adding the leakage-induced increases in deforestation/degradation to the baseline deforestation/ degradation rates in the leakage belts. Estimate then forest strata-specific deforestation and forest degradation rates using the land use model previously calibrated (Section 8.1.5) for every time t of the crediting period.

8.3.2.1 Calculate the Leakage-Induced Increase in Deforestation and Forest Degradation Rates

$$\Delta D_{LK,DF}(t) = RelativeLeakageImpact_{DF}(t) \cdot D_{projectArea,baselineScenario,DF}(t) \qquad \text{[EQ81]}$$

$$\Delta D_{LK,DG}(t) = RelativeLeakageImpact_{DG}(t) \cdot D_{projectArea,baselineScenario,DG}(t) \qquad \text{[EQ82]}$$

---

[13] Not all forest fires are a source of leakage, only the forest fires caused by displaced agents such as hunters or beekeepers. The cause of the fire is not specified in the name of the leakage source, however, since, in practice, it is impossible to determine the source of fire. Any statistically significant increase in fire occurrence relative to a 10-yr baseline period must be considered as leakage.

where:

$\Delta D_{LK,DF}(t)$ and $\Delta D_{LK,DG}(t)$	=	Leakage induced increase in deforestation and forest degradation rates during year t of the crediting period. [ha yr^{-1}]
$RelativeLeakageImpact_{DF}(t)$ and $RelativeLeakageImpact_{DG}(t)$	=	Total relative impact of leakage on the decrease in GHG emissions due to project activities for deforestation and forest degradation respectively for year t of the crediting period. [-]
$D_{projectArea,baselineScenario,DF}(t)$, and $D_{projectArea,baselineScenario,DG}(t)$	=	Baseline rate of deforestation/degradation within the project area during year t of the crediting period. [ha yr^{-1}]

The relative impact of leakage is quantified by *ex-ante* leakage cancellation factors, which express the driver-specific relative amount of leakage for the amount of deforestation or degradation that is avoided. This quantity describes the proportion of the (expected) gross emission reductions inside the project area that are lost again due to leakage outside of the project area. Only changes that are directly attributed to project activities must be included in the cancellation rate. For example, if preventing illegal encroachment within the project area by patrolling saves 500 ha of forest per year, but directly leads to an increased deforestation outside of the project area of 300 ha, the achieved GHG emissions reductions benefits are cancelled due to leakage. The cancellation of GHG emissions reductions benefit is 60%. Once the leakage cancellation rates $leakage(d)$ are fixed for every driver d, the $RelativeLeakageImpact$ can be calculated as following:

$$RelativeLeakageImpact_{DF}(t)$$
$$= \sum_{d=1}^{nrCDrivers} leakage_{constrained}(d) \qquad [\text{EQ83}]$$
$$\cdot RelativeDriverImpact_{DF}(t,d)$$

$$RelativeLeakageImpact_{DG}(t)$$
$$= \sum_{d=1}^{nrCDrivers} leakage_{constrained}(d) \qquad [\text{EQ84}]$$
$$\cdot RelativeDriverImpact_{DG}(t,d)$$

where:

$RelativeLeakageImpact_{DF}(t)$ and $RelativeLeakageImpact_{DG}(t)$	=	Total relative impact of leakage on the decrease in GHG emissions due to project activities for deforestation and forest degradation respectively at time t. [-]
$nrCDrivers$	=	Number of geographically constrained drivers. [-]

$leakage_{constrained}(d)$	=	Leakage cancellation rate for avoiding deforestation/degradation of geographically constrained driver d. [-]
$RelativeDriverImpact_{DF}(t,d)$ and $RelativeDriverImpact_{DG}(t,d)$	=	Relative impact of a driver d on deforestation and forest degradation, respectively at time t of the crediting period. [-]

Every driver is assigned a leakage cancellation rate based expert knowledge, social assessments and past project experience. Summarize all cancellation rates for each driver in a separate table for avoided deforestation or avoided forest degradation. Any variable with subscript "allowed" indicates that the amount contained in that variable is allowed under the project. Similarly, variables with subscript "project" and "baseline" respectively indicate amount demanded under project and baseline. For example, as part of the REDD project strategy, measures can be put in place to reduce the allowed extraction of certain forest products and reduce the demand for these forest products. Any demand for forest products which cannot be eliminated and cannot be met by the allowed production can cause leakage. Leakage must be calculated as a function of baseline demand, project demand and project supply. If the project intervention does not expect any reduction in demand under the project scenario, any parameter with subscript "project" must be equal to corresponding parameters with subscript "baseline". Similarly, if no deforestation and/or degradation parameter is allowed/expected under project scenario then parameter with subscript "allowed' must be set to "0" in these calculations.

8.3.2.1.1 *Leakage Cancellation Rate for Conversion of Forest Land to Cropland for Subsistence Farming by Participating Communities*

$$leakage_{constrained}(cropland\ conversion\ by\ participating\ communities) =$$
$$\frac{\Delta area_{cropLand,project} - \Delta area_{cropLand,allowed}}{\Delta area_{cropLand,baseline} - \Delta area_{cropLand,allowed}} \qquad \text{[EQ85]}$$

Where:

$leakage(cropland\ conversion)$	=	Leakage cancellation rate for avoiding deforestation/degradation due to conversion of forest land to settlements. [-]
$\Delta area_{cropLand,baseline}$	=	Area that would be converted to cropland by participating communities under the baseline scenario. [ha yr^{-1}]
$\Delta area_{cropLand,project}$	=	Area that will be converted to cropland by participating communities under the project scenario after reduction in demand for cropland conversion. [ha yr^{-1}]

$\Delta area_{cropLand,allowed}$	=	Area that will be converted to cropland within the project area under the project scenario as defined in the management plan or project document. [ha yr^{-1}]

If the data are missing to calculate $leakage(cropland\ conversion)$, use a conservative rate of 100%. This is allowed because no *ex-post* NERs are dependent on this rate estimated. If the project does not anticipate or allow any conversion after the project start date then, $\Delta area_{cropLand,allowed}$ must be "0".

8.3.2.1.2   *Leakage Cancellation Rate for Conversion of Forest Land to Settlements by Local Communities*

$$leakage_{constrained}(settlement\ conversion) = \frac{\Delta area_{settlement,project} - \Delta area_{settlement,allowed}}{\Delta area_{settlement,baseline} - \Delta area_{settlement,allowed}} \quad [EQ86]$$

where:

$leakage_{constrained}(settlement\ conversion)$	=	Leakage cancellation rate for avoiding deforestation/degradation due to conversion of forest land to settlements. [-]
$\Delta area_{settlement,baseline}$	=	Area that would be converted to settlements by participating communities under the baseline scenario. [ha yr^{-1}]
$\Delta area_{settlement,project}$	=	Area that will be converted to settlements by participating communities under the project scenario after reduction in demand for settlement to conversion. If reduction in demand is not applicable, then this must be equal to $area_{settlement,baseline}$. This area is required by communities. [ha yr^{-1}]
$\Delta area_{settlement,allowed}$	=	Area that will be converted to settlements within the project area under the project scenario as defined in management plan/project document. [ha yr^{-1}]

If the data are missing to calculate $leakage(settlement\ conversion)$, use a conservative rate of 0.9. This is allowed because no *ex-post* NERs are dependent on this rate estimated.

8.3.2.1.3   Leakage Cancellation Rate for Conversion of Forest Land to Infrastructure

$$leakage_{constrained}(infrastucture\ conversion)$$
$$= \frac{\Delta area_{infrastucture,project} - \Delta area_{infrastucture,allowed}}{\Delta area_{infrastucture,baseline} - \Delta area_{infrastucture,allowed}} \qquad [EQ87]$$

where:

$leakage_{constrained}(infrastucture\ conversion)$	=	Leakage cancellation rate for avoiding deforestation/degradation due to conversion of forest land to infrastructure. [-]
$\Delta area_{infrastucture,baseline}$	=	Area that would be converted to infrastructure under the baseline scenario. [ha yr^{-1}]
$\Delta area_{infrastucture,project}$	=	Area that will be converted to infrastructure under the project scenario after reduction in demand for infrastructure development. If reduction in demand is not applicable, then this must be equal to $\Delta area_{infrastructure,baseline}$. [ha yr^{-1}]
$\Delta area_{infrastucture,allowed}$	=	Area that will be converted to infrastructure within the project area under the project scenario as defined in management plan/project document. [ha yr^{-1}]

If the data tocalculate $leakage(infrastructure\ conversion)$ is not available, use a conservative rate of 100 %. If the similar project activities have proven to achieve 100% reduction in demand for infrastructure development elsewhere in the reference region or in areas similar to reference region in the same jurisdiction as the location of project area, then $leakage(infrastructure\ conversion)$ can be set to 0%. If the project does not anticipate or allow any conversion for infrastructure after the project start date then, $\Delta area_{infrastructure,allowed}$ must be "0".

8.3.2.1.4 *Leakage Cancellation Rate for Logging of Timber for Local Enterprises and Domestic Use.*

The timber needed for local and domestic use is non-elastic. If the project activities allows extraction of timber from forest, then the leakage is "0" and if the project activities does not allow extraction of timber for such uses, then the leakage cancellation rate is 100%. For any value less than 100%, sufficient proof must be provided to justify lower leakage rate and must be assessed by the validation/verification body. In order to justify a lower leakage, the project proponent must be able to demonstrate a lower demand for timber products or supply from the sources that are not causing deforestation within the country boundary such as managed forest lots.

$$leakage_{constrained}(domestic\ timber) = 0 - 100\% \qquad \text{[EQ88]}$$

8.3.2.1.5 *Leakage Cancellation Rate for Fuelwood Collection for Domestic and Local Industrial Energy Needs*

Estimate the leakage cancellation rate as:

$$leakage_{constrained}(fuel\text{-}wood) = \frac{DFW_{project} - DFW_{allowed}}{DFW_{baseline} - DFW_{allowed}} \qquad \text{[EQ89]}$$

where:

$leakage_{constrained}(fuel\text{-}wood)$	=	Leakage cancellation rate for avoiding deforestation/degradation of fuelwood collection for domestic and local energy needs. [%]
$DFW_{baseline}$	=	Biomass (dry matter) of fuelwood collected by project participants under the baseline scenario. [m³ yr⁻¹]
$DFW_{project}$	=	Biomass (dry matter) of fuelwood collected by project participants under the project scenario after any adjustments to demand. [m³ yr⁻¹]
$DFW_{allowed}$	=	Biomass (dry matter) of allowed fuelwood collection in the project area under the project scenario as defined in a management plan/project document. [m³ yr⁻¹]

An example of applying this equation is given here for illustration. Assuming that collection of fuel-wood for domestic uses is one of the drivers of deforestation and under the baseline, the demand for fuel-wood within participating communities is equivalent to 100 arbitrary units ($DFW_{baseline} = 100$). As part of project activities, a forest management plan and land use planning will be in place. These plans streamline the extraction and limit the amount of wood that can be harvested from the forest. When it is allowed to harvest only 80 units of fuel-wood (as part of project activity) in the REDD project area ($DFW_{allowed} = 80$) without implementing any energy efficiency measures, the demand will remain constant under the project scenario ($DFW_{project} = 100$), causing a leakage of 20 units or 100%, because:

$$leakage_{constrained}(fuel\text{-}wood) = \frac{100 - 80}{100 - 80} = 100\%$$

However, when the project implementation reduces the demand for forest products itself, such as by increasing the efficiency and reducing the demand from 100 to only 90 units, $DFW_{project} = 90$), then there is leakage of 10 units or 50%, since:

$$leakage_{constrained}(fuel\text{-}wood) = \frac{90 - 80}{100 - 80} = 50\%$$

A number of project activities may be implemented to decrease the need for the resource either directly (e.g., the introduction of fuel-efficient woodstoves) or indirectly by providing alternative sources for the resource (e.g., solar stoves instead of woodstoves) must be used. Estimate $B_{projectScenario}$ as:

$$DFW_{project} = \sum_{i=1}^{nrfuelWoodReductionActions} adoption(i) \cdot \big(1 - efficiency(i)\big) \cdot DFW_{baseline}$$

[EQ90]

where:

$nrfuelWoodReductionActions$	=	The number of project activities that reduce the need for fuelwood. E.g., introduction of fuel-efficient woodstoves, biogas plants. [-]
$adoption(i)$	=	Adoption rate of project activity i which reduces fuelwood consumption. [-]
$efficiency(i)$	=	Rate at which project activity i reduces fuelwood consumption. [-]
$DW_{baseline}$	=	Biomass (dry matter) of fuelwood collected in the project area in the baseline scenario. [Mg DM yr^{-1}]

8.3.2.1.6   *Leakage Cancellation Rate for Cattle Grazing in Forests.*

Cattle grazing will be reduced or avoided as part of project activities by replacing in-forest grazing activities with stall feeding. Livestock feeds will be supplied by intensification of agricultural activities and farm woodlot management. When stall feeding is used and there is no displacement of grazing activities, there is no leakage from grazing. The leakage from displacement of grazing activities must be estimated using the latest version of the CDM A/R Methodological Tool *Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity*.

$$leakage_{constrained}(grazing) = 0 - 100\%$$

[EQ91]

8.3.2.1.7   *Leakage Cancellation Rate for Extraction of Understory Vegetation.*

Understory vegetation extraction that is required by communities for purposes such as roofing, livestock bedding and poles needs to be quantified and alternatives should be provided. Non-biomass alternatives for roofs could help defray the displacement of biomass

extraction in leakage belts. Similarly, intensification of agriculture and farm wood management can provide alternatives to understory vegetation extraction.

$$leakage_{constrained}(VG) = \frac{VG_{project} - VG_{allowed}}{VG_{baseline} - VG_{allowed}}$$ [EQ92]

where:

