VCS Methodology

VM0037

Methodology for Implementation of REDD+ Activities in Landscapes Affected By Mosaic Deforestation and Degradation

Version 1.0

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Sectoral Scope 14

This methodology was developed by:

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1 SOURCES

This methodology refers to the latest version of the following approved methodologies:

- CDM methodology *AR-AMS0007 Afforestation And Reforestation Project Activities Implemented On Lands Other Than Wetlands*
- VCS methodology *VM0006 Carbon Accounting for Mosaic and Landscape-scale REDD Projects*
- VCS methodology *VM0009 Methodology for Avoided Ecosystem Conversion*

This methodology also refers to the latest version of the following approved tools and modules:

- CDM tool *Tool for testing significance of GHG emissions in A/R CDM project activities*
- CDM tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
- CDM tool *Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*
- CDM tool *Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*
- CDM tool *Procedure to determine when accounting of the soil organic carbon pool may be conservatively neglected in CDM A/R project activities*
- CDM tool *Calculation of the number of sample plots for measurements within A/R CDM project activities*
- CDM tool *A/R Methodology Tool, Estimation of direct nitrous oxide emission from nitrogen fertilization*
- CDM tool *Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*
- CDM tool *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*
- VCS tool *VT0001 Tool for the demonstration and assessment of additionality in VCS AFOLU project activities*
- VCS module *VMD0010 Estimation of emissions from activity shifting for avoided unplanned deforestation (LK-ASU)*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project Method
Crediting Baseline	Project Method

This methodology is applicable to project activities that reduce greenhouse gas (GHG) emissions from mosaic unplanned deforestation and forest degradation, and that enhance GHG sequestration through afforestation, reforestation and revegetation (ARR) activities. This methodology was developed with the intended use in India, but is globally applicable.

Mosaic degradation of forest lands may be the result of many drivers, such as unsustainable fuelwood extraction and uncontrolled grazing. Reduction of these activities is important since their continuation may lead to deforestation.

This methodology was developed with a focus on the specific drivers listed in Table 1 below. For the purposes of this methodology, these drivers are categorized as either a deforestation or forest degradation activity.

Table 1: List of Drivers Considered

Drivers and activities considered under this methodology	Deforestation or degradation
Unsustainable extraction of fuel wood	Degradation
Unsustainable extraction of non-timber forest produce (NTFP)	Degradation
Unplanned timber harvesting	Degradation
Uncontrolled grazing and fodder collection	Degradation
Anthropogenic forest fire	Deforestation
Unplanned mining and quarrying	Deforestation
Expansion of subsistence agriculture by conversion of forest lands	Deforestation
Encroachment	Deforestation

The drivers listed in Table 1 were identified, based on observed practices in India,[1] as the most impactful in terms of their contribution to emissions from deforestation and degradation.

[1] Drivers and localized agents that are active in forest areas facing pressure were shortlisted based on literature review, focal group interviews and stakeholder consultation. Different landscapes in India were chosen as pilot study sites for analyzing driver dynamics. Choosing Indian sites for the study was important due to the following:

The main elements of this methodology include:

- A project method for demonstrating both additionality and the crediting baseline.
- Separate quantification methods for REDD and ARR project activities.
- An optional method for monitoring the project area with the help of local communities.
- Options to use secondary data from sources already available, such as censuses, working plans, and existing participatory rural appraisals (PRAs)[2] to form detailed references of active drivers and their physical extent.

3 DEFINITIONS & ACRONYMS

3.1 Definitions

In addition to the definitions set out in VCS document *Program Definitions*, the following definitions apply to this methodology:

Activity-shifting Leakage
Leakage caused by the application of conservation practices in the project area which leads to undesirable and unintended movement of Drivers of Forest Change (DoFC) outside the project area, leading to GHG emissions due to deforestation and forest degradation in those other areas. Where the shifting of activities increases the rate of DoFC, the related land use change, carbon stock/density changes and non-CO_2 emissions must be estimated and accounted for as leakage.

Anthropogenic Forest Fires
Forest fires which originate due to human activity

Avoiding Planned Deforestation and/or Degradation (APDD)
Activities that stop planned deforestation and/or degradation of forest lands

Avoiding Unplanned Deforestation and/or Degradation (AUDD)
Activities that stop unplanned deforestation and/or degradation of forest lands

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1) India, having a large geographical area, a forest cover of 21.34% (ISFR 2015 http://fsi.nic.in/isfr-2015/isfr-2015-executive-summary.pdf),and more than 300 million forest dependent people (including around 87 million tribal peoples), is an ideal candidate to study mosaic deforestation and degradation of forest lands under varied drivers.
2) Management regime and land tenure is different from state to state, and so the country is a good candidate to study jurisdictional aspects of baseline development.
3) No large scale deforestation has occurred in recent years, and so few cases of frontier deforestation are observed. This helps in better understanding the dynamics of deforestation and degradation caused due to drivers in mosaic deforestation and degradation.

[2] Note that existing PRAs can be used only for data comparison where a new PRA has been conducted.

Baseline Validation Period

The 10 year period for which the baseline remains valid. The baseline must be reassessed every 10 years throughout the project crediting period in accordance with the VCS rules.

Deforestation

Direct human-induced conversion of forest land to non-forest land. Deforestation implies the long-term or permanent loss of forest cover. For this methodology, the change in land use from forest land to non-forest land must not be less than three years.

Degradation

The persistent reduction of canopy cover and/or carbon stocks in a forest due to human activities such as animal grazing, fuelwood extraction, timber removal or other such activities, but that does not result in the conversion of forest to non-forest land, and falls under the *IPCC 2003 Good Practice Guidance* land category of *forest remaining forest*. For this methodology, continued loss of carbon stock from forest land for at least three years qualifies as degradation.

Drivers of Forest Change (DoFC)

Activities that lead to losses in forest carbon

Historical Reference Period

The period during which the selected reference region transitions from forest land to non-forest land, or in the case of degradation, the period during which degradation occurs

Land Use and Land Cover (LULC) Classes

The six LULC classes as specified by IPCC, or LULC classes which the host country has specified, provided that all the land classes under IPCC are covered by the latter

Leakage Area

An area outside the project area to where the drivers of deforestation and degradation of forest lands are displaced in the case of REDD activities.

Leakage Management Zone (LMZ)

An area earmarked as an area which is intended to reduce leakage

Logging Slash

Dead wood residues (including foliage) left on the forest floor after timber removal

Market Leakage

Leakage caused by conservation practices inside the project area such that there is impact on the supply chain of forest products which result in a shift of production of forest product elsewhere to fulfill demand

Minimum Mapping Unit (MMU)
The minimum unit that is used in classification and RS analysis, and is fixed as 1 ha

Project Area (PA)
The geographical area where REDD activities (with or without ARR activities) are implemented. ARR and REDD areas must be separately mapped and must not share the same area. The project area must be forest land for a minimum of 10 years prior to the project start date.

Reference Region (RR)
The region from which the historical trends of changes in forest land are modeled. From these trends, the change that is expected to occur within the project area in the baseline scenario is predicted.