$leakage_{constrained}(VG)$	=	Leakage cancellation rate for avoiding deforestation/degradation of understory vegetation extraction. [-]
$VG_{baseline}$	=	Biomass (dry matter) of understory vegetation extraction by project participants under the baseline scenario. [Mg DM yr^{-1}]
$VG_{project}$	=	Biomass (dry matter) of understory vegetation extraction by project participants under the project scenario. [Mg DM yr^{-1}]
$VG_{allowed}$	=	Biomass (dry matter) allowed as understory vegetation extraction under the project scenario. This amount is typically fixed in a management plan. [Mg DM yr^{-1}]

A number of project activities may be implemented to decrease the demand of understory vegetation (e.g., the introduction of alternative roofing material, biomass from intensification of agriculture). Estimate $VG_{project}$ as:

$$VG_{project} = \sum_{i=1}^{nrVGReductionActions} adoption(i) \cdot \left(1 - efficiency(i)\right) \cdot VG_{baseline}$$ [EQ93]

where:

$nrVGReductionActions$	=	The number of project activities that reduce the need for understory vegetation extraction. [-]
$adoption(i)$	=	Adoption rate of project activity i which reduces understory vegetation extraction.[-]
$efficiency(i)$	=	Rate at which project activity i reduces fuelwood consumption. [-]
$VG_{baseline}$	=	Biomass (dry matter) of understory vegetation extraction. [Mg DM yr^{-1}]

8.3.2.1.8   *Leakage Cancellation Rate for Forest Fires Not Part of Natural Ecosystem Dynamics.*

Most forest fires that are avoided through fire prevention activities and education will not lead to increased occurrence of forest fires outside of the project area. Select a conservative leakage cancellation rate between 0-100%. For example, fires induced by hunters or beekeepers may be partially or fully displaced by patrolling the project areas. Substantiate the selected rate based on rational arguments, field observations and scientific

literature.

$$leakage_{constrained}(forest\ fires\ by\ participating\ communities) = 0 - 100\% \qquad [EQ94]$$

8.3.2.2 Demarcate the Leakage Belts

Leakage from drivers that are geographically constrained will remain close to the project areas. Leakage from these drivers is monitored in an *ex-ante* fixed geographical region around each discrete project area parcel (a leakage belt). Note that the leakage areas must contain both forest and non-forest land. The leakage belts are identical for all geographically constrained drivers (see Table 18). A correct *ex-ante* demarcation of each leakage belt is crucial to accurately account for the GHG benefits of the REDD project since the leakage belt is the area where leakage from geographically constrained drivers will be monitored and deducted from the actual NERs. The size and location[14] of the leakage belts is determined using a cost-of-transportation-based GIS approach and social assessments. Use the following steps:

- Determine the average "cost" to move across an LULC class, forest stratum, or road/track. The relative costs must be calculated by reciprocating the maximal speed for every class or road category and relevant mode of transportation, and therefore represent the fastest time it takes to cross a set distance. The speeds were analyzed in Section 8.1.3.3.

- Using a GIS, generate a raster map of the reference region in which every pixel contains the cost to cross this pixel, based on the class or roads/tracks on this pixel. The cost to cross areas that are not accessible to agents of deforestation must be set to an arbitrary large value. Examples of inaccessible areas include protected areas, national parks, economic land concessions, and large plantations. These must have been excluded already from the reference region.

- This map must have an identical resolution as the remote sensing images of the historical reference period.

- Using the cost map, generate a cost-distance map of the reference region in which every pixel contains the cost (time) to reach the nearest point of the project area.

- For every agent of deforestation/degradation, estimate the extra time this agent is willing to take to move its deforestation activities from the project area to the nearest accessible forest. Determine this value using social assessments by asking what the extra time is that a single household would have to spend if the project area is not accessible anymore.

- Select the area in the cost-distance map that is accessible from the boundary of the project area within the maximal time determined in the previous step multiplied by a

---

14   Note that the leakage belt encompasses both forest land and non-forest land.

factor 1.5.[15] This area must contain both forest and non-forest land. Therefore, when different agents and drivers of deforestation are active, the most mobile agent of deforestation must determine the size of a leakage belt. Note that the leakage area should be fully encompassed within the reference region. Increase the size of the reference region, if necessary, to accommodate the defined leakage belts.

8.3.2.3 Calculate the Forest Strata-specific Deforestation and Degradation Rates in the Leakage Belts

Once the leakage area is demarcated, the total deforestation/ degradation rates in the leakage belts are calculated using:

$$D_{leakageArea,baselineScenario,DF}(t) = D_{projectArea,baselineScenario,DF}(t)\frac{size_{leakageArea}}{size_{projectArea}} \qquad \text{[EQ95]}$$

$$D_{leakageArea,baselineScenario,DG}(t) = D_{projectArea,baselineScenario,DG}(t)\frac{size_{leakageArea}}{size_{projectArea}} \qquad \text{[EQ96]}$$

$$D_{leakageArea,projectScenario,DF}(t) = \Delta D_{LK,DF}(t) + D_{leakageArea,baselineScenario,DF}(t) \qquad \text{[EQ97]}$$

$$D_{leakageArea,projectScenario,DG}(t) = \Delta D_{LK,DG}(t) + D_{leakageArea,baselineScenario,DG}(t) \qquad \text{[EQ98]}$$

where:

$D_{leakageArea,baselineScenario,DF}(t)$ and $D_{leakageArea,baselineScenario,DG}(t)$	=	Baseline rate of deforestation/degradation within the leakage area at time t of the crediting period. [ha yr⁻¹]
$D_{projectArea,baselineScenario,DF}(t)$ and $D_{projectArea,baselineScenario,DG}(t)$	=	Baseline rate of deforestation/degradation within the project area at time t of the crediting period. [ha yr⁻¹]
$size_{leakageArea}$	=	Size of the leakage area. [ha]
$size_{projectArea}$	=	Size of the project area. [ha]
$D_{leakageArea,projectScenario,DF}(t)$ and $D_{leakageArea,projectScenario,DG}(t)$	=	Rate of deforestation/degradation within the leakage area under the project scenario at time t of the crediting period. [ha yr⁻¹]
$\Delta D_{LK,DF}(t)$ and $\Delta D_{LK,DG}(t)$	=	Leakage induced increase in deforestation and forest degradation rates during year t of the crediting period. [ha yr⁻¹]

---

[15] The factor of 1.5 takes into account that an agent of deforestation that is living close to the project area and who used to rely on the project area for certain activities may shift the activities to a forest in the opposite direction of the project area. However, this effect will gradually decrease. With a factor of 1.5, 95% of all potential leakage is captured.

- The total deforestation and forest degradation rates in the leakage area are calculated by adding the leakage-induced increase in deforestation/degradation rates to the baseline deforestation/ degradation rates. The baseline deforestation and forest degradation rates are calculated by taking the size-wise proportion of the deforestation/degradation rates in the project area under the baseline scenario. Add the total deforestation and forest degradation rates in the leakage area in two separate tables such as Table 15.
- Subsequently, estimate the forest strata-specific deforestation and forest degradation rates for every year of the crediting period using the land use model previously calibrated (Section 8.1.5).

8.3.3   Estimate Leakage from Geographically Unconstrained Drivers

Activity-shifting leakage from geographically unconstrained drivers is quantified using a factor approach in both the *ex-ante* and *ex-post* cases. All leakage from reducing logging of timber for commercial on-sale or wood collection for commercial on-sale of fuelwood and charcoal production is considered through the 'market leakage evaluations' mechanism from the VCS *AFOLU Requirements* document. The only other geographically unconstrained drivers are conversion of forests by migrants to either cropland or settlements outside of the leakage belts. Conversion of forest land to cropland or settlements by migrants or other people outside of the participating communities must be minimized with leakage prevention activities[16] such as the creation of alternative livelihoods and the intensification of land-use. The emissions from leakage are calculated by first quantifying the area of the leakage by multiplying the area of deforestation and degradation that is avoided with a leakage factor. Next, this area of leakage is multiplied with an average emission factor (EF_{forest}), a representative emission factor for the entire forest strata within the project area (i.e. average emission factor excluding non-forest strata) to calculate emissions from leakage by unconstrained drivers. This approach is fully conservative: in contrast to the deforestation by geographically constrained agents, it is not possible to predict in which forests the deforestation through leakage from unconstrained drivers will take place.

The following equation is to be used:

$$GHG_{otherLeakageSources}(t) =$$

$$+EF_{forest} \cdot D_{projectArea,baselinScenario,DF} \cdot \sum_{d=1}^{nrUDrivers} leakage_{unconstrained}(d) \cdot RelativeDriverImpact_{DF}(t,d)$$

$$+EF_{forest} \cdot D_{projectArea,baselinScenario,DG} \cdot \sum_{d=1}^{nrUDrivers} leakage_{unconstrained}(d) \cdot RelativeDriverImpact_{DG}(t,d)$$

[EQ99]

---

16 A list of the allowed leakage prevention activities and the associated applicability criteria can be found in Step 12, section 8.3.4.

where:

$GHG_{otherLeakageSources}(t)$	=	GHG emissions from leakage due to unconstrained geographic drivers during year t of the crediting period. [tCO₂e]
EF_{forest}	=	Emission factor related to leakage. If comprehensive national-level statistics on biomass densities are available, EF_{forest} must be calculated based on the average biomass of the country, if local data is not available. Sources of the data allowed are (1) academic research papers and (2) studies and reports published by the forestry administration or other organizations, including the FAO's Forest Resource Assessment reports, (3) the upper range of biomass in the GPG-LULUCF (2003) Table 3A.1.2. [tCO₂e]
$D_{projectArea,baselinScenario,DF}$ and $D_{projectArea,baselinScenario,DG}$	=	Baseline rate of deforestation and forest degradation respectively within the project area during year t of the crediting period. [ha yr⁻¹]
$nrUDrivers$	=	Number of geographically unconstrained drivers that are not covered by market leakage, i.e., "Conversion of forest land to cropland for subsistence farming by migrants" and "Conversion of forest land to settlements by migrants"
$leakage_{unconstrained}(d)$	=	Leakage cancellation rate for avoiding deforestation/degradation from geographically unconstrained drivers such as area of cropland conversion displaced beyond the leakage belts relative to the area of cropland conversion avoided within the project area. Unless a lower rate can be justified, a default rate of 100% must be used. The burden of proof lies with the project developer[17]. Valid sources to substantiate a smaller leakage rate include social assessments, scientific literature, and reports from civil society or governments. Sources have to be reliable and based on scientific methods and a good statistical design.

---

[17] For example, REDD Project participants can demonstrate that different measures to reduce leakage in the country are effective. Evidence from other areas could be used to substantiate a smaller leakage rate after it is demonstrated that the circumstances are similar.

$RelativeDriverImpact_{DF}(t, d)$
and
$RelativeDriverImpact_{DG}(t, cd)$

= Relative impact of the geographically unconstrained driver d at time t of the crediting period. [-]

Calculate values for $GHG_{otherLeakageSources}(t)$ for every year of the project crediting period and report in the overview table.

8.3.4 Estimate Applicability of and Emission sources from Leakage Prevention Activities

Leakage can be minimized by implementing a number of leakage prevention activities. Under this methodology, a number of potential leakage prevention activities are allowed. Note that the implementation of potential leakage prevention activities is optional. However, if leakage prevention activities are implemented, they must follow the relevant applicability criteria detailed in Section 4.2 as well as the requirements specified below.

Any significant increase in GHG emissions due to the implementation of leakage prevention activities ($E_{sources,leakagePrevention}(t)$) must be subtracted from the project's overall GHG emissions according to the procedures included within this Section. In addition, as part of the validation, the validation/verification body must analyze that no other significant emissions exist originating from any measure associated with the project and intended to prevent leakage.

The following sources of GHG emissions from leakage prevention activities are included in this methodology:

$$GHG_{sources,leakagePrevention}(t) = \Delta E_{flooded\ rice}(t) + \Delta E_{livestock}(t) \qquad \text{[EQ100]}$$

where:

$GHG_{sources,leakagePrevention}(t)$ = Emission sources from leakage prevention activities during time t of the crediting period. [tCO$_2$e]

$\Delta E_{flooded\ rice}(t)$ = Annual difference in GHG emissions due to increased use of flooded rice production systems as agricultural intensification measures during year t of the crediting period. [tCO$_2$e]

$\Delta E_{livestock}(t)$ = Annual difference in GHG emissions by enteric fermentation and manure management from increased animal stocking rates as an agricultural intensification measure during year t of the crediting period. [tCO$_2$e]

The significance of these and other emissions is tested according to the procedures provided in CDM EB31, Appendix 16 to determine whether it must be included. If an emission source is found insignificant, it must be omitted.

8.3.4.1 Check Conditions and Quantify Emissions from Intensification of Annual Cropping Systems

See Section 4.2.4 for a list of applicability conditions related to intensification of annual crop production systems. In addition, intensification of annual crop production systems must only be done by implementing one or more of the following measures:

- Increasing synthetic or organic N inputs.

- The use of fallow crops or shrubs.

- Replacing subsistence crops by cash crops.

- Replacing low-yielding crop varieties by higher-yielding, or less pest-sensitive crop varieties.

- Introduction of irrigation systems, except for flooded rice production systems.

The emissions from intensification of annual cropping systems are considered negligible and considered '0'.