3.2 Acronyms

ACoGS	Avoided Conversion of Grasslands and Shrublands
AFOLU	Agriculture, Forestry and Other Land Use
AGB	Above Ground Biomass
BGB	Below Ground Biomass
CIFOR	Center for International Forestry Research
DBH	Diameter at Breast Height
FGD	Focal Group Discussion
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
IFM	Improved Forest Management
KML	Keyhole Markup Language
LIDAR	Light Detection and Ranging
LMZ	Leakage Management Zone
LULC	Land Use Land Cover
NTFP	Non Timber Forest Produce
PA	Project Area
PRA	Participatory Rural Appraisal
RR	Reference Region
RS	Remote Sensing
SAR	Synthetic Aperture Radar
SOC	Soil Organic Carbon
SOP	Standard Operating Procedures

4 APPLICABILITY CONDITIONS

This methodology is globally applicable under the following conditions:

1) The project activities include AUDD[3] or a combination of AUDD and ARR.
2) The project area must meet the definition of forest land for at least 10 years prior to the start date of any REDD activities.
3) The project area must not be forest land for at least 10 years prior to the start date of any ARR activities and must not convert native ecosystems.
4) Biofuel crop production is allowed in ARR activities.

This methodology is not applicable under the following conditions:

1) The project activities include APDD.
2) The project activities only include ARR.
3) ARR activities displace more than 50 percent of agricultural lands from the project area.
4) The project activities take place on wetlands or peatlands.
5) The project activities include ACoGS.

5 PROJECT BOUNDARY

5.1 Reference Region

A reference region (RR) must be identified and analyzed in order to effectively capture the trends of deforestation and degradation of forest lands that would occur in the baseline scenario within the project area (PA). There are two approaches to assess the historical rate of deforestation and forest degradation within the reference region. Approach 2 may be employed only when the project area is equal to, or is less than, 1000 ha and in proximity to the reference region. In all other cases, approach 1 must be applied. Further requirements for the RR and PA are as follows:

- The area of the RR must not be less than that of the PA.
- The RR need not share a boundary with the PA.
- The RR need not be contiguous, and may be formed by distinct parcels.
- REDD components and ARR components of the project must be distinctly mapped.

[3] AUDD activities will be referred to as REDD activities for the remainder of the methodology.

Approach 1: When selecting a RR, the project proponent must satisfy all points of comparison between the RR and PA mentioned in Table 2 below.

Table 2: Comparison between Project Area and Reference Region

Factor	Points of Comparison
Forest types and landscape factors	The forest types and landscape factors within the RR must be similar to the forest types and landscape factors within the PA. With respect to forest types, a list of all the forest types within the PA and RR must be prepared, and the RR must be comparable in proportion (within ±20%) to those present in the PA. The forest classification (e.g., revised Champion and Seth Forest Classification by ICFRE)[4] used in the host country may be used for this exercise. Any forest type that composes at least 5% of the PA must be present within the RR, and any forest type composing more than 5% of the RR that is not present in the PA must be removed from any LULC analysis. With respect to landscape factors, a comparison of elevation, slope, and climactic conditions (e.g., temperature and rainfall) must be undertaken between the PA and RR, and each factor must be demonstrated to be similar in proportion.
Drivers	The types of prevalent drivers (e.g., extraction of fuel wood and other drivers listed in Table 1) must be the same between the RR and PA. To determine this, two lists of all possible drivers must be prepared, one for RR and one for PA. All the drivers in the respective region are marked and selected for comparison. All the drivers which are present in the RR, but absent in the PA must be identified, and the areas which are affected by such drivers must be identified. RR is again modified by removing such areas, and conducting the exercise once again until all such areas are removed from the RR. A similar comparison of agents of forest change also must be conducted after finalizing the list of drivers. Any agent not active in the PA must be excluded from RR. The requirements for analysis of drivers of forest change (DoFC) are discussed more in detail in Section 8.1.7 below.
Land tenure and management	The land tenure system and management practices

[4] This is just an indicative method, where the Indian case is taken as an example. Every country will have the freedom to choose the forest classification that they want to use.

Factor	Points of Comparison
practices	prevalent in the RR must be demonstrated to be similar to the land tenure system and management practices in the PA, as demonstrated through reference to peer-reviewed literature, reports, or expert opinion. Such must be demonstrated even if RR does not share a boundary with the PA, and is comprised of discrete parcels. Therefore, RR and PA may not be subject to two completely different land tenure and management practices, either partially or for the whole area.
Policies and regulations	Policies and regulations having an impact on land-use change patterns within the RR and the PA must be of the same type, or have an equivalent effect, taking into account the current level of enforcement.
Population factors and transportation infrastructure	Where navigable rivers are present in the PA, navigable river/stream density must be similar in proportion in the RR. In addition, proximity and/or potential of the proximity to the transportation infrastructure (e.g., roads) must be similar between the RR at the start of the historical reference period and PA. Finally, proximity to population centers with similar population density must also be similar in proportion between the RR at the start of the historical reference period and PA.

If no area exists within the country that satisfies all points of comparison, the project proponent must justify use of a reference region that satisfies the requirements for forest type and drivers, and is justified to be conservative for other points of comparison, or a conservative deduction is applied for uncertainty when analyzing LULC change.

Examples of different spatial configurations of the RR and PA are given in Figures 1, 2 and 3 below.

Figure 1: Project Area Inside the Reference Region

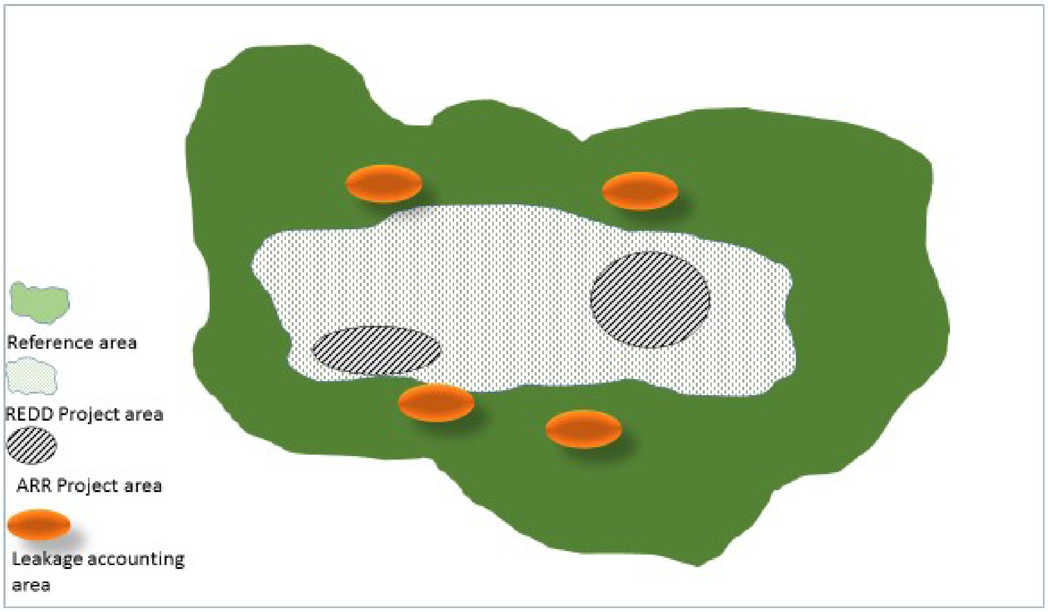


Figure 2: Project Area and Reference Region Not Sharing Boundary

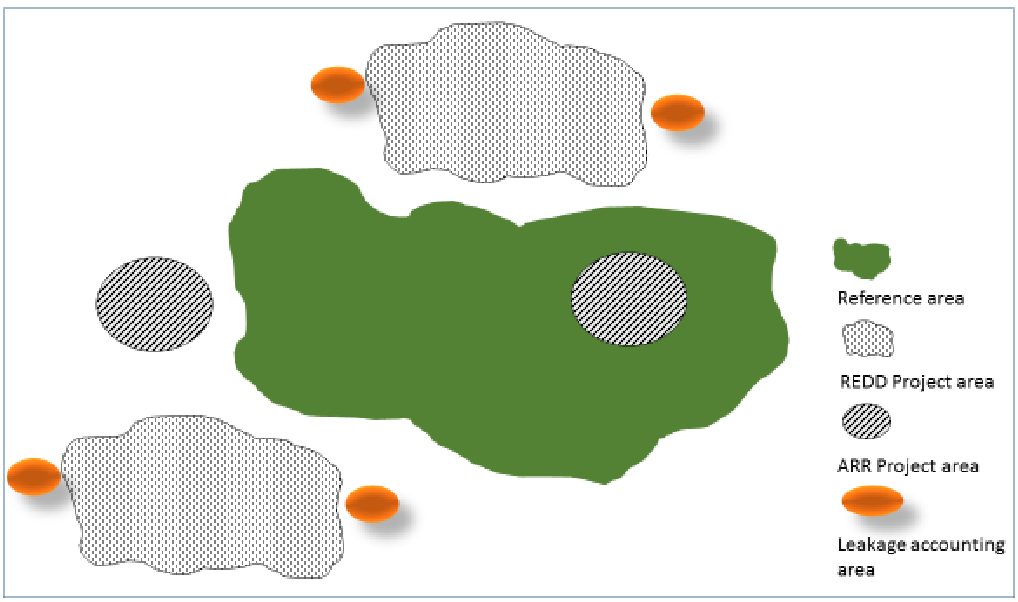
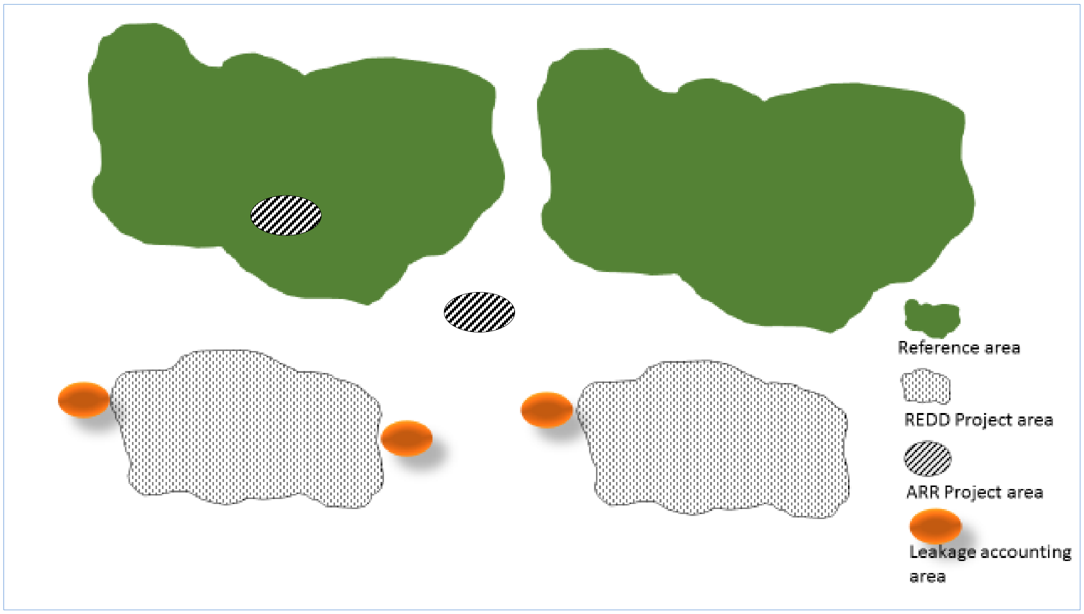


Figure 3: Discrete Parcels of Project Area and Reference Region



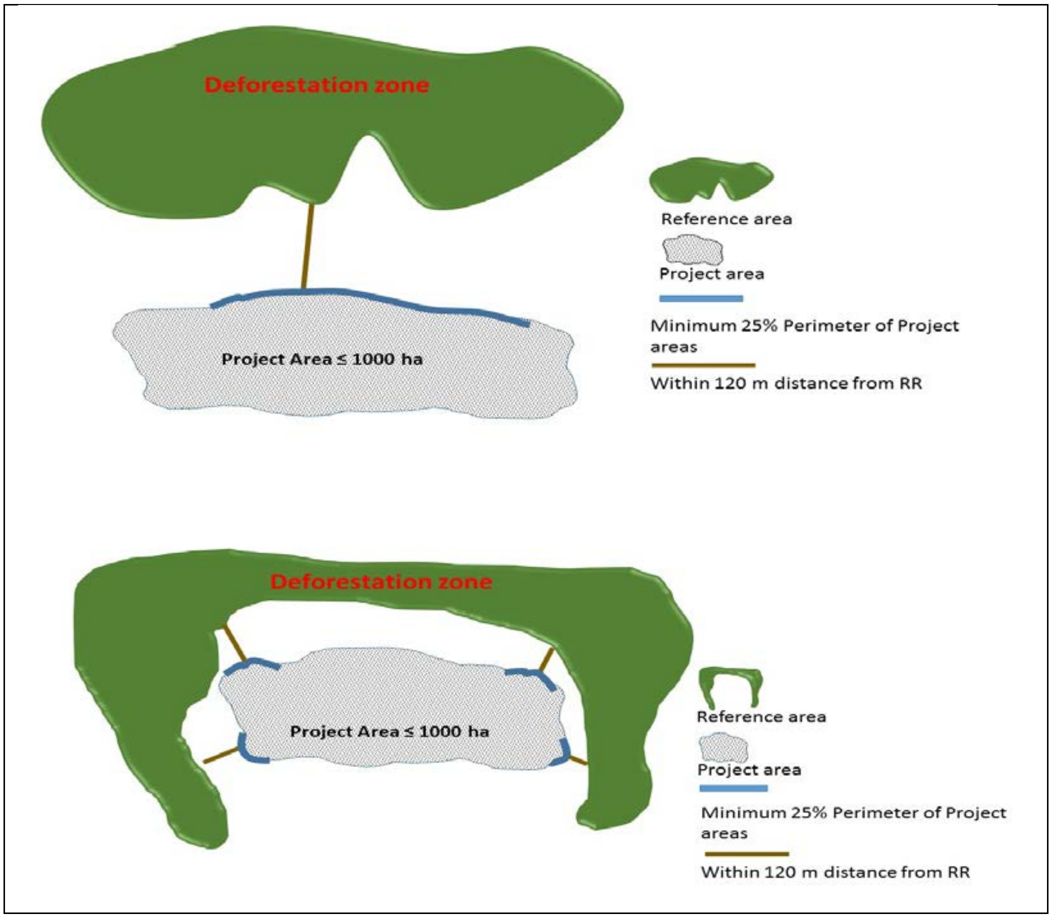
Approach 2: This approach is applicable only under the following conditions:

1) Each project parcel is demonstrated to be equal to, or less than, 1000 ha.
2) Project parcels must lie within 120 meters of an anthropogenic deforested area where it can be demonstrated that such deforestation occurred within 10 years prior to the project start date.
3) It is demonstrated that at least 25 percent of the perimeter of the project parcel lies within 120 meters of the deforested area identified (2) above.