8.3.4.2 Check Conditions and Quantify Emissions from Introduction of Flooded Rice Production

8.3.4.2.1 Scope and Applicability

See Section 4.2.5 for a list of applicability conditions when introducing flooded rice production

8.3.4.2.2 Emissions

A simple yet conservative estimate of the CH_4 emissions from flooded rice fields is used to discount emission reductions. Emissions are calculated based on a maximal daily emission rate multiplied with the maximal length of the growing season determined by PRAs. Equation 5.1 of Chapter 5, Volume 4 of IPCC sets out the calculation for estimating total CH_4 emissions from flooded rice fields for a given year. The change in CH4 emissions due to agricultural intensification in flooded rice production systems is estimated by quantifying the annual expansion of flooded rice harvest area. Therefore annual difference in GHG emissions due to increased use of flooded rice production systems must be estimated as:

$$\Delta E_{flooded\ rice}(t) = GWP_{CH4} \cdot \Delta A_{rice}(t) \cdot t_{flooded,max} \cdot EF_{rice,max} \cdot 10^{-6} \qquad \text{[EQ101]}$$

where:

t	=	Time after project start. [yr]
$\Delta E_{flooded\ rice}(t)$	=	Annual difference in GHG emissions due to increased use of flooded rice production systems as agricultural intensification measures during year t of the crediting period. [tCO$_2$e]
GWP_{CH4}	=	Global Warming Potential for CH$_4$ [-]
$\Delta A_{rice}(t)$	=	Total and cumulative increase in harvested area of rice due to leakage prevention measures since the start of the project and until year t. The increase in area of rice cultivation must be quantified using social assessments [ha yr^{-1}].
$t_{flooded,max}$	=	Maximal period of time a field is flooded [days yr^{-1}]
$EF_{rice,max}$	=	Maximal emission rate for methane. By default, an emission rate of 36 kg CH4 ha^{-1} day^{-1} must be used, which is 25% greater than the maximal value found in a review study comparing 25 studies of CH4 fluxes in rice fields (Le Mer and Roger, 2001). The project proponent may use a smaller emission rate if it can be demonstrate that the rate remains conservative for the project conditions. [kg CH$_4$ ha^{-1} day^{-1}]

Add annual values of $\Delta E_{flooded\ rice}(t)$ to the summary table of all GHG emissions due to project activities.

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

8.3.4.3.1 Scope and Applicability

See Section 4.2.6 for a list of applicability conditions when increasing livestock stocking rates. Livestock stocking rates must be increased through either or both of the following measures:

- Increasing the stocking density of livestock on existing grazing land.

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

8.3.4.3.2 *Quantification and Monitoring of Emissions from Increased Stocking rates*

Use the leakage procedures provided in the latest version of approved CDM methodology AR-AM0006 and as well as the latest version of CDM A/R Tool *Estimation of GHG emissions related to displacement of grazing activities in A/R CDM project activity* to determine the CH_4 and N_2O emissions from livestock, [18]. The sum of variable $LK_{FFL,t}$ within the latest version of CDM methodology AR-AM0006 and the variable $LK_{Displacement,t}$ (minus $LK_{Deforestation,t}$ and $LK_{N2O-Displacement,t}$ which are already accounted in the carbon stock change assessment) within the CDM A/R tool is equivalent to $\Delta E_{livestock}(t)$ within this methodology. Add annual values of $\Delta E_{livestock}(t)$ to the summary table of all GHG emissions due to project activities.

Use the variables list of default parameters and parameters to be monitored from the latest versions of AR-AM0006 and the CDM tool for displacement of grazing activities. Livestock population increases must be quantified using social assessments or peer-reviewed literature, and re-evaluated after every baseline update. Livestock population increases must be monitored using social assessments or peer-reviewed literature.

8.4 Summary of GHG Emission Reduction and/or Removals

8.4.1 Estimate Change in Carbon Stocks in the Long-Lived Wood Product Pool

This methodology considers the carbon in long-lived wood products sequestered for over 100 year as permanently sequestered carbon. First, the carbon in harvested wood products must be calculated for the project and baseline scenarios. Then, the carbon in long-lived wood products must be calculated for the project and baseline scenarios. The net change in carbon in long-lived wood products is then calculated by subtracting the carbon in long-lived wood products under the baseline scenario and the project scenario.

8.4.1.1 *Calculate Carbon in Harvested Wood Products.*
The carbon in harvested wood products is calculating based on the volume of timber extracted within the project area in both the baseline scenario and the project scenario.

$$C_{HWP,project}(ty,t)$$
$$= \sum_{h=1}^{H_{PS}} \sum_{j=1}^{S_{PS}} \left(\left(DT_{project}(h,j,ty,t) + CT_{project}(h,j,ty,t) \right) \cdot \rho_{wood,J} \cdot CF \right) \qquad \text{[EQ102]}$$

---

[18]   This tool has been approved for A/R CDM projects, but is applicable to REDD projects. All references to "A/R CDM" within this tool should be interpreted as "REDD".

$C_{HWP,baseline}(ty,t)$

$$= \sum_{h=1}^{H_{PS}} \sum_{j=1}^{S_{PS}} \left(\left(DT_{baseline}(h,j,ty,t) + CT_{baseline}(h,j,ty,t) \right) \right.$$
$$\left. \cdot \rho_{wood,J} \cdot CF \right)$$

where:

$C_{HWP,project}(ty,t)$ and $C_{HWP,baseline}(ty,t)$	=	Total carbon stock in long-lived wood products within the project boundary for class ty during time t of wood product ty in the project and baseline scenario, respectively [Mg C]
$DT_{project}(h,j,ty,t),$ $DT_{baseline}(h,j,ty,t),$ $CT_{project}(h,j,ty,t)$ $CT_{baseline}(h,j,ty,t)$	=	The volume of timber extracted from within the project boundary during harvest h by species j and wood product class ty during year t in the project and baseline scenario, respectively. DT = domestic timber; CT = commercial timber [m³].
$\rho_{wood,j}$	=	Wood density of harvested species or species group j [Mg DM m⁻³]
h	=	1, 2, 3, …, H_{PS} number of harvests [-]
j	=	1, 2, 3, …, S_{PS} harvested tree species [-]
ty	=	Wood product class – defined here as sawn wood (sw), wood-based panels (wp), other industrial round wood (oir), and paper and paper board (ppb).
CF	=	Carbon fraction of wood [Mg C (Mg DM)⁻¹] (default value = 0.5)

- Under the baseline scenario $DT_{baseline}$ and $CT_{baseline}$ must be calculated using Section 8.1.3.2 and Table 8. The uncertainty around the estimates of $DT_{baseline}$ and $CT_{baseline}$ must be estimated and/or justified with appropriate methods, such as reported uncertainties from scientific literature, or calculated uncertainties when social assessments are used. In situations when uncertainty cannot be estimated, the most conservative estimate must be used.

- For the *ex-ante* project case, $DT_{project}$ and $CT_{project}$ must be calculated using the procedures in Section 8.2.1.

- *Ex-post*, $DT_{project}$ and $CT_{project}$ must be monitored and quantified using forest operation records (i.e., log books kept as part of forest management plan). The uncertainty around the monitored volume of timber must be explicitly reported.

In case the uncertainty, as quantified by the half-width of the confidence interval, is less than 15% of the volume of timber extracted, no adjustment for uncertainty must be applied. If, however, the uncertainty is greater than 15% of the volume of timber extracted, $C_{HWP,baseline}(ty,t)$ must be adjusted upwards with its associated uncertainty and $C_{HWP,project}(ty,t)$ must be adjusted downwards with its associated uncertainty.

8.4.1.2 Calculate the Carbon in Long-Lived Wood Products

Carbon in long-lived wood products is defined as being sequestered for at least 100 years. Instead of tracking annual emissions through retirement, burning and decomposition, the methodology calculates the proportion of wood products that have not been emitted to the atmosphere 100 years after harvest and assumes that this proportion is permanently sequestered. All factors are derived from Winjum et al. (1998).

$$
\begin{aligned}
C_{LWP,project}(t) = &\sum_{s,wp,ppb,oir}^{ty} C_{HWP,project}(ty,t) \\
&\cdot \left(1 - wwf(ty)\right)\left(1 - slp(ty)\right)\left(1 - fo(ty)\right) \\
C_{LWP,baseline}(t) = &\sum_{s,wp,ppb,oir}^{ty} C_{HWP,baseline}(ty,t) \\
&\cdot \left(1 - wwf(ty)\right)\left(1 - slp(ty)\right)\left(1 - fo(ty)\right)
\end{aligned}
$$

[EQ103]

where:

$C_{LWP,project}(t)$ and $C_{LWP,baseline}(t)$	=	Carbon stock of long-lived wood products at time t in the project and baseline scenario, respectively. [Mg C]
$C_{HWP,project}(ty,t)$ and $C_{HWP,baseline}(ty,t)$	=	Total biomass carbon harvested within the project boundary by wood class ty during year t in the project and baseline scenario, respectively [Mg C]
$wwf(ty)$		Fraction of carbon in harvested wood products that is emitted immediately because of mill inefficiency for wood class ty. This can be estimated by multiplying the applicable fraction to the total amount of carbon in different harvested wood product category. The default applicable fraction is 24% and 19% respectively for developing and developed countries (Winjum et al. 1998).
$slp(ty)$	=	Proportion of short lived products. These fractions are 0.2, 0.1, 0.4 and 0.3 respectively for wood class ty, i.e., sawnwood, wood-based panel, paper and paper boards and other industrial round woods as described in Winjum et al. (1998). The methodology assumes that all other classes of wood products are emitted within 5 years.
$fo(ty)$	=	Fraction of carbon that will be emitted to the atmosphere between 5 and 100 years of harvest for wood class ty. See Table 19. [-]
t	=	*1, 2, 3….. t* years elapsed since the start of the project. [yr]
ty	=	Wood product class – defined here as sawnwood (sw), wood-based panels (wp), other industrial round wood (oir),

and paper and paper board (ppb)

Table 19. Proportion of remaining wood products oxidized between 5 and 100 years after initial harvest by wood product class and forest region

Wood product category	Forest region		
	Boreal	Temperate	Tropical
Sawnwood	0.378	0.613	0.850
Wood base panel	0.613	0.850	0.977
Other industrial round wood	0.850	0.977	0.999
Paper and paperboard	0.378	0.613	0.999

Source: Winjum et al. 1998

8.4.1.3 Calculate Net Change in Carbon in Long-Lived Wood Products

The net change in carbon in long-lived wood products is then calculated by subtracting the carbon in long-lived wood products under the baseline scenario and the project scenario.

$$\Delta C_{LWP}(t) = C_{LWP,project}(t) - C_{LWP,baseline}(t) \qquad \text{[EQ104]}$$

where:

$\Delta C_{LWP,t}$ = Net carbon stock change in long-lived wood products during year t [Mg C]

$C_{LWP,project}(t)$ = Carbon stock in long-lived wood products under the baseline scenario during year t [Mg C]

$C_{LWP,baseline}(t)$ = Carbon stock in long-lived wood products under the project scenario during year t [Mg C]

8.4.2   Summarize the Projected Land Use Change

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

- Present tables with the LULC class and forest-strata specific land transitions for the project and leakage area under the baseline and project scenarios.

- Subtract the land transition changes under the baseline scenario from the changes under the project scenario, and multiply with the difference of the appropriate emission factor and baseline net annual increment. Apply all applicable uncertainty discounting factors.

- Calculate values for $GHG_{otherLeakageSources}(t)$ from the procedure in 8.3.3.

- Calculate the net GHG benefits from ANR without taking emission sources into account for every year t of the crediting period.

- Calculate the net GHG benefits from harvested wood products pool.

- Calculate the net GHG benefits from fuel-efficiency activities only if the degradation is not included in the REDD project.

- Calculate the net GHG benefits from areas subject of harvest activities.

8.4.3   Test the Significance of GHG Emissions

In this step, the significance of emission sources is determined. This test has to be carried out at validation for for each of the first ten years of the project crediting period, and the procedure has to be repeated at every baseline update. All insignificant emissions can be omitted from the *ex-ante* calculation of the NERs. The CDM *Tool for testing significance of GHG emissions in A/R CDM project activities* from EB31 appendix 16 should be used to test the significance of GHG emissions.

The sum of increases in emissions that may be excluded must be less than 5% of the emission reductions. If it is determined that a specific GHG emission source will never reach this threshold and will never become significant, it may be omitted from the monitoring plan.

8.4.4   Estimate *Ex-ante* NERs

Use Equation [EQ105] to estimate the *ex-ante* NERs; only use the significant GHG sources as determined in the step above. Prepare a table with all the individual terms of Equation [EQ105]. Calculate the *ex-ante* NERs for every year of the crediting period. After NERs are calculated, use Equation [EQ106] to calculate the VCUs.

Cumulative emissions reductions/removals from ANR activities must account for less than 50% of the cumulative emissions reductions/removals generated by the project. For every year of the crediting period, divide the total emissions reduction from ANR by the total NERs in the overview table, and confirm that the result is less than 50%. Note that *ex-ante* NERs are are calculated and reported for the entire project crediting period but the estimates must be re-validated at every baseline update. (i.e., every ten years.

Net Emission Reductions(NERs)	=		
		ΔGHG from avoided deforestation excluding ANR and harvest areas	❶
		+ ΔGHG from deforestation due to leakage	❷
		+ ΔGHG from avoided degradation	❸
		+ ΔGHG from degradation due to leakage	❹
		+ΔGHG from leakage by unconstrained geographic drivers	❺
		+ ΔGHG from assisted natural regeneration	❻
		+ ΔGHG from changes in long-lived wood products	❼
		+ ΔGHG from improved cookstoves	❽
		+ ΔGHG from other and secondary sources	❾

<div align="right">+ΔGHG from avoided deforestation from areas under   ❿</div>
<div align="right">harvest</div>

[EQ105]

$$\text{Verified Carbon Units} = \text{NERs} - buffer \cdot (\mathbf{❶} + \mathbf{❸} + \mathbf{❺} + \mathbf{❼} + \mathbf{❿}) \qquad \text{[EQ106]}$$

where:

Note that i and tt are simple indices to the summations and do not have any further meaning; t is the year for which the emissions and removals are calculated.