The above must be demonstrated by applying different social and geographical survey tools and techniques, which include, *inter alia*, land survey reports/records, PRA, FGD, official LULC records and revenue department records. Peer reviewed and published papers may be referenced where they were published within 10 years prior to the project start date. Scalable maps that clearly demarcate project areas and reference region(s) must be available at the time of validation.

It is anticipated that if immediate intervention activities are not initiated in approach 2 scenarios, that the agents active in the reference region will imminently affect the project parcel. Examples of such configurations are shown in Figure 4 below.'

Figure 4: Approach 2 Scenarios



5.2 Leakage Management Zone (LMZ)

The LMZ is the area designated to manage potential leakage. An LMZ must be developed for all project areas where the same amount of goods and services from forests will be extracted in the project scenario as compared to the baseline scenario. It must be established that LMZs are within the maximum distance the agent is willing to travel to avail the specific goods and services that has been availed in the baseline scenario. The maximum distance the agent is willing to travel may be ascertained by using tools such as PRA, RRA, key informant interview, FGD, survey and expert opinion.

Where an LMZ is not developed, the project proponent must map the sources from where these goods and services will be availed/procured for the first 10 years from the start date of the project activity. These sources must be considered as potential points of leakage, and must be spatially mapped. This must be updated every 10 years along with the baseline reassessment. In those instances where there is a decrease in the goods and services availed due to project activities, such LMZs are not mandated[5].

5.3 Carbon Pools

The carbon pools included in or excluded from the project boundary are shown in Tables 3 and 4 below.

Table 3: Carbon Pools Included In or Excluded From the Project Boundary for REDD Activities

REDD Activity	Carbon Pool	Included?	Justification/Explanation
REDD with annual crop as the land cover in the baseline scenario	Aboveground tree biomass	Yes	Carbon stock will increase and is one of the major carbon pools
	Aboveground non-tree Biomass	Optional	May be conservatively excluded
	Below ground biomass	Optional	May be conservatively excluded
	Dead wood	Optional	May be conservatively excluded
	Litter	No	Excluded as per the VCS *AFOLU Requirements*
	Wood products	Yes	Major carbon pool affected by the project activities and must be included
	Soil Organic carbon	Optional	May be conservatively excluded
REDD with pasture grass as the land cover in the baseline scenario	Aboveground tree biomass	Yes	Carbon stocks will increase and is one of the major carbon pools
	Aboveground non-tree Biomass	Optional	May be conservatively excluded
	Below ground biomass	Optional	May be conservatively excluded
	Dead wood	Optional	May be conservatively

[5] For example, if improved cook stoves are designed as intervention, then there is a drop in the resources used from forests. LMZ is still desirable, but not mandated in such instances.

			excluded
	Litter	No	Excluded as per the VCS *AFOLU Requirements*
	Wood products	Yes	Major carbon pool affected by the project activities and must be included
	Soil Organic carbon	No	Excluded as per the VCS *AFOLU Requirements*
REDD with perennial tree crop as the land cover in the baseline scenario	Aboveground tree biomass	Yes	Carbon stock will increase and is one of the major carbon pools
	Aboveground non-tree Biomass	Yes	May be conservatively excluded
	Below ground biomass	Optional	May be conservatively excluded
	Dead wood	Optional	May be conservatively excluded
	Litter	No	Excluded as per the VCS *AFOLU Requirements*
	Wood products	Yes	Major carbon pool affected by the project activities and must be included
	Soil organic carbon	No	Excluded as per the VCS *AFOLU Requirements*

Table 4: Carbon Pools Included In or Excluded From the Project Boundary for ARR Activities

ARR	Included?	Justification/Explanation
Aboveground woody biomass	Yes	One of the major carbon pools
Aboveground non-woody biomass	Optional	May be conservatively excluded
Below ground biomass	Yes	One of the major carbon pools
Dead wood	Optional	May be conservatively excluded
Litter	Optional	May be conservatively excluded
Wood products	Optional	May be conservatively excluded

Soil Organic Carbon	Optional	May be conservatively excluded

Carbon pools may be excluded if they are determined to be *de minimis*. To determine if a carbon pool is *de minimis*, the project proponent may use peer reviewed literature, or the latest version of CDM tool *Tool for testing significance of GHG emissions in A/R CDM*, or use primary data collected from the project site or reference site(s).

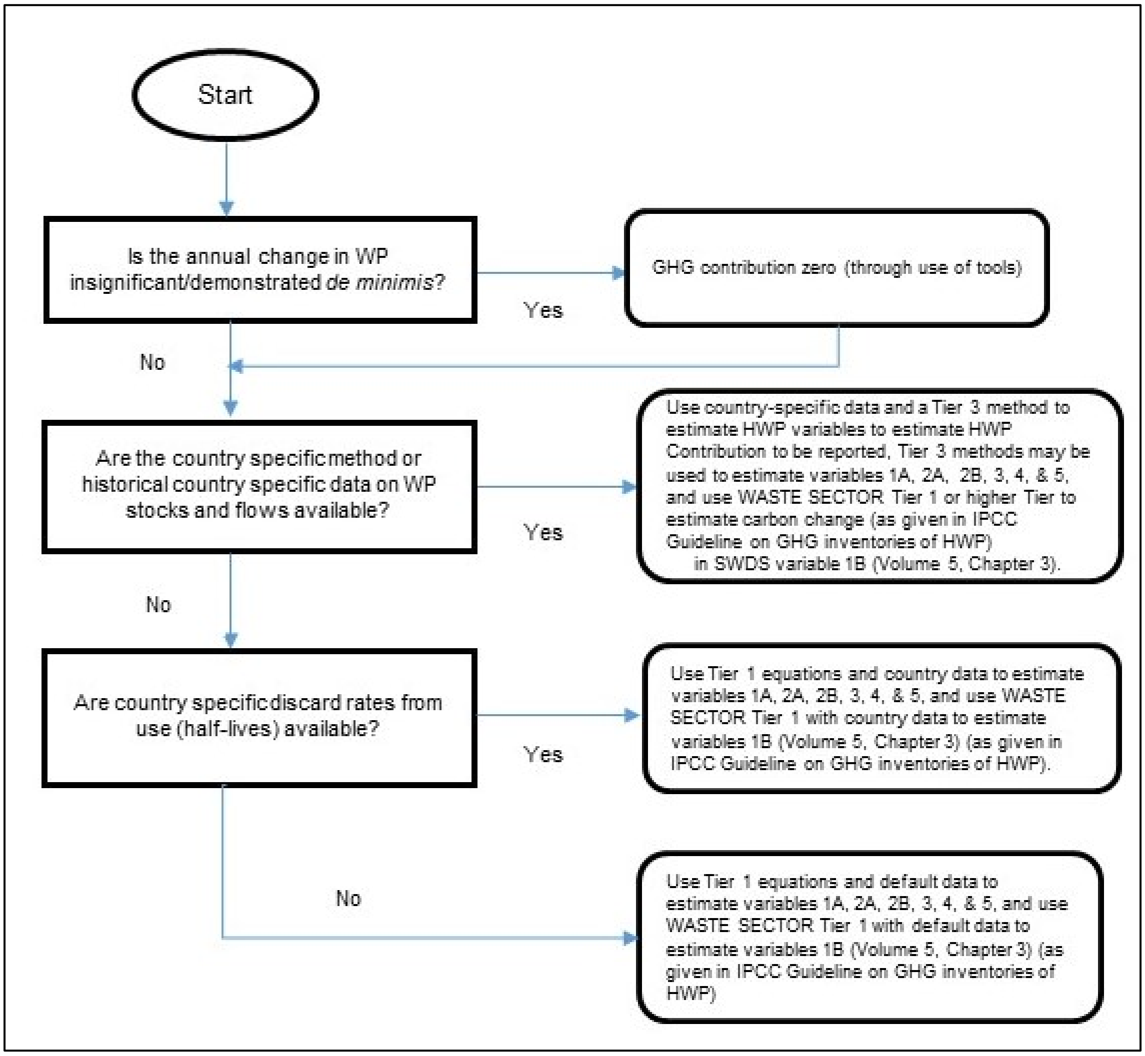
When below ground biomass and dead wood carbon pools are included as part of the project boundary, dead wood must be modeled using a 10- year linear decay function and soil carbon loss must be modeled based upon a 20-year linear decay function, taking into account the depth of affected soil layers and the total portion of the pool that would have been lost and affected.

When wood products are included, carbon loss must be modelled as follows:

- For short-term wood products and wood waste (i.e., decay within 3 years), all carbon must be assumed to be lost immediately.
- For medium-term wood products (i.e., decay between 3 and 100 years), a 20-year linear decay function must be applied.
- For long-term wood products that are considered permanent (i.e., carbon is stored for 100 years or more), no carbon released may be considered.

A decision tree for determining whether wood product pools must be accounted for is described in Figure 5 below and equations for calculating wood products may be derived from *IPCC Guideline on GHG Inventories of Harvested Wood Products*.

Figure 5 : Decision Tree of Reporting Wood Products[6]



5.4 GHG Sources

The greenhouse gases included in or excluded from the project boundary are shown in Table 5 below.

Table 4: GHG Sources Included In or Excluded From the Project Boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Baseline Deforestation and Forest Degradation	CO_2	Yes	Emissions are related to changes in carbon pools.
		CH_4	Yes	Included only in the case of certain intervention activities such as cook stove and fuel efficiency activities

[6] Adapted from IPCC Guideline on GHG Inventories of HWP

Source		Gas	Included?	Justification/Explanation
				(CFE). In the baseline scenario, if biomass is burnt during land preparation in the case of ARR, CH_4 is included. In the baseline scenario, if grazing and animal management is involved, CH_4 is not included for reasons of conservativeness.
		N_2O	Yes	Included where cook stove and fuel efficiency activities (CFE) are involved. If biomass is burnt in the baseline or project scenarios, N_2O is included. If the baseline scenario involves application of fertilizers, N_2O is not included for reasons of conservativeness.
	Baseline ARR	CO_2	Yes	Emissions are related to changes in carbon pools.
		CH_4	No	Emissions are expected to be negligible and are therefore excluded.
		N_2O	No	Emissions are expected to be negligible and are therefore excluded.
Project	Biomass burning from unplanned large and small scale fires	CO_2	No	Emissions are excluded as they are a part of the changes in carbon pools.
		CH_4	Yes	CH_4 emissions of burning woody biomass from unplanned fires must be included. If the fires are catastrophic, CH_4 emissions must be estimated and demonstrated negligible, or otherwise accounted for.
		N_2O	Yes	N_2O emissions of burning woody biomass from unplanned fires are to be accounted. If the fires are catastrophic, N_2O emissions must be estimated and demonstrated negligible, or otherwise accounted

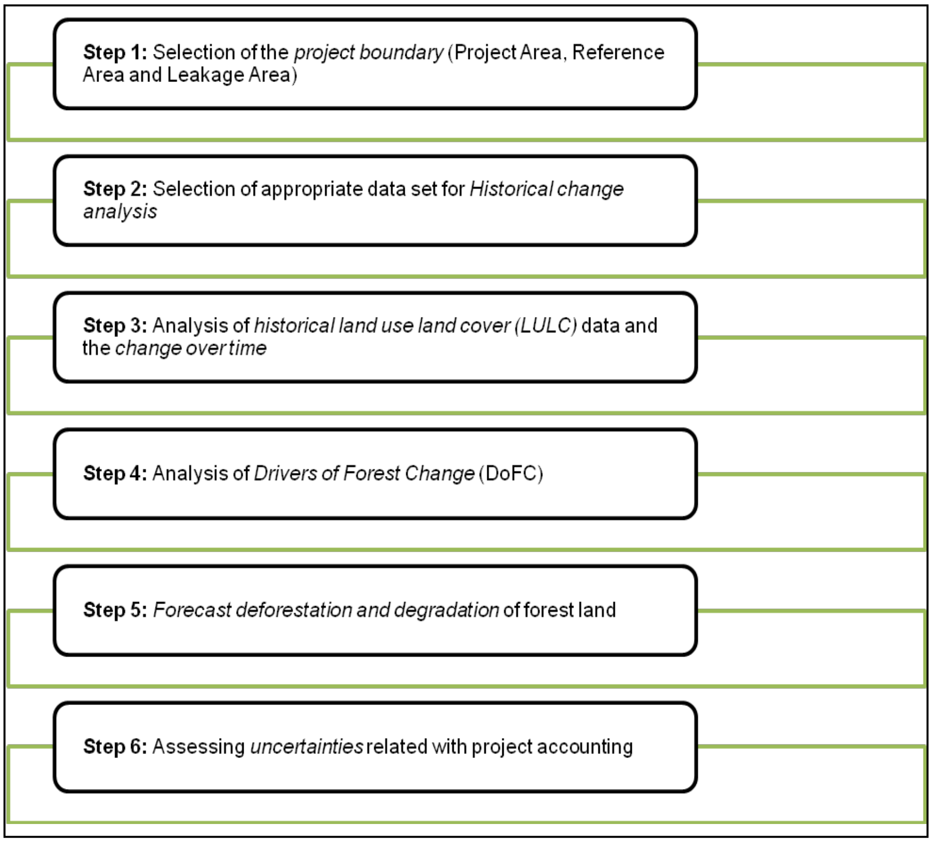
Source		Gas	Included?	Justification/Explanation
				for.
	Fossil fuel used during operations	CO_2	No	Emissions from fossil fuel combustion is considered *de minimis* for REDD and ARR, and is therefore excluded.
		CH_4	No	Insignificant
		N_2O	No	Insignificant
	Removal of woody biomass during assisted natural regeneration (ANR and ARR) 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_2O	No	N_2O emissions from burning woody biomass during ANR activities are assumed negligible and are therefore conservatively excluded.
	Fertilizer used during enrichment planting for assisting natural regeneration and ARR	CO_2	No	Assumed negligible
		CH_4	No	Assumed negligible
		N_2O	No	Assumed negligible
	Increased fertilizer use	CO_2	No	Not applicable
		CH_4	No	Not applicable
		N_2O	No	N2O emissions related to increased fertilizer use are *de minimis*.