ΔGHG from avoided deforestation:

$$\mathbf{❶} = \sum_{i=1}^{nrFNFtransitions} \sum_{tt=1}^{t} u_{classification} \cdot u_{transition}(i) \qquad \text{[EQ107]}$$

$$\cdot \left(\frac{+\Delta area_{projectAreaEAH,projectScenario}(t,i)}{-\Delta area_{projectAreaEAH,baselineScenario}(t,i)} \right)$$

$$\cdot \left(EF_{AGL}(i) + EF_{AGD}(i, t-tt) + EF_{BG}(i, t-tt) + EF_{SOM}(i, t-tt) \right)$$

ΔGHG from deforestation due to leakage:

$$\mathbf{❷} = \sum_{i=1}^{nrFNFtransitions} \sum_{tt=1}^{t} u_{classification} \cdot u_{transition}(i) \qquad \text{[EQ108]}$$

$$\cdot \left(\frac{+\Delta area_{leakageArea,projectScenario}(t,i)}{-\Delta area_{leakageArea,baselineScenario}(t,i)} \right)$$

$$\cdot \left(EF_{AGL}(i) + EF_{AGD}(i, t-tt) + EF_{BG}(i, t-tt) + EF_{SOM}(i, t-tt) \right)$$

ΔGHG from avoided degradation:

$$\mathbf{❸} = \sum_{i=1}^{nrStrataTransitions} \sum_{tt=1}^{t} u_{stratification} \cdot u_{transition}(i) \qquad \text{[EQ109]}$$

$$\cdot \left(\frac{+\Delta area_{projectAreaEAH,projectScenario}(t,i)}{-\Delta area_{projectAreaEAH,baselineScenario}(t,i)} \right)$$

$$\cdot \left(EF_{AGL}(i) + EF_{AGD}(i, t-tt) + EF_{BG}(i, t-tt) + EF_{SOM}(i, t-tt) \right)$$

ΔGHG from degradation due to leakage: [EQ110]

$$\mathbf{❹} = \sum_{i=1}^{nrStrataTransitions} \sum_{tt=1}^{t} u_{stratification} \cdot u_{transition}(i)$$

$$\cdot \left(\frac{+\Delta area_{leakageArea,projectScenario}(t,i)}{-\Delta area_{leakageArea,baselineScenario}(t,i)} \right)$$

$$\cdot \left(EF_{AGL}(i) + EF_{AGD}(i, t-tt) + EF_{BG}(i, t-tt) + EF_{SOM}(i, t-tt) \right)$$

ΔGHG from leakage by unconstrained geographic drivers:

$$❺ = -GHG_{otherLeakageSources}(t) - GHG_{marketLeakage}(t) \qquad \text{[EQ111]}$$

ΔGHG from assisted natural regeneration:

$$❻ = C_{ANR}(t) \qquad \text{[EQ112]}$$

ΔGHG from changes in long-lived wood products:

$$❼ = \frac{44}{12} \cdot \left(C_{LWP,project}(t) - C_{LWP,baseline}(t) \right) \qquad \text{[EQ113]}$$

ΔGHG from GHG Emissions Reduction from Cookstove and Fuel Efficiency (CFE):

$$❽ = ER_{CFE}(t) \qquad \text{[EQ114]}$$

ΔGHG from other and secondary sources:

$$❾ = -GHG_{fireBreaks}(t) - GHG_{sources,leakagePrevention}(t) - GHG_{sources,ANR}(t) \qquad \text{[EQ115]}$$

ΔGHG from avoided deforestation and degradation from areas under harvest

In case:

[EQ116]

$$\sum_{i}^{t} \Delta C_{areaWithHarvest}(i)$$

$$\geq \sum_{i=1}^{nrStrata} area_{projectAreaWithHarvest,projectScenario}(t,i) \cdot LTAC_{Harvest}$$

$$❿ = 0$$

In case the inequality above does not hold, (10) must be:

$$❿ = \Delta C_{areaWithHarvest}(t)$$

[EQ117]

Positive leakage is not allowed. Therefore, values for equations [EQ108] and [EQ110] must be set to "0" if they are found to be greater than 0. In order to avoid over compensation for leakage, the leakage from avoided deforestation and forest degradation i.e., [EQ108], [EQ110], and [EQ111] must be set to '0' if GHG emissions from leakage exceed the total GHG emissions reductions from avoided deforestation and/or forest degradation for each crediting period.

Variable	Explanation
$NERs(t)$	Net emission reductions during time t. Section 8.4.4. [tCO$_{2e}$]
$VCUs(t)$	Verified Carbon Units generated during year t. [tCO$_{2e}$]

$buffer$	Buffer withholding percentage according to the latest version of the VCSA *FOLU Non-Permanence Risk Tool* analysis and buffer determination. [-]
$nrFNFtransitions$	Number of forest/non-forest transitions among land classes or forest strata, meaning transitions in which either the "from" or the "to" class are non-forests. Section 8.1.2.3
$nrStrataTransitions$	Number of transitions among forest strata. Section 8.1.2.3
$nrStrata$	Number of strata within the ANR area. Section 8.1.2.3
$\Delta area_{projectAreaEAH,projectScenario}(t,i)$	Hectares undergoing transition i within the project area, excluding ANR and harvest areas, under the project scenario during year t. [ha yr^{-1}]. Section 8.2.3
$\Delta area_{projectAreaEAH,baselineScenario}(t,i)$	Hectares undergoing transition i within the project area, excluding the ANR area and harvest areas, under the baseline scenario during year t. [ha yr^{-1}]. Section 8.1.5.4
$C_{ANR}(t)$	Net anthropogenic greenhouse gas removals due to biomass increase in assisted natural regeneration during year t. [tCO$_2$e]. Section 8.2.5.2.
$\Delta area_{leakageArea,projectScenario}(t,i)$	Hectares undergoing transition i within the leakage area under the project scenario during year t. [ha yr^{-1}]. Section 8.3.2.3
$\Delta area_{leakageArea,baselineScenario}(t,i)$	Hectares undergoing transition i within the leakage area under the baseline scenario during year t. [ha yr^{-1}]. Section 8.1.5.4
$GHG_{otherLeakageSources}(t)$	GHG emissions from leakage by unconstrained geographic drivers during year *t*. [tCO$_2$e yr^{-1}]
$GHG_{marketLeakage}(t)$	GHG emissions from market leakage during time t. [tCO$_2$e]. Section 8.3.1.
$EF_{AGL}(i)$, $EF_{AGD}(i,t-tt)$, $EF_{BG}(i,t-tt)$, and $EF_{SOM}(i,t-tt)$	Aboveground live, aboveground dead, belowground, and soil emission factor for transition i, and time after transition $t-tt$. Section 8.1.4.5
CF	Carbon fraction of wood (use 0.5 by default).
$area_{projectAreaWithHarvest,projectScenario}(t$	Size of strata i within the project area with harvest activities during year t under the project scenario.

$u_{stratification}$	Discounting factor for NERs from avoided degradation, based on the accuracy of stratification, i.e. dividing forest into individual forest biomass classes. Section 8.1.2.7
$u_{classification}$	Discounting factor for NERs from avoided deforestation, based on the accuracy of classification, i.e. dividing land into broad land use types. Section 8.1.2.7
$u_{transition}(i)$	Discounting factor for all emission reductions, based on the uncertainty of biomass inventory related to transition i.
$\Delta C_{ANR}(t)$	Annual change in carbon stock in all selected carbon pools for forest stratum during year t. Section 8.2.5.3 [EQ72]. [tCO$_2$e yr^{-1}]
$u_{inventory,ANR}(i)$	Uncertainty discounting factor around biomass stock densities in transition stratum i within ANR areas. $[-]$
$GHG_{sources,projectArea}(t)$	Annual GHG emissions from implementation of fire-preventing actions as REDD project activities. Section 8.2.4. [tCO$_2$e yr^{-1}]
$GHG_{sources,leakagePrevention}(t)$	Emissions from sources of methane, nitrous oxide or fuel-CO$_2$ from leakage prevention activities during year t. Emission sources within the leakage area are included in Table 1. Section 8.3.4. [tCO$_2$e yr^{-1}]
$GHG_{sources,ANR}(t)$	Emissions of sources of methane, nitrous oxide or fuel-CO$_2$ from assisted natural regeneration activities during year t. Section 8.2.5.5. [tCO$_2$e yr^{-1}]
$ER_{CFE}(t)$	Emission reductions from reducing biomass use through high efficiency cookstoves and fuel efficiency activities during year t when degradation is not included in general quantification i.e. [EQ78]. [tCO$_2$e yr^{-1}]
$C_{LWPbaseline}(t)$	GHG sink in long-lived wood product in baseline scenario at year t [Mg C]
$C_{LWPProject}(t)$	GHG sink in long-lived wood product in project scenario at year t [Mg C]
$CreditingPeriod$	Project crediting period. [year]
$C_{harvest}(t,i)$	Carbon stock density in harvested areas in stratum i at year t. [tCO$_2$ ha-1]
$LTAC_{Harvest}$	Long term average carbon stock density in harvest areas. [tCO$_{2e}$ ha-1]

| $u_{inventory,harvest}(i)$ | Uncertainty in estimated carbon stock density in harvest areas in stratum i . [-] |
| $\Delta C_{areaWithHarvest}(i)$ | Net greenhouse gas emissions or removals in project area with harvest activities during year t. [tCO₂e] |

9 MONITORING

9.1 Data and Parameters Available at Validation

The following data and parameters are defined for standalone projects. For projects that are nested within a jurisdictional REDD+ program, at the time of validation the project will identify any data or parameters in the project document, if any, that will be adopted from the jurisdictional REDD+ program.

Data/parameter [EA1]:	CF
Data unit:	[Mg C (Mg DM)⁻¹]
Description:	Carbon fraction of dry matter in wood
Sources of data:	Default value of 0.5 (IPCC GPG-LULUCF 2003)
Measurement procedures:	
Any comment:	

Data/parameter [EA2]:	E
Data unit:	[-]
Description:	Average combustion efficiency of the aboveground tree biomass
Sources of data (*):	The project proponent must use project-specific measurements where available . Where such measurements are not available, the following data sources may be used in the order described below. • Regionally valid estimates from recognized, peer reviewed sources • Estimates from Table 3.A.14 of IPCC GPG LULUCF • If no appropriate combustion efficiency can be used, use the IPCC default of 0.5
Measurement procedures:	
Any comment:	

Data/parameter [EA3]:	P
Data unit:	[-]

Description:	Average proportion of mass burned from the aboveground tree biomass.
Sources of data:	GPG-LULUCF Table 3A.1.13
Measurement procedures:	
Any comment:	

Data/parameter [EA4]:	GWP_{CH4}
Data unit:	[-]
Description:	Global Warming Potential for CH_4
Sources of data:	GWP values shall be derived from sources specified by the VCS rules
Measurement procedures:	
Any comment:	

Data/parameter [EA5]:	ER_{CH4}
Data unit:	Proportion
Description:	Emission ratios for CH_4
Sources of data:	Table 3A.1.15 in IPCC GPG-LULUCF 2003
Measurement procedures:	IPCC default value of 0.012
Any comment:	

Data/parameter [EA6]:	sc_1
Data unit:	[-]
Description:	First shape factor for the forest scarcity equation; steepness of the decrease in deforestation rate (greater is steeper).
Sources of data:	Statistical fitting procedure. Using remotely sensed forest cover data in heavily deforested areas close to the project area such as neighboring provinces, states or countries
Measurement procedures:	Use procedure from Section 8.1.5.4
Any comment:	

Data/parameter [EA7]:	sc_2
Data unit:	[-]
Description:	Second shape factor for the forest scarcity equation; relative deforested area at which the deforestation rate will be 50% of the initial deforestation rate.

Sources of data:	Statistical fitting procedure. Using remotely sensed forest cover data in heavily deforested areas close to the project area such as neighboring provinces, states or countries
Measurement procedures:	Use procedure from Section 8.1.5.4
Any comment:	

Data/parameter [EA8]:	$wwf(ty)$
Data unit:	[-]
Description:	Fraction of carbon in harvested wood products that are emitted immediately because of mill inefficiency for wood class ty. This can be estimated by multiplying the applicable fraction to the total amount of carbon in different harvested wood product category.
Sources of data:	The default applicable fraction is 24% and 19% respectively for developing and developed countries (Winjum et al. 1998).
Measurement procedures:	
Any comment:	Any new updates from locally generated results can be used instead of the default values.

Data/parameter [EA9]:	$slp(ty)$
Data unit:	[-]
Description:	Proportion of short lived products
Sources of data:	Default values are 0.2, 0.1, 0.4 and 0.3 respectively for wood class ty, i.e., sawnwood, wood-based panel, paper and paper boards and other industrial round woods as described in Winjum et al. (1998).
Measurement procedures:	
Any comment:	Any new updates from locally generated results can be used instead of the default values. The methodology assumes that all other classes of wood products are emitted within 5 years.

Data/parameter [EA10]:	$fo(ty)$
Data unit:	[-]
Description:	Fraction of carbon that will be emitted to the atmosphere between 5 and 100 years of harvest for wood class ty.
Sources of data:	See Table 19 Winjum et al. 1998)
Measurement procedures:	
Any comment:	Any new updates from locally generated results can be used instead

	of the default values.

Data/parameter [EA11]:	$\rho_{wood,j}$
Data unit:	[Mg DM m^{-3}]
Description:	Average basic wood density of species or species group j
Sources of data:	GPG-LULUCF Table 3A.1.9. or published data/literature.
Measurement procedures:	
Any comment:	When no species-specific or species-group specific densities are available, an average representative density may be used for all species or species groups.

Data/parameter [EA12]:	BEF_2
Data unit:	[-]
Description:	Biomass expansion factor for converting volumes of extracted round wood to total aboveground biomass (including bark).
Sources of data:	IPCC GPG LULUCF Table 3A.1.10 or published data from scientific peer reviewed literature
Measurement procedures:	
Any comment:	

Data/parameter [EA13]:	$EF_{rice,max}$
Data unit:	[kg CH$_4$ ha^{-1} day^{-1}]
Description:	Maximal emission factor for methane
Sources of data:	By default, an emission rate of 36 kg CH$_4$ ha^{-1} day^{-1} must be used, which is 25% greater than the maximal value found in a review study comparing 23 studies of CH4 fluxes in rice fields (Le Mer and Roger, 2001). The project proponent may use a smaller emission rate if it can be demonstrated from empirical data or other supporting information such as published data that the rate remains conservative for the project conditions.
Measurement procedures:	
Any comment:	Only to be included if rice production is increased as a leakage prevention measure.