6 BASELINE SCENARIO

The baseline scenario for this methodology is the historic and/or continued LULC and the changes in associated carbon stocks in all selected carbon pools within the project boundary. This is the case for both REDD and ARR components of the project. A step-by-step procedure for determining the baseline scenario is given below in Figure 6 below. Each step is expanded upon in Section 8.

Where a jurisdictional baseline has been developed and reference emission levels have been published by an appropriate entity (e.g., national or sub-national government agencies), the available jurisdictional baseline data must inform the development of the project-specific baseline.

Figure 6: Procedure to Determine Baseline Scenario and Emissions



The sources and sinks of the identified baseline scenario must be determined ex-ante for each year in the baseline validation period. Reassessment of the baseline must be conducted as per the VCS rules.

7 ADDITIONALITY

To demonstrate additionality, the project proponent must apply the steps given below:

Step 1: Regulatory Surplus

Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in latest version of the *VCS Standard*.

Step 2: VT0001 AFOLU Additionality Tool

After ensuring that the project meets the conditions of regulatory surplus, the project proponent must determine additionality by applying the latest version of VCS tool *VT0001 Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities*.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions (BE)

Baseline emissions include all emissions that would have happened in the project area in the absence of the implementation of the project. This is the case for both REDD and ARR components of the project. Baseline emissions are quantified based on the requirements in the sections that follow.

8.1.1 Select Project Area

The project area must be selected and clearly defined. The project boundary must not be finalized until due consideration of inputs from local stakeholder consultations have been taken into account.

The project area may coincide with a combination of natural boundaries and geopolitical or administrative boundaries (e.g., forest management and administration units such as beat boundaries, range boundaries, or revenue administration boundaries such as revenue districts). This will assist the management of projects and boundaries, and avoid duplication of boundaries. Discrete parcels of the project area are permitted.

8.1.2 Select Reference Region

The reference region must meet the conditions detailed in Section 5.1 above. The Land Use Land Cover (LULC) changes within the reference region are analyzed to develop the baseline of the project area. It must be demonstrated that the drivers causing changes in forest lands within the reference region are also active in the project area. The same reference region used for REDD activities must also be used to validate the baseline of any ARR activities.

8.1.3 Select Data Set for Historical Change Analysis

Appropriate data sets are to be selected for analyzing historical change in the reference region. The selected datasets must be of the same season, or of the same expected phenological variations in order to maintain uniformity.

Data sets must meet the following requirements:

- The change analysis must start no more than 30 years prior to the project start date.
- The change analysis must start no less than 10 years before the project start date.
- The change analysis must include at least 3 points to consider the historical LULC change analysis.
- The time points must be at least 4 years apart.
- At least one dataset must be within 2 years of the project start date.

The time horizon of the change analysis must be selected after taking into consideration all local, provincial, and national policies, laws, and trends that may have a general impact on forest carbon.

During validation, special care must be taken by the VVB to assess that the time horizon was not artificially expanded to account for more changes in carbon stocks. This may be done by analyzing the detailed policy changes and impact assessment that the project proponent must conduct and present to the VVB.

8.1.4 Land Use Land Cover Stratification Scheme

The project proponent must identify and describe the land-use and land-cover (LULC) strata present in the reference region at the project start date. The sampling and stratification strategy must follow regional/national strategies, or one that is in line with IPCC and international guidelines. Stratification must consider LULC classification as per the national classification scheme, and should consider all six IPCC classes (forest, cropland, grassland, wetlands, settlements, and other land). All forest types within the project area must also be considered. Any other significant sub-strata must be considered based on established scientific principles.

Forest land must therefore be further stratified based on forest types and density. This methodology allows the project proponent the use of nationally accepted canopy density classes with proper justifications. These classes may be further optionally subdivided based on spatial and spectral classification technique as found suitable by the project proponent.

Non-forest land may be further stratified in strata representing different non-forest classes. IPCC land classes used for national GHG inventories may be used to define such classes. However, where appropriate, additional or different sub-classes may be specified. Croplands may be further classified into smaller strata, as it is possible that cropping systems/plantations and associated practices directly or indirectly act as drivers of deforestation and forest degradation. This will provide for loss of forest carbon in each such stratum during the transition from forest lands. However, such a classification is not deemed mandatory.

The description of a LULC class must include criteria and thresholds that are relevant for the discrimination of that class from all other classes. Such criteria may include different kinds of information such as elevation above mean sea level, aspect, soil type, distance to roads and villages, and forest management category. Land with temporary unstocking of forest will not be considered under this methodology.

The minimum mapping unit (MMU) must be equal to, or less than, 1 ha.

8.1.5 Geo-spatial Analysis and Techniques

The stratification of forest and non-forest components is achieved using either digital classification algorithms such as maximum likelihood, decision trees, knowledge classifier, support vector machines or nationally approved forest/non-forest maps. The stratification approach also allows the project proponent to generate forest/non-forest masks using different vegetation indices and classification algorithms to ease the image classification process (P. Bholanatha, K. Cort, 2015) and (R. Suraj Reddy, 2014[7]).

The final classification map must include a minimum of six IPCC LULC classes to quantify deforestation. In case of heterogeneous forest types in the reference area, the classified map must also contain major forest types available in the landscape (see detailed workflow in Figure 7 below). The project proponent may use the existing administrative forest/non-forest boundaries or land use dynamics studies in or around the landscape to improve classification accuracy. The methodology also allows the project proponent to use any nationally or sub-nationally approved data. In such cases, further classification by the project proponent is not required.

8.1.5.1 Vegetation Index Model

A vegetation index model must be determined. The model must be based on satellite derived temporal vegetation indices images. Using these indices-based images, a vegetation fraction map or forest canopy density must be generated using spectral un-mixing or machine learning algorithms (Matricardi et al 2010).

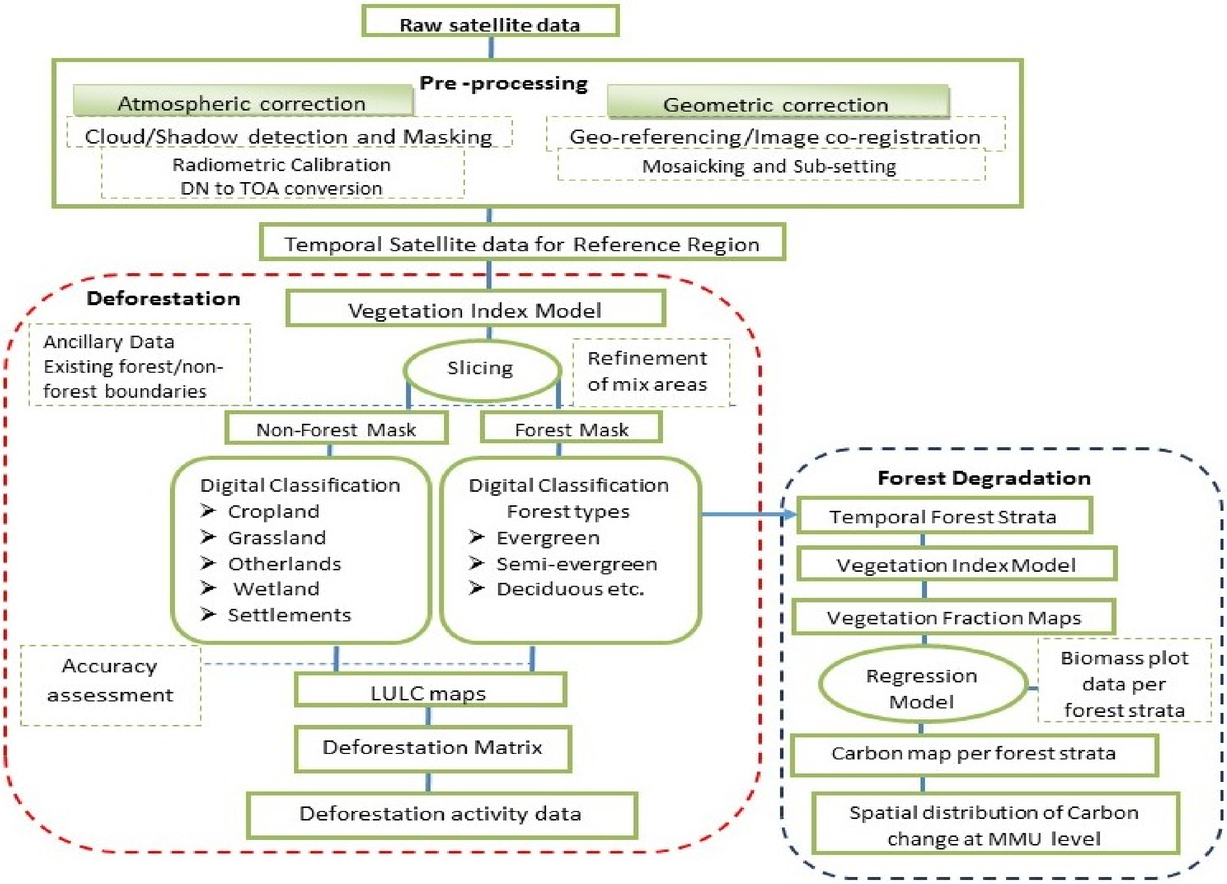
The vegetation fraction map/density map must be divided as per the forest types present in the landscape to form the forest strata. The project proponent may use strata based on forest type or density or a combination of both. In order to assess forest degradation, a transition matrix must be developed between the changes in area among the fractional cover/density classes in a particular forest type.

The basis of applicability of forest degradation mapping is the integration of temporal vegetative fraction or canopy density with field carbon data (emission factor), which may be done separately for each forest stratum. Nationally accepted sampling strategies for forest inventory may be used in this process. In the absence of such sampling designs, the project proponent may use a peer reviewed sampling technique. In such scenarios, in order to decide the number of sample plots per strata, refer to the equations in CDM methodological tool *Calculation of the number of sample plots for measurements within A/R CDM project activities*.

An example of a detailed workflow is shown in Figure 7 below.

[7] Decadal forest cover loss analysis over Indian forests using MODIS 250m imagery, Conference: ISPRS Technical Commission VIII Symposium, 09 – 12 December 2014, Hyderabad, India, At Hyderabad, India, Volume: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-8, 2014

Figure 7: Workflow of Remote Sensing Approach for Baseline Emissions Estimation



8.1.5.2 Analyze LULC Change

Based on the remote sensing analysis, the historical LULC in the reference region must be analyzed for assessing the baseline scenario and quantifying the rates of deforestation and forest degradation. Analysis of the RS data provides the historical changes and current status of LULC dynamics within the reference region.

8.1.5.3 Accuracy Assessment of LULC Maps

Reporting accuracy and verification of results are essential components of a monitoring system. Accuracy may be quantified following recommendations of Section 5 of IPCC *Good Practice Guidance 2003, Chapter 3A.2.4 of IPPC 2006 Guidelines for AFOLU*, and the most recent version of the *GOFC-GOLD Sourcebook* on monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation.

Complete cloud-free satellite maps must be used where available. However, multiple images of the same year may be used so that the cumulative impact of cloud cover for all time points is ≤ 10% of the RR (e.g., in t1, t2 and t3, percent cloud covers are x, y & z, where x+y+z ≤10). Cloud cover and cloud shadow areas must be removed from the baseline calculation. The project proponent may also refer to VCS tool *VT0006 Tool for Calculating LULC Transitions and Deforestation Rates Using Incomplete Remote Sensing Images* for guidance. As an alternative option, project proponents may also use a hybrid approach of Synthetic Aperture Radar (SAR) techniques in areas where heavy cloud cover exists most of the year. In that scenario, combined carbon stock maps must be prepared from both optical and SAR datasets and merged to create a seamless dataset of any year.

With reference to the above, accuracy must be estimated on a class-by-class (LULC map) basis and, where applicable, category-by-category (LULC-change map) basis, respectively. At least 25 validation points for each strata of the area being analyzed must be selected and an error matrix must be presented. The diagonal must show the proportion of correct classification and the off-diagonal cells must show the relative proportion of misclassification of each class or category into the other class or, respectively, categories. Based on the error matrix (or confusion matrix), a number of accuracy indices may be derived.

The minimum accuracy for the forest to non-forest map must be 85 percent. The minimum classification accuracy of each class or category in the Land-Use and Land-Cover Map and Land-Use and Land-Cover Change Map, respectively, must be 80 percent. Where the classification of a class or category is lower than 80 percent, the project proponent should consider merging the class/category with other classes/categories, or excluding the forest-classes from the Forest Cover Benchmark Map that are causing the greatest confusion with non-forest classes according to the error matrix (e.g., initial secondary succession and heavily degraded forest may be difficult to distinguish from certain types of grassland or cropland, such as agro-forestry and silvopastoral systems not meeting the definition of forest).

Both commission errors (false detection of a class/category, such as deforestation) and omission errors (non-detection of actual class/category, such as deforestation) must be estimated and reported.

In order to assess the accuracy of forest degradation mapping, the vegetation fraction/forest cover density model outputs must be validated for each density classes within the forest type with ground observation. The correlation of mapped and ground observed density must be analyzed based on linear regression, or any other statistically appropriate technique with proper justification and a minimum correlation coefficient of 0.7.