Data/parameter [EA14]:	$NCV_{biomass}$
Data unit:	[TJ (Mg DM)$^{-1}$]
Description:	Net calorific value of non-renewable biomass that is substituted.

Sources of data:	0.015 TJ (Mg DM) $^{-1}$ IPCC default value.
Measurement procedures:	
Any comment:	

9.2 Data and Parameters Monitored

Where multiple sources of data are provided, the project proponent must use the higher-ranked data sources where available.

9.2.1 Sizes, areas, and transitions

Data/parameter [MN1]:	$size_{projectArea}, size_{leakageArea}. size_{referenceregion}, size_{referenceForest}$
Data unit:	[ha]
Description:	Size of project area, leakage area, reference region, and forest area in the reference region
Sources of data:	Project design
Measurement procedures:	
Frequency of monitoring:	$size_{projectArea}$ and $size_{leakageArea}$ may be adjusted during crediting period per the rules for grouped projects and updated at verification, but only for the additional instances that were added after the project start date..
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN2]:	$\Delta area_{projectAreaEAH,projectScenario}(t, i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the project area, excluding ANR and harvest areas, under the project scenario during year t. [ha yr^{-1}]. Section 8.2.3
Sources of data:	Remote sensing analysis
Measurement procedures:	Follow the procedures described in Section 8.2.3
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN3]:	$\Delta area_{projectAreaEAH,baselineScenario}(t,i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the project area, excluding the ANR area, and harvest areas, under the baseline scenario for year t.
Sources of data:	Land-use change modeling
Measurement procedures:	Follow the procedures described in Section 8.1.5.4
Frequency of monitoring:	At least once before every baseline. For added instances, may be recalculated at verification.
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN4]:	$\Delta area_{projectAreaWithANR,baselineScenario}(t,i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the leakage area under the project scenario for year t.
Sources of data:	Land-use change modeling
Measurement procedures:	Follow the procedures described in Section 8.1.5.4
Frequency of monitoring:	At least once before every baseline update. For added instances, may be recalculated at verification.
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN5]:	$\Delta area_{leakageArea,projectScenario}(t,i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the leakage area under the project scenario for year t
Sources of data:	Remote sensing analysis
Measurement procedures:	Follow the procedures described in Section 8.1.2.4. In case emissions reductions/removals from avoided degradation are included, this parameter will provide the data required to calculate the activity data to estimate the emissions from both deforestation and forest degradation.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be	

applied:	
Any comment:	

Data/parameter [MN6]:	$\Delta area_{leakageArea,baselineScenario}(t,i)$
Data unit:	[ha yr⁻¹]
Description:	Hectares undergoing transition i within the leakage area under the baseline scenario during year t
Sources of data:	Land-use change modeling
Measurement procedures:	Follow the procedures described in Section 8.1.5.4
Frequency of monitoring:	Once every baseline update. May also be updated at the time of instance inclusion that requires new leakage area.
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN7]:	$\Delta area_{historical}(CS_1 \rightarrow CS_2, t_1 \rightarrow t_2)$
Data unit:	[ha yr⁻¹]
Description:	Area of transition from LULC class or forest stratum 1 to 2 from time 1 to 2 during the historical reference period
Sources of data:	Remote sensing analysis
Measurement procedures:	Calculate based on the remote sensing-based classification and stratification procedures detailed in Section 8.1.2
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN8]:	$RFRGrate(CS_1 \rightarrow CS_2)$
Data unit:	[yr⁻¹]
Description:	Relative annual forest cover increase and regeneration factor for the transition from class or stratum 1 to 2.
Sources of data:	Remote sensing analysis
Measurement procedures:	Calculate based on the remote sensing-based classification and stratification procedures detailed in Section 8.1.2. Multiply with 100 to obtain a forest cover increase and regeneration rate in percentage per year.
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	

Any comment:	It can be used for producing baseline transition matrix for new instances to be added into the project area.

Data/parameter [MN9]:	$area_{historical}(CS_1, t_1)$
Data unit:	[ha]
Description:	Total area of LULC class or forest stratum 1 at time 1
Sources of data:	Remote sensing analysis
Measurement procedures:	Calculate based on the remote sensing-based classification and stratification procedures detailed in Section 8.1.2
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN10]:	$area_{biomassLoss}(i)$
Data unit:	[ha yr^{-1}]
Description:	Total annual area of LULC class i that was cleared for creating firebreaks
Sources of data:	Records of implemented activities or management plan
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN11]:	$area_{fireBiomassLoss}(i)$
Data unit:	[ha yr^{-1}]
Description:	Annual area of forest stratum i that was cleared by using prescribed burning
Sources of data:	Records of implemented activities or management plan
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN12]:	$area_{fireBiomassLoss,ANR}(t, i)$

Data unit:	[ha]
Description:	Area of biomass removed by prescribed burning within ANR stratum i during year t
Sources of data:	Records of implemented activities
Measurement procedures:	Only to be included if ANR activities are implemented.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN13]:	$area_{projectAreaWithANR,projectScenario}(t,i)$
Data unit:	[ha]
Description:	Amount of land on which ANR activities are planned under the project scenario for year t and in stratum i
Sources of data:	Records of implemented activities
Measurement procedures:	Only to be included if ANR activities are implemented.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN14]:	$area_{harvest}(t,i)$
Data unit:	[ha]
Description:	Area of forest in harvest stratum i that is harvested at time t.
Sources of data:	Project Description or Forest/Harvest Management Plan
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN15]:	$area_{projectAreaWithHarvest,projectScenario}(t,i)$
Data unit:	[ha yr^{-1}]
Description:	Size of strata i within the project area with harvest activities during year t under the project scenario.
Sources of data:	Remote sensing analysis

Measurement procedures:	Follow the procedures described in Section 8.1.5.4
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN16]:	$\Delta area_{projectAreaWithHarvest,baselineScenario}(t, i)$
Data unit:	[ha yr^{-1}]
Description:	Hectares undergoing transition i within the harvest areas under under the baseline scenario during year t.
Sources of data:	Land-use change modeling
Measurement procedures:	Follow the procedures described in Section 8.1.5.4
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN17]:	$BetaReg_{DF}(t)$ and $BetaReg_{DG}(t)$
Data unit:	[ha yr^{-1}]
Description:	Beta regression model describing the relationship between time and deforestation/degradation rate in the reference region during the historical reference period.
Sources of data:	Historic forest degradation and deforestation modeling
Measurement procedures:	Procedure described in Section 8.1.5.1 or similar approach from peer-reviewed scientific literature.
Frequency of monitoring:	At least once every baseline update
QA/QC procedures to be applied:	
Any comment:	

9.2.2 Locations, Descriptions, Qualitative, and Social Data

Data/parameter [MN18]:	Area under agricultural intensification
Data unit:	[ha]
Description:	Size of the area of agricultural intensification separated for each agricultural intensification measure
Sources of data:	Participatory rural appraisals
Measurement procedures:	Calculate based on areas of cropland in the leakage and project areas

	Only to be included if agricultural intensification activities are implemented.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN19]:	Yields under agricultural intensification
Data unit:	[Mg ha^{-1}]
Description:	Harvested yield for agricultural intensification practices
Sources of data:	Participatory rural appraisals
Measurement procedures:	Only to be included if agricultural intensification activities are implemented.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

9.2.3 Data on Drivers and Actions

Data/parameter [MN20]:	$CFW_{baseline}$
Data unit:	[m^3 yr^{-1}]
Description:	Annual volume of fuelwood gathering for commercial sale and charcoal production in the baseline scenario
Sources of data (*):	1. Participatory rural appraisals 2. Recent (<10 yr) literature in the reference region 3. Recent (<10 yr) literature in an area similar to the reference region
Measurement procedures:	If emission reductions from avoided degradation were excluded due to insufficient accuracy, in which case $u_{classification} = 0$, and emission reductions from fuel-efficient woodstoves are included, $CFW_{baseline}$ may only be measured using the first option, social assessments.
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN21]:	$DFW_{baseline}$

Data unit:	[m³ yr⁻¹]
Description:	Annual volume of fuelwood gathered for domestic and local energy in the baseline scenario
Sources of data (*):	- Participatory rural appraisals - Recent (<10 yr) literature in the reference region - Recent (<10 yr) literature in an area similar to the reference region
Measurement procedures:	If emission reductions from avoided degradation were excluded due to insufficient accuracy, in which case $u_{classification} = 0$, and emission reductions from fuel-efficient woodstoves are included, $DFW_{baseline}$ may only be measured using the first option, social assessments.
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN22]:	$DFW_{project}$
Data unit:	[m³ yr⁻¹]
Description:	Biomass (dry matter) of fuelwood collected by project participants under the project scenario.
Sources of data (*):	1. Participatory rural appraisals 2. Recent (<10 yr) literature in the reference region 3. Recent (<10 yr) literature in an area similar to the reference region
Measurement procedures:	If emission reductions from avoided degradation were excluded due to insufficient accuracy, in which case $u_{classification} = 0$, and emission reductions from fuel-efficient woodstoves are included, $DW_{baseline}$ may only be measured using the first option, social assessments.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN23]:	$DFW_{allowed}$
Data unit:	[m³ yr⁻¹]
Description:	Biomass (dry matter) of allowed fuelwood collection in the project area under the project scenario. This amount is typically fixed in a management plan. [m3 yr-1]
Sources of data (*):	Forest management plan

Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN24]:	$VG_{baseline}$
Data unit:	[m^3 yr^{-1}]
Description:	Biomass (dry matter) of understory vegetation extraction by project participants under the baseline scenario. [Mg DM yr-1]
Sources of data (*):	1. Participatory rural appraisals 2. Recent (<10 yr) literature in the reference region 3. Recent (<10 yr) literature in an area similar to the reference region
Measurement procedures:	Calculate by multiplying the number of households involved in extraction of vegetation with the average annual extraction rate by household for different vegetation types
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN25]:	$VG_{project}$
Data unit:	[Mg DM yr-1]
Description:	Biomass (dry matter) of understory vegetation extraction by project participants under the project scenario.
Sources of data (*):	1. Participatory rural appraisals 2. Recent (<10 yr) literature in the reference region 3. Recent (<10 yr) literature in an area similar to the reference region
Measurement procedures:	Calculate by multiplying the number of households involved in extraction of vegetation with the average annual extraction rate by household for different vegetation types
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN26]:	$VG_{allowed}$
Data unit:	[Mg DM yr-1]
Description:	Biomass (dry matter) of allowed as understory vegetation extraction under the project scenario. This amount is typically fixed in a management plan
Sources of data (*):	Forest management plan
Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN27]:	$CT_{baseline}(h, j, ty, t)$
Data unit:	[m³ yr⁻¹]
Description:	Annually extracted volume of harvested timber round-wood for commercial on-sale under the baseline scenario during harvest h by species j and wood product class ty during year t
Sources of data (*):	1. Participatory rural appraisals conducted by the project proponent. 2. Recent (<10 yr) literature in the reference region 3. Recent (<10 yr) literature in an area similar to the reference region 4. Recent (<10 yr) non peer-reviewed reports by local organizations
Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN28]:	$CT_{allowed}$
Data unit:	[m³ yr⁻¹]
Description:	Annually allowed volume of harvested timber round-wood for commercial on-sale under the project scenario
Sources of data (*):	Project document and/or management plan
Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be	

applied:	
Any comment:	Estimate volume for mixture of species

Data/parameter [MN29]:	$CT_{project}(h, j, ty, t)$
Data unit:	[m³ yr⁻¹]
Description:	Annually extracted volume of harvested timber round-wood for commercial on-sale inside the project area under the project scenario during harvest h by species j and wood product class ty during year t.
Sources of data (*):	Project design, surveys, statistical records.
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN30]:	$DT_{baseline}(h, j, ty, t)$
Data unit:	[m³ yr⁻¹]
Description:	Annually extracted volume of timber for domestic and local use, round wood under the baseline scenario during harvest h by species j and wood product class ty during year t.
Sources of data (*):	1. Participatory rural appraisals conducted by the project proponent 2. Recent (<10 yr) literature in the reference region 3. Recent (<10 yr) literature in an area similar to the reference region 4. Recent (<10 yr) non peer-reviewed reports by local organizations
Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN31]:	$DT_{allowed}$
Data unit:	[m³ yr⁻¹]
Description:	Annually allowed volume of harvested timber round-wood for domestic and local use under the project scenario
Sources of data (*):	Project document and/or management plan

Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	Estimate volume for mixture of species

Data/parameter [MN32]:	$DT_{project}(h, j, ty, t)$
Data unit:	[m³ yr⁻¹]
Description:	Annually extracted volume of timber for domestic and local use, round wood inside the project area under the project scenario during harvest h by species j and wood product class ty during year t.
Sources of data (*):	Project design, surveys, statistical records.
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	

Data/parameter [MN33]:	$contribution_{DF}(d)$ and $contribution_{DG}(d)$
Data unit:	[-]
Description:	Relative contribution of driver i respectively to total deforestation and forest degradation.
Sources of data:	Calculated using procedure described in 8.1.3.
Measurement procedures:	
Frequency of monitoring:	At least once before baseline update.
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN34]:	$RelativeDriverImpact_{DF}(t, d)$ and $RelativeDriverImpact_{DG}(t, d)$
Data unit:	[-]
Description:	Relative impact of the geographically unconstrained driver d at time t of the crediting period respectively on deforestation and forest degradation.
Sources of data:	Calculated using procedure described in 8.2.2.
Measurement procedures:	
Frequency of monitoring:	At least once before baseline update.

QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN35]:	$leakage_{unconstrained}(d)$
Data unit:	[-]
Description:	Leakage cancellation rate for avoiding deforestation/degradation from geographically unconstrained drivers.
Sources of data:	Valid sources to substantiate a smaller leakage rate include social assessments, scientific literature, and reports from civil society or governments. Sources have to be reliable and based on scientific methods and a good statistical design.
Measurement procedures:	
Frequency of monitoring:	At least once before baseline update.
QA/QC procedures to be applied:	
Any comment:	Unless a lower rate can be justified, a default rate of 100% must be used.

Data/parameter [MN36]:	$effectiveness(a,d)$
Data unit:	[-]
Description:	Effectiveness of every project activity a in decreasing any driver of deforestation d relative to that driver's contribution to deforestation and forest degradation,
Sources of data:	Relevant academic literature or documented expert opinion.
Measurement procedures:	
Frequency of monitoring:	At least once before baseline update.
QA/QC procedures to be applied:	
Any comment:	The $effectiveness(a,d)$ factor represents the maximal effectiveness during the crediting period.

Data/parameter [MN37]:	$\Delta A_{rice}(t)$
Data unit:	[ha]
Description:	Annual increase in harvested area of rice due to leakage prevention measures.
Sources of data:	Project design decision
Measurement procedures:	Only to be included if rice production is increased as a leakage prevention measure.

Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN38]:	$t_{flooded,max}$
Data unit:	[days yr^{-1}]
Description:	Maximal period of time a field is flooded
Sources of data:	Participatory rural appraisals or expert opinion
Measurement procedures:	Only to be included if rice production is increased as a leakage prevention measure.
Frequency of monitoring:	At least once before baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN39]:	$GR_{baseline}$
Data unit:	[-]
Description:	Number of grazing animals of type g within the project boundary baseline
Sources of data:	1. Local agricultural records 2. Social assessments conducted by the project proponent
Measurement procedures:	Calculate by multiplying the number of animals taking into account different types of grazing animals.
Frequency of monitoring:	At least once before baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN40]:	$GR_{allowed}$
Data unit:	[-]
Description:	Number of grazing animals of type g allowed for grazing within the project boundary in the project scenario
Sources of data:	Project management plan
Measurement procedures:	Calculate by multiplying the number of animals taking into account different types of grazing animals.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN41]:	$Fuelwood(t),$ $Fuel(t)$
Data unit:	[m³ yr⁻¹ HH⁻¹]
Description:	Average annual volume of biomass fuel consumed by households in the absence of the project activity in year t for cooking purpose.
Sources of data:	Social assessments results or wood energy statistics applicable to the project
Measurement procedures:	
Frequency of monitoring:	At least once every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN42]:	$HH_{non-CFE}(t)$
Data unit:	[-]
Description:	Total number of household in the project area that collect biomass fuel from the project area and do not use CFE in year t.
Sources of data:	Social assessments results or wood energy statistics applicable to the project
Measurement procedures:	*Ex-post,* this value must be obtained from socio-economic survey.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN43]:	η_{old}
Data unit:	[-]
Description:	Efficiency of the project cookstoves or appliances.
Sources of data:	Default value of 0.10 for three stone stove or conventional stove that lacks improved combustion air supply mechanism and flue gas ventilation systems i.e., without a grate as well as a chimney; for rest of the systems 0.2 default value may be used.
Measurement procedures:	Measured using representative sampling method or based on referenced literature values. Use weighted average values if more than one type of systems are used. If measured, the procedure must comply with the Water Boiling Test (WBT) based on VITA 1985 - the 'International Standards'.
Frequency of monitoring:	At least once every baseline update
QA/QC procedures to be	

applied:	
Any comment:	

Data/parameter [MN44]:	η_{new}
Data unit:	[-]
Description:	Efficiency of the baseline cookstoves or appliances.
Sources of data:	1. Values obtained from the manufacturer of the stove. 2. Calculated from field testing using ISO standards.
Measurement procedures:	Measured using representative sampling method or based on referenced literature values. Use weighted average values if more than one type of systems is used.
Frequency of monitoring:	• If the stoves used are manufactured by a recognized company that is still in business and provides a warranty for the stoves stated life, then the monitoring must be done during every baseline update. • If the manufacturer does not provide any warranty or the manufacturer of the stove is no longer in the business, then the efficiency must be monitored annually using the water boiling test (WBT) protocol carried out in accordance with national standards (if available) or international standards or guidelines as specified in the latest version of Approved CDM Methodology – AMS.II.G. *Energy efficiency measures in thermal applicants of non-renewable biomass*. Biennial monitoring (i.e. monitoring once every two years) may be chosen, if the project proponent are able to demonstrate that the efficiency of the cookstove does not drop significantly as compared to the initial efficiency of the new device, over a time period of two years of typical usage. • Finally, if the conservativeness of the used efficiency can be demonstrated, the monitoring frequency can be once every baseline update. Demonstration of the conservativeness must be based on historical efficiency data for the type of stoves showing how efficiency declines from the initial efficiency level through the life of the stoves and the lowest efficiency value must be used for that type of stove.
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN45]:	$U_{CFE}(t)$
Data unit:	[-]
Description:	Fraction of cumulative usage rate for technologies in project scenario in year t.

	[-]
Sources of data:	Social assessments or wood energy statistics applicable to the project
Measurement procedures:	Cumulative adoption rate and drop off rate revealed by usage surveys [-].
Frequency of monitoring:	Annual
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN46]:	$DF_{LeakageCFE}(t)$
Data unit:	[-]
Description:	Leakage discount factor applicable to GHG emissions reduction benefits from CFE activities [-]
Sources of data:	1. Social assessments or wood energy statistics applicable to the project. 2. Default value of 0.95 following AMS.II.G CDM methodology.
Measurement procedures:	Leakage related to the non-renewable biomass saved by the project activity must be assessed based on surveys of users and the areas from which woody biomass saved under the project by non-project households that previously used renewable energy or efficient appliances must be considered. If this leakage assessment quantifies an increase in the use of non-renewable biomass, that is attributable to the project activity, then biomass used in the baseline must be adjusted by a factor ($DF_{LeakageCFE}$) to account for the leakage.
Frequency of monitoring:	Annual
QA/QC procedures to be applied:	
Any comment:	If the default value of 0.95 is used, no survey is required.

Data/parameter [MN47]:	$EF_{non-CO2,fuel}, EF_{CO2,fuel}$
Data unit:	[t CO_2 TJ^{-1}]
Description:	Respectively, non--CO2 emission factor of the fuel that is reduced and CO2 emission factor for the substitution of non-renewable biomass by similar consumers.
Sources of data:	Social assessments or wood energy statistics applicable to the project
Measurement procedures:	Emission factor can include a combination of emission factors from fuel production, transport, and use. Both CO_2 and Non-CO2 of the fuel such as emissions factors for charcoal can be estimated from project specific monitoring or alternatively by researching a conservative wood to charcoal production ratio (from IPCC, credible

	published literature, project-relevant measurement reports, or project-specific monitoring) and multiplying this value by the pertinent emission factor of wood.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN48]:	EF_{forest}
Data unit:	[t CO₂e]
Description:	Emission factor related to leakage.
Sources of data:	1. If comprehensive national-level statistics on biomass densities are available, EF_{forest} must be calculated based on the average biomass of the country. 2. If local data is not available. Sources of the data allowed are (1) academic research papers and (2) studies and reports published by the forestry administration or other organizations, including the FAO's Forest Resource Assessment reports, (3) the upper range of biomass in the GPG-LULUCF (2003) Table 3A.1.2.
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

9.2.4   Data on Organic Matter and Carbon Densities

Data/parameter [MN49]:	$OM_o(i)$
Data unit:	[Mg DM ha-1]
Description:	Plant-derived organic matter of LULC class or forest stratum i in pool o. [Mg DM ha-1]
Sources of data:	Field measurements using sampling plots in forest strata or LULC classes.
Measurement procedures:	The average biomass stock density in applicable organic matter pools: aboveground tree - $OM_{AGT}(i)$, aboveground non-tree - $OM_{AGNT}(i)$, lying dead wood - $OM_{LDW}(i)$, standing dead wood $OM_{SDW}(i)$, belowground $OM_{BG}(i)$, and soil organic matter $OM_{SOM}(i)$
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be	Follow uncertainty deduction procedures described in methodology.

applied:	Re-measure plots by independent teams.
Any comment:	Summed across multiple pools and divided into $OM_{plant}(i)$ and $OM_{soil}(i)$

Data/parameter [MN50]:	$proportion_{DF}(d)$ and $proportion_{DG}(d)$
Data unit:	[-]
Description:	Proportion of the gradual carbon loss that leads to deforestation or forest degradation, respectively, due to driver d
Sources of data:	Estimate using the procedure detailed in Table 9.
Measurement procedures:	
Frequency of monitoring:	At least once before every baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN51]:	$C(t,i)$
Data unit:	[Mg C ha^{-1} yr^{-1}]
Description:	Carbon stock density at time ☐ in stratum ☐.
Sources of data:	Estimate within the biomass inventory plots
Measurement procedures:	
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	Used in estimating change in carbon stock density such as in ANR areas.

Data/parameter [MN52]:	$f_{allometric}(y)$
Data unit:	Equation
Description:	Allometric relationship to convert a tree metric such as DBH or tree height into biomass
Sources of data (*):	1. Allometric equations developed by the project proponent
	2. Allometric equations developed locally by groups other than the project proponent
	3. Allometric equations developed for forest types that are similar to the ones in the project as found in found in Tables 4.A.1. and 4.A.2. of the GPG LULUCF
Measurement procedures:	

Frequency of monitoring:	May be updated at baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN53]:	$f_{belowground}(y)$
Data unit:	Equation
Description:	Relationship between aboveground and belowground biomass, such as a root-to-shoot ratio
Sources of data (*):	1. A relationship calculated from destructive sampling data obtained within the project area 2. A relationship obtained from the local/national studies that closely reflect the conditions of the project activity 3. Standard root-to-shoot ratios as found in Table 4.4 of the IPCC GPG-LULUCF 2003
Measurement procedures:	
Frequency of monitoring:	May be updated at baseline update
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN54]:	$C_{Harvest}(t, i)$
Data unit:	Mg C ha-1
Description:	Biomass carbon stock density at time t in stratum i in harvested areas.
Sources of data:	Field inventory
Measurement procedures:	Generic procedure is described in Section 8.1.4.4. Estimate must be made from plots located areas where harvesting takes place.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	Carbon stocks in harvested strata must come from sampling. It may be necessary to include additional plots in harvested strata for a precise estimation of carbon stocks. The exact measurement of aboveground and below tree carbon must follow international standards and follow IPCC GPG LULUCF 2003. These measurements are explained in detail in CDM approved methodology AR-AM0002 *Restoration of degraded lands through afforestation/reforestation*.

Data/parameter [MN55]:	$CE_{inventory,harvest(t,i)}$
Data unit:	[-]
Description:	Combined error in estimate of average biomass stock density in harvest areas in stratum i at time t.
Sources of data (*):	Field inventory
Measurement procedures:	Generic procedure is described in Section 8.1.4.4. Estimate must be made from plot located in areas where harvesting takes place.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	Uncertainty estimate in carbon stocks in harvested strata must come from sampling of plots in harvested areas.

Data/parameter [MN56]:	$CE_{inventory,ANR(t,i)}$
Data unit:	[-]
Description:	Combined error in estimate of average biomass stock density in ANR areas in stratum i at time t.
Sources of data (*):	Field inventory
Measurement procedures:	Procedure is described in Section 8.2.5.3.
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	Uncertainty estimate in carbon stocks in harvested strata must come from sampling of plots in ANR areas.

Data/parameter [MN57]:	$u_{classification}$
Data unit:	[-]
Description:	Discounting factor for NERs from avoided deforestation, based on the accuracy of classification, i.e. dividing land into broad land use types.
Sources of data:	
Measurement procedures:	Section 8.1.2.7
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN58]:	$u_{stratification}$
Data unit:	[-]

Description:	Discounting factor for NERs from avoided degradation, based on the accuracy of stratification, i.e. dividing forest into individual forest biomass classes. Section 8.1.2.7
Sources of data:	
Measurement procedures:	Section 8.1.2.7
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

Data/parameter [MN59]:	$u_{transition}(i)$
Data unit:	[-]
Description:	Discounting factor for the emission factor for the transition from LULC class or forest stratum 1 to class 2 according to the uncertainty of the biomass inventory.
Sources of data:	
Measurement procedures:	Section 8.1.2.4.3
Frequency of monitoring:	At least once before verification
QA/QC procedures to be applied:	
Any comment:	

9.3   Description of the Monitoring Procedures

This methodology requires the following monitoring components for calculating actual NERs:

- Monitoring of drivers of deforestation, project activities and emission sources related to REDD project activities inside and outside of the project area.

- Monitoring LULC class and forest strata transitions in the project area, leakage area, and reference region using remote-sensing technologies, and validated with ground-truthing data.

- Monitoring carbon stock densities in LULC classes and forest strata.

- Monitoring carbon stock increases in the area on which ANR are performed.

- Monitoring of carbon stock in long-lived wood products.

- Monitoring of natural disturbances.

- Monitoring of cookstoves and fuel efficiency activities.

- Monitoring of harvesting activities.

A monitoring report is produced which contains all of the information above, and which outlines the calculations for actual NERs generated. At each monitoring event, the project proponent must confirm that there are GHG projects in the project area and a formal statement to that effect must be included in the monitoring report.

Given that any natural disturbance is fully accounted as part of the on-going monitoring during the crediting period, any loss of biomass during the credited period must also accounted for and reported in the monitoring report regardless of the cause of the loss. However, where an event that qualifies as a loss event occurs and VCUs have previously been issued, project proponent must follow the applicable VCS rules.

The project proponent must follow the requirements below for monitoring project activities.