For past data validation, high-res and in-situ maps must be used. In the absence of high-res and in-situ maps, accuracy may be assessed by surveys such as Focused Group Discussions (FGDs), expert interviews, focal point interviews and published scientific literatures.

8.1.6 Assess Forest Transition and Forest Scarcity

The “forest transition” concept was introduced by Mather in 1992 (Mather A. , 1992), and is used to demonstrate the manner in which forest cover first declines, reaches a minimum, and then the forest cover again rises and eventually stabilizes. It was demonstrated that with economic development, industrialization, and other DoFC, the forest cover changes in predictable ways.

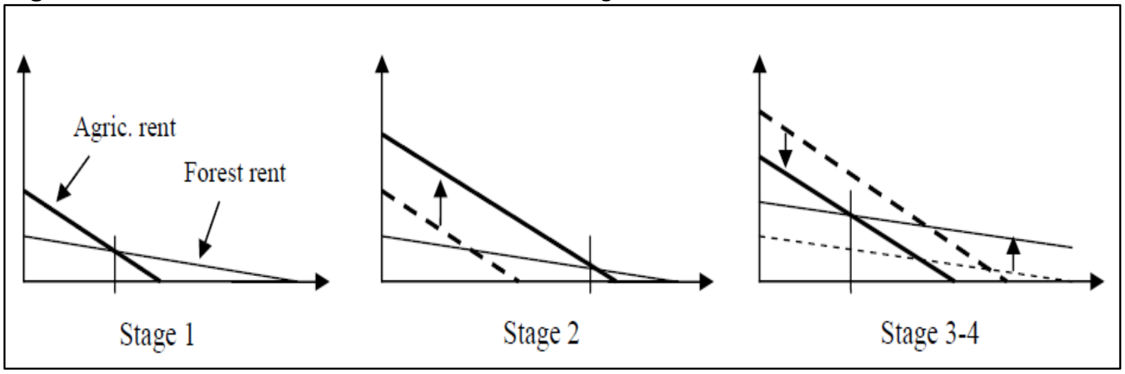
(Mather A. a., 1998). The theory also demonstrates that areas with vast forest cover which are initially characterized by rapid deforestation rates eventually stabilize the forest area after some time. Hence, it would be incorrect to assume that there will be linear decrease in forest until the forest land changes to other land use class. Forest transition was also demonstrated on the basis of Von Thünen framework (Angelsen, 2007).

The stages of forest transition are as follows:

1) Undisturbed forest: inaccessible forest with poor infrastructure and access to market.
2) Deforestation starts: DoFC starts acting on the forest and deforestation begins at a high level leading to forest scarcity. As deforestation begins, a reinforcing loop enlarges the DoFC due to expanded infrastructure and access. Further, the socio-economic and political pressure leads to converting reinforcing into stabilization loops (i.e., leading to a reduction in the rate of deforestation).
3) Forest scarcity: leads to mosaic deforestation/degradation as well.
4) Stabilizing loops dominate leading to recovery of the forest cover (natural or assisted). This was demonstrated by Rudel et al, 2005[8], that the stabilizing loops are mainly due to forest scarcity (i.e., increase in forest demand) and an economic development path (i.e., increased opportunity outside the triggering forces of forest change, like agriculture, and NTFP marketing). In 2013, Angelsen and Rudel, found that forest scarcity and other drivers like scarcity of ecosystem services, diminishing agriculture rent, economic development and policy/regulations changes may provide a strong stimulus for forest conservation and better forest management.

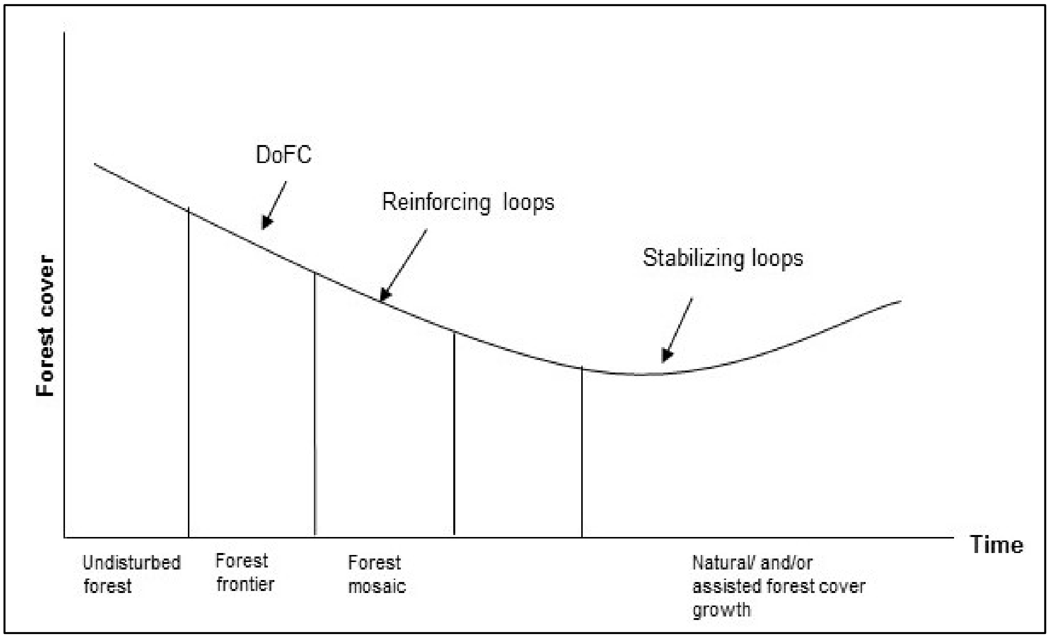
An example of the stages of forest transition is adapted from the Angelsen 2007 paper, as seen in Figures 8 and 9 below.

Figure 8: Shifts in the Land Rent Curves Using a von Thünen Model[27]



[8] Rudel, Thomas K., Oliver T. Coomes, Emilio Moran, Frederic Achard, Arild Angelsen, Jianchu Xu, and EricLambin. 2005. Forest transitions: towards a global understanding of land use change. Global Environmental Change 15:23-31. http://www.greenbiz.com/sites/default/files/document/CustomO16C45F64217.pdf

Figure 9: Main Stages of Forest Loss[9]



The forest transition theory makes two claims:

1) Where there is a significant area of forest there will (eventually) be a significant area of deforestation, while there will be limited deforestation in areas with little forest.
2) Forest cover eventually will be fully or partially restored and stabilized either through natural re-growth or plantations or both.

Since anthropogenic *forest transition* is not a natural process, and is influenced by various socio-economic scenarios, countries may be able to bridge the forest transition and save it from reaching very low levels before it stabilizes.

Detailed assessment of forest transition on the basis of forest scarcity must be made. Published and peer reviewed prediction and assessment methods must be adapted to calibrate and calculate forest scarcity (e.g., *Modeling the Forest Transition: Forest Scarcity and Ecosystem Service Hypotheses*, Akiko Satake and Thomas K. Rudel