9.3.1   Calculation of *Ex-post* Actual Net GHG Emission Reductions

A monitoring report must contain the *ex-post* values of the actual net GHG emission reductions. Actual net NERs must be based on Equation [EQ105]; actual VCUs must be based on Equation [EQ106].

9.3.2   Calculation of *Ex-post* GHG Emissions and Changes in Sinks Under the Project Scenario Inside the Project Area

The changes in carbon sinks under the project scenario in the project area must be calculated based on remote sensing change analysis and field measurements. Carbon stock densities must be re-measured at least once before every baseline update using ground-based biomass inventories, as described in Section 8.1.4.4. However, carbon stock densities may be measured more frequently. For the calculation of the NERs, the most recent values of the carbon stock densities must be used. Therefore, if new carbon stock densities are available, values for the emission factors must be updated and the new values must be reported in the monitoring report based on the procedure in Section 8.1.4.

- Acquire (a) remote sensing image(s) between validation or the last verification and the current date, and use the same procedure as used for the baseline to produce (a) land use, land cover, and forest cover map(s). As explained in Section 8.1.2.5, if any part of the project area is covered in clouds or cloud shadows, its GHG accounting should be postponed on that portion of the project area in this monitoring period until cloud-free imagery in this portion of the project area is available. The postponed NERs may be added to the NERs generated in the subsequent monitoring period. Note that if a different remote sensing data source is used than for the historical baseline analysis, the provisions in Section 9.3.9 must be followed.

- Execute an image classification on the acquired image according to the procedures in Section 8.1.2.4. If emissions reductions/removals from avoided degradation are included, apply exactly the same stratification model as the one used for validation. Perform an accuracy assessment of the LULC classification as described in Section 8.1.2.4 using data from field sampling and independent remote sensing data. Ensure that the accuracy of the LULC classification is equal or greater to the average accuracy achieved for the historical remote sensing. The same $u_{classification}$ used for ex-ante calculations must be used ex-post until the next baseline update. When additional biomass plots were measured, update $u_{stratification}(i)$, all relevant emission factors as well as $u_{transition}(CS1 \rightarrow CS2)$.

- Compare the changes in between consecutive map(s) since the last time the project was verified and until the current map of land use, land cover, and forest cover. For the project area where no ANR or harvesting activities were performed, produce (a) land transition matrix/matrices between the consecutive map(s) since the last verification.

- Annualize the land transition matrix/matrices by dividing the land transition rates by the duration in between the two states represented by the maps. The annual rates of land transition changes for the project area on which no ANR activities are planned is $\Delta area_{projectAreaEAH,projectScenario}(t,i)$.

- For the ANR and harvesting areas, in which increases in forest biomass are quantified using biomass inventories, follow the procedures in Sections 8.2.5 and 8.2.7, respectively.

- The project proponent may choose to increase the number of sampling plots during the crediting period or replace previous plots when the biomass plots are located on land that has been deforested or lost through some other cause.

9.3.3 Calculation of *Ex-post* GHG Emissions and Changes in Sinks Under the Project Scenario
Outside the Project Area (Leakage)

Similar to Section 8.3.1, a distinction is made between the calculation of leakage from geographically constrained drivers and leakage from geographically unconstrained drivers. See Section 8.3.1 for a distinction between these two categories.

9.3.3.1 Calculation of Ex-post Leakage from Geographically Constrained Drivers

The land-use and land cover changes[19] in the leakage belts and leakage area must be calculated using exactly the same remote sensing change analysis as for the project area:

- Acquire (a) remote sensing image(s) between validation or the last verification and the current date, and use a similar procedure as used for the baseline to produce (a) land use, land cover, and forest cover map(s) in the leakage belts.

---

[19] These land-use and land cover (LULC) changes do not only include deforestation and forest degradation, but also LULC changes on non-forest land such as the conversion of woodlands to grasslands due to fuelwood collection.

- Compare the changes in between consecutive map(s) since the last time the project was verified and until the current map of land use, land cover, and forest cover. Produce (a) land transition matrix/matrices between the consecutive map(s) since the last verification for the leakage area.

- Annualize the land transition matrix/matrices by dividing the land transition rates by the duration in between the two states represented by the maps. The annual rates of land transition changes for the leakage area is $\Delta area_{leakageArea,projectScenario}(t,i)$.

However, in case the project proponent can justify in the monitoring report that observed change in deforestation and/or forest degradation in the leakage area compared to deforestation and/forest degradation in baseline in the leakage area is not caused by project activities, but rather through some external factor, the project proponent are allowed to adjust the baseline rate of deforestation and forest degradation within the leakage area as explained in this paragraph. This justification may include the case when in the monitoring period the deforestation and/or forest degradation rate in the reference region is higher than the monitored rate of deforestation and forest degradation within the leakage area. Under this case, the project proponent may adjust the baseline rate of deforestation and/forest degradation rate in the leakage area before calculating the geographically constrained leakage. The rate of deforestation and/or forest degradation within the leakage area under the baseline is adjusted by first estimating the rate of deforestation and/or forest degradation in the reference region through remote sensing, and then using this rate as the total rate of deforestation (and/or forest degradation) in estimating the adjusted baseline rate of deforestation and forest degradation for the monitoring period within the leakage areas following the procedures described in Section 8.1.5.4. All other variables and inputs to the procedure in Section 8.1.5.4 must remain the same as the values used at validation or last baseline update.

Once the project proponent elects to adjust the baseline rate of deforestation and/or forest degradation in the leakage area, the project proponent must continue to demonstrate that the adjusted rate is valid for the next monitoring period, or readjust the baseline rate of deforestation and/or forest degradation in leakage areas relevant to that monitoring period until the next baseline update.

9.3.3.2 *Calculation of Ex-post Leakage from Geographically Unconstrained Drivers*

Activity-shifting leakage from geographically unconstrained drivers must be quantified *ex-post* using a factor approach in which the leakage cancellation factors, set at validation following the procedure in Section 8.3.3, are used.

9.3.3.3 *Calculation of Ex-post Emission Sources from Leakage Prevention Activities*

Actual emissions from sources from leakage prevention activities, $GHG_{sources,leakagePrevention}(t)$, must be calculated using the equations in Section 8.3.4, but with monitored data.

9.3.4   Monitoring of CFE Activities

Any CFE appliances that have been brought from outside the project boundary does not qualify for emission removals/reductions as this can cause potential leakage. Similarly, non-operational appliances must be excluded. If the baseline appliances still continue to operate on the top of project cookstoves (i.e. CFE appliances are secondary), the project proponent must ensure that the fuelwood consumption of those stoves is excluded from the estimation of baseline emissions.

The GHG emissions reductions benefits from CFE activities must also be excluded once the project site is no longer threatened by the fuel-wood collection activities. This can happen either as a result of effective implementation of the REDD projects or as a result of reduced household energy needs. The following are indicators of such shifts and must be monitored periodically.

- Trend showing decrease in the time spent or distance travelled by users (or drivers of deforestation and degradation or fuel-wood suppliers) for gathering fuelwood.

- Survey results, national or local statistics, studies, maps or other sources of information such as remote sensing data that show that carbon stock are not depleting in the project area and leakage belt i.e. when fraction of non-renewable biomass (f_{NRB}) is 0.

- Decreasing trend in fuel-wood price indicating abundance of fuelwood.

9.3.5   Monitoring of Long-Term Average Carbon Stock in Harvest Areas

- The long term average carbons stock density, i.e., $LTAC_{Harvest}$, in the harvest areas must be updated at least once every verification period and at every baseline update using the most recent forest inventory carried out in the harvest areas. The procedure to estimate $C_{harvest}(i)$ and $u_{inventory,harvest}(i)$ is as described in Section 8.1.4.4 but the estimates are based on only the plots located in harvest areas.

- The project proponent must use the log-book for timber product harvest in the project area. When the actual harvest differs from the estimated harvest by more than 15% then $LTAC_{Harvest}$ must be updated and NERs adjusted accordingly i.e., to safeguard from over issuance of emissions reductions/removals have occurred due to the change in $LTAC_{Harvest}$.

- The harvest plan/description in PD must be updated with any changes in the harvest plan.

9.3.6   Monitoring Grouping of Project Area Parcels

Where new project area parcels are added subsequent to project validation, information on the new project area parcels must be included in the monitoring report as per VCS rules on grouping. In addition, the following conditions must be met and documented in the monitoring report.

The following conditions must be met before a new project area parcel can be added to an existing project:

- If the new project area and leakage area are located entirely within the existing reference region boundary and the size of the total new project area (ie, cumulative since the beginning of the project) is less than half of the size of the reference region, that area can be added to the existing project area without the need to update the reference region and the baseline. However, if a new project area is not inside the existing reference region boundary, or the size of the total new project area is greater than half the size of the reference region, a new reference region must be created. This must only be done when the baseline is updated.

- The new project area must pass the similarity to the reference region test outlined in Table 3. The similarity must be demonstrated for the new project area as a whole and not for each individual parcel.

- Leakage must be re-assessed for all new project instances, including activity-shifting, market leakage and ecological leakage assessments. The boundaries of existing leakage belts can be expanded or new leakage belts can be demarcated around the new project area parcels. The new leakage belts must remain located within the boundary of the reference region. If new project parcels are added within the leakage belts, the boundaries of existing leakage belt must be reassessed.

9.3.7   Monitoring Addition of New Project Activities

Despite the implementation of REDD activities, it is possible that some deforestation may still occur in the project area during the project crediting period. This deforestation can be either a catastrophic or non-catastrophic reversal as defined by the VCS. In case a reversal event occurs within the project area after the start of the crediting period, the project proponent must follow the VCS *AFOLU Requirements* for treatment of areas that suffer losses of forest cover . However, this methodology allows addition of new ANR activities (see 8.2.5) on deforested or degraded forest areas to incentivize good forest management, accelerate forest re-growth, and enable the project proponent to recuperate part of the suffered losses under the following conditions.

Where ANR activities are added in existing project areas after the project is validated, the new ANR activities must be described in the monitoring report and the following requirements must be met and demonstrated in the monitoring report.

- Only areas that were forest at the start of the project but become deforested or degraded after the start of the project are eligible regardless of whether the reversal occurred due to anthropogenic or non-anthropogenic reasons such as a natural disaster.

9.3.8   Update of the Sampling Design of Biomass Inventory Plots

If the project proponent have set-up permanent sampling plots in the project area, it is likely that during the crediting period, permanent forest sampling plots will have to be abandoned due to unforeseen deforestation or natural disasters. Similarly, with continuous increases in forest carbon stocks, additional sample plots must be required to accurately account for forest carbon stocks. In such cases, new permanent sampling plots must be established, or the sampling procedure must be switched to temporary sampling plots and measured following the procedure in this methodology. Ex-post emission reductions/removals must be calculated using the most recent emission factors that are calculated using the most up-to-date set of biomass inventories.

9.3.9   Updates to Baseline Net GHG Removals by Sinks

Once the baseline (calculated *ex-ante*) is validated, it is fixed for ten years and must be re-assessed and updated every ten years. The updated baseline must be validated at the subsequent verification as per VCS *AFOLU Requirements*.

Baseline updates must follow the procedures in Section 8, using updated values for all variables indicated as such in the monitoring table. The following exceptions to the procedures of Section 8 must be followed:

- The baseline must be re-calculated for the entirety of the crediting period, meaning from the start of the crediting period until the end of the crediting period. However, only the *ex-ante* NERs and baseline calculations until the next baseline update will be validated. Note that the re-calculation of previous years is necessary to understand the baseline state in the project area at the time of the baseline update.

- The new historical reference period used for the baseline update extends from the original start date of the historical reference period to the time at which the baseline update event is scheduled. In other words, all intermediate values for deforestation and forest degradation rates from the beginning of the historical reference period until the current time must be included. During the crediting period, the graphs of deforestation and forest degradation rates versus time will contain an increasing number of points.

- In addition, after the start of the crediting period, the reference region must exclude project areas and leakage belts. If after project start, new areas within the reference region become protected, these must be excluded from the updated reference region. Protected areas include:

  - National parks that are effectively protected.

  - Areas under conservation that are effectively protected.

  - Areas under a logging or economic land concession where access is effectively being restricted.

  - Large plantations that are effectively protected.

- Allometric equations used for biomass stock density calculations may be revised during a baseline update.

- The project proponent must use the same remote sensing data sources and analysis procedures as were used for project design or in the previous baseline update. However, if improved (i.e., spectral resolution of minimally 20% higher) data sources and remote sensing data analysis procedures become available to the project participants during the crediting period, or if the sensors used for the previous *ex-ante* baseline calculations become unavailable, changing the procedures previously used is allowed under the following conditions:

- Any change in data sources and analysis procedures must be duly explained and recorded. The Standard Operations Procedure for remote sensing analyses must be updated when a new sensor is used and the baseline is updated.

- Similar spectral bands (e.g., Red, Green, Blue, NIR, SWIR, MIR, etc.) used for classification from the original sensor must be present in the alternative sensor. A formal comparison of the sensors must be added to the baseline update Section within the monitoring report.

- If a new sensor is used and the baseline is not updated, the spectral resolution must be down-sampled to the spectral resolution of the original sensor, so that the same remote sensing procedure used during the baseline calculation can be used. Demonstrate that the classification results of the images from the previous sensor and the new sensor are comparable.

- Full resolution may only be used forward-looking after a baseline update and if sufficient historical images of the higher resolution are available to calculate the baseline, according to the procedures in Table 5. As a consequence, the inclusion of forest degradation based on higher-resolution data may only occur during a baseline update.

- The discounting factors $u_{stratification}$ and $u_{classification}$ must be updated during the baseline update period based on the classification and stratification accuracies for the period until the baseline update.

- The relative forest cover increase and regeneration rates may only be updated using data that is less than 10 years old.

- Summarize all updated baseline land transitions. Update the *ex-ante* NERs using the updated baseline estimates, and present an updated version of the overview table in the monitoring report.

Similarly, all requirements for biomass inventories, social surveys, etc. that were included in Section 8 must be followed.

9.3.10 Procedures for Verification of Allometric Equations

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

- The proposed equation(s) must have an r^2 value of greater than 0.5 (50%) and a p-value that is significant at 95% confidence level as reported in the source publications.

- The proposed equation(s) was developed from trees where the largest and smallest DBH (or any other tree metric used in the equation) of the trees fall within the range of the metric of the trees within the project areas.

- If the proposed equation(s) was/were derived from data solely from within the reference region then such equations can be used. If the proposed equation(s) was/were derived outside of the reference region, the project proponent must justify the similarity in climatic, edaphic, geographical and species composition between the project area and the location from where the equations were derived. The source publication must include an estimate of the uncertainty or sufficient data to estimate the uncertainty. If this uncertainty is within ±15% of the mean values and is not biased in a non-conservative manner (i.e., the equation(s) do(es) not systematically overestimate the project net anthropogenic removals by sinks), the equation(s) may be used.

- For any other equations that do not satisfy criteria (d) or if new equations or equations which do not have estimate of uncertainty are to be used, then one of the following two steps must be carried out:

- Step 1:Destructive Sampling

  - Selecting at least 5 trees covering the range of DBH (or any other tree metric used in the allometric equation) existing in the project area, and felling and weighing the aboveground biomass to determine the total (green) weight of the stem an branch components

  - Extracting and immediately weighing subsamples from each of the green stems and branch component, followed by oven drying at 105°C to determine dry biomass.

  - Determine the total dry weight of each tree from the green weights and the averaged ratios of wet and dry weights of the stem and branch components.

- Step 2: Limited Measurements.

  - Select at least 10 trees per species or species group distributed across the project area.

  - Calculate volume of tree from basal and top diameters and tree height. Multiply by species-specific density to gain biomass of bole. Add an additional 20 percentage of weight to approximately cover the biomass of branches.

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

Note – The project proponent must follow the remote sensing procedures provided in

Section 8.1.4.1 and should refer to guidance provided in Appendix 1 for procedures with regard to conducting social assessments, , QA/QC procedures and on verification of allometric equations.

APPENDIX 1: ADDITIONAL GUIDANCE

1.1 Guidance for Social Assessments

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

- Assemble all information that must be collected and determine the goals of the questionnaire. Identify all information that is required by the methodology.

- Determine the target group of the questionnaire, and sub-divide the group into different strata. Strata should be defined according to geography, household size, age, gender, etc. Take proper care to avoid the selection of a biased target group.

- Determine the total sample size and the number of samples required in each stratum. Identify the population in each of the strata categories defined in the previous step. Set quotas, a minimal number of surveys from each of the sample strata. Surveys must be collected until the quotas have been reached.

- Create your questionnaire. Transform the required data into neutral, simple and systematic questions. If possible and relevant, generate a set of expected answers. Include partially redundant questions to ensure consistency of data. Include space for some sketch mapping, if relevant. Expected answers could be complemented with graphs, figures, maps and pictures. Allow a "not applicable" or "uncertain" category. Group questions logically according to their contents and leave difficult or sensitive questions until near the end of a survey.

- Choose interviewing methodology and develop a standard operations procedure for interviewing. Include QA/QC procedures such as re-sampling a randomly selected sub-group by different experts, and the requirement to take geo-tagged pictures. All surveys must contain date, time, location, and name of the expert who conducted the survey. In addition, include a Section on how to introduce the purpose of the questionnaires to the interviewees.

- Pre-test the questionnaire and methodology, and adjust the questionnaire and its methodology, if necessary. More specifically, if questions are multiple choices (discrete), ensure that all potential answers are included.

- Train experts for conducting interviews. Through instruction, role playing exercises, and test sessions followed by immediate feedback, train experts to conduct interviews. Experts should be properly trained in explaining the broader scope of the social assessments.

- Conduct interviews and enter data. Make sure a copy is made of all surveys and put in a secure archive. Furthermore, all surveys should be scanned and stored electronically to avoid loss of data. Surveys should be immediately evaluated and if systematic problems arise, the survey must be adjusted or experts conducting the interviews should be re-trained. Make sure that experts are accompanied by an experienced supervisor for at least 10% of the interviews throughout the surveying campaign, and not only in the beginning of the campaign.

- Analyze the data.

- Produce reports.

1.2   Guidance for Quality Assurance and Quality Control

To ensure the precise, verifiable and transparent calculation of net NERs, a quality assurance and quality control (QA/QC) procedure must be implemented. The stipulations in the *IPCC 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry* on quality assurance/quality control (QA/QC) were followed within this methodology, and should be followed by the project proponent when designing a QA/QC plan.

1.2.1   QA/QC for Field Measurements

QA/QC should be conducted as follows:

- Persons involving in the field measurement work should be fully trained in the field data collection and data analyses.

- List all names of the field teams and the project leader and the dates of the training sessions.

- Record which teams have measured each sampling plot. Record that was responsible for each task.

- Develop Standard Operating Procedures (SOPs) for each step of the field measurements and adhere to these at all times, both *ex-ante* and *ex-post.*

- Put a mechanism in place to correct potential errors or inadequacies in the SOPs by a qualified person.

- Verify that plots have been installed and measured correctly, by having approximately 10% of all plots re-measured by an independent team. If the deviation between measurement and re-measurement is larger than 5%, investigate the source of the error, record and correct.

1.2.2 QA/QC for Data Entry, Documentation and Analyses

QA/QC should be conducted as follows:

- Review the entry of data into the data analyses spreadsheets by an independent source.

- Archived all original data sheets safely. Electronic data must be backed up adequately on durable media.

- Ensure that all files are named appropriately. Ensure that all database fields, spreadsheet headings or cells are adequately documented in such a way that it can be verified independently.

- Verify calculations for trivial errors such as unit conversion errors.

- If parameters are common between analyses (e.g., emission factors), ensure that consistent values are used.

- Check for consistency among time series data. Identify outliers as soon after the actual measurement as possible. Investigate the cause of the outlying observation, and correct if needed.

- Compare estimates from field measurements or social appraisals with literature values.

- An SOP for non-biomass monitoring must be developed and adhered to at all times.

1.2.3 QA/QC for Remote Sensing Analyses

QA/QC should be conducted as follows:

- Develop Standard Operating Procedures (SOPs) for each step of the remote sensing analyses and adhere to these at all times, both *ex-ante* and *ex-post*.

- Use ground-truthing data to validate the LULC classification and forest stratification. Use confusion matrices and accuracy indices to analyze and quantify the accuracy of the classification.

- Use visual interpretation of high-resolution satellite imagery to complement the medium resolution imagery.

- Check for consistency among time series data. If outliers are present (e.g., in deforestation quantities), analyze the cause and correct if errors were made.

- Compare estimates of deforestation and forest degradation rates with relevant estimates from the literature.

1.2.4 QA/QC for Land Use Change Modeling

QA/QC should be conducted as follows:

- Split the available data in 2/3 for calibration purposes, and 1/3 for validation purposes. Never use the same data for calibration and validation.

- Report a measure for the accuracy of the land use change model.

APPENDIX 2: REFERENCES

Angelsen, A., and D. Kaimowitz. 1999. Rethinking the causes of deforestation: Lessons from economic models. World Bank Research Observer 14:73-98.

Aukland, L., P.M. Costa, and S. Brown. 2003. A conceptual framework and its application for addressing leakage; the case of avoided deforestation. Climate Policy 3:123–136.

Boer, R., U.R. Wasrin, Perdinan, Hendri, B. D. Dasanto, W. Makundi, J. Hero, M. Ridwan, and N. Masripatin. 2006. Assessment Of Carbon Leakage In Multiple Carbon-Sink Projects: A Case Study In Jambi Province, Indonesia.

Chambers, J, Higuchi, N, Schimel, J. P., Ferreira, L. V., Melack, J. M. 2000. Decomposition and carbon cycling of dead trees in tropical forests of the central Amazon. Oecologia, 122: 380-388.

Cochran, W.G. 1977. Sampling Techniques. Wiley. New York.

Chomitz, K.M., P. Buys, G. De Luca, T.S. Thomas, and S. Wertz-Kanounnikoff. 2006. At loggerheads. Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests World Bank, Washington, DC.

Congalton, R.G. 1991. A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. Remote Sensing of Environment 37:35-46.

De Jong, B.H.J., E. Esquivel Bazan, and S. Quechulpa Montalvo. 2007. Application of the "Climafor" baseline to determine leakage; the case of Scolel Te. Mitigation and Adaptation Strategies for Global Change.

Fenstermaker, L. 1991. A proposed approach for national to global scale error assessments. In: Proceedings GIS/LIS '91, ASPRS, ACSM, AAG, AM/FM International and URISA, Vol. 1:293-300.

Freudenberger, K.S. 1994. Tree and land tenure rapid appraisal tools. Food and Agricultural Organization of the United Nations. Rome.

Harmon, M. E. and J. Sexton. 1996. Guidelines for Measurements of Woody Detritus in Forest Ecosystems. US LTER Publication No. 20. US LTER Network Office, University of Washington,, Seattle, WA, USA.

Hay, A. 1979. Sampling designs to test land-use map accuracy. Photogrammetric Engineering and Remote Sensing, 45(4):529-533.

Hoover, C.M. (ed). 2008. Field Measurements for Forest Carbon Monitoring: A Landscape-Scale Approach. Springer, New York. Hardcover. ISBN 978-1-4020-8505-5.

Kish, L. 1995. Survey Sampling. Wiley Interscience.

IPCC. 2003a. Good Practice Guidance for Land Use, Land Use Change and Forestry Projects (GPG-LULUCF) Intergovernmental Panel on Climate Change, Geneva, Switzerland.

IPCC. 2003b. Definitions and Methodological Options to Inventory Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types Intergovernmental Panel on Climate Change, Geneva, Switzerland.

IPCC. 2006. Good Practice Guidance for National Greenhouse Gas Inventories. Chapter 4: Agriculture, Forestry, And Other Land Uses (AFOLU). Intergovernmental Panel On Climate Change, Geneva, Switzerland.

ISO. 2006. ISO 14064-2:2006 - Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements. ISO, Geneva, Switzerland.

Krejcie, R.V. and Morgan, D.W. 1970. Determining sample size for research activities. Educational and psychological measurement 30: 607-610.

Lambin, E.F. 1997. Modelling and monitoring land-cover change processes in tropical regions. Progress in Physical Geography 21:375-393.

Le Mer, J. and P. Roger. 2001. Production, oxidation, emission and consumption of methane by soils: A review. Eur. J. Soil Biol. 37: 25-50.

Mather AS, Needle CL (1998) The forest transition: a theoretical basis. Area, 30, 117–124.

Meyfroidt P, Lambin EF (2008) Forest transition in Vietnam and its environmental impacts. Global Change Biology, 14 (6), 1319-1336 Miles, L., and V. Kapos. 2008. Reducing greenhouse gas emissions from deforestation and forest degradation: Global land-use implications. Science 320:1454-1455.

Ormerod, D W, 1973. A simple bole model. Forestry Chronicle. 49:136-138

Pontius, R.G. 2002. Statistical methods to partition effects of quantity and location during comparison of categorical maps at multiple resolutions. Photogrammetric Engineering and Remote Sensing 68:1041-1049.

Sathaye, J.A., and K. Andrasko. 2007. Land use change and forestry climate project regional baselines: a review. Mitigation and Adaptation Strategies in Global Change 12:971–1000.

Schlamadinger, B., L. Ciccarese, M. Dutschke, P.M. Fearnside, S. Brown, and D. Murdiyarso. 2005. Should we include avoidance of deforestation in the international response to climate change?, *In* D. Murdiyarso and H. Herawati, eds. Carbon forestry: who will benefit? Proceedings of the Workshop on Carbon Sequestration and Sustainable Livelihoods, Bogor, Indonesia.

Thompson, S.K. 2000. Sampling. John Wiley and Sons, Hoboken, NJ.

Top N, Mizoue N, Ito S, Kai S. 2004. Spatial analysis of woodfuel supply and demand in Kampong Thom Province, Cambodia. Forest Ecology and Management. 194: 369-378.

Van Wagner, C. E. 1968. The line intersect Method in forest Fuel Sampling. Forest Science 14:20-26.

Verburg, P.H., K.P. Overmars, and N. Witte. 2004. Accessibility and land-use patterns at the forest fringe in the northeastern part of the Philippines. The Geographical Journal 170:238–255.

Warren, W.G. and Olsen, P.F. (1964) A line transect technique for assessing logging waste, *Forest Science* 10: 267-276.

Winjum, J.K., Brown, S., Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. Forest Science 44:272-284

UN [United Nations]. 2008. Designing Household Survey Samples: Practical Guidelines. Department of Economics and Social Affairs, Statistics Division. ST/ESA/STAT/SER.F/98. United Nations. New York.

APPENDIX 3: DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version released
v2.0	21 Oct 2013	• Revisions were made to accommodate a wider range of drivers of deforestation and degradation as well as a wider range of project activities. • Simplifications were made in the procedures to determine historical LULC transition rates and the area of the reference region. • Quantification of carbon in above ground non-tree pools and soil carbon pools have been incorporated. • The decay of carbon in belowground biomass and soil carbon pools have been quantified such that immediate release of carbon is not assumed.
v2.1	24 Jan 2014	• A procedure to determine a leakage cancellation rate for the conversion of forest land to infrastructure has been incorporated. • Revisions were made to align all market leakage procedures with the discount factor approach set out in *AFOLU Requirements v3.4.*
v2.2	17 Mar 2017	• Incorporated 10 December 2014 errata which removed unnecessary applicability conditions related to data requirements for determining the baseline scenario (Section 4.1.1) • Clarified that GWP values shall be derived from sources specified by the VCS rules (Sections 8.2.4, 8.2.5.5, 8.3.4.2.2, 9.1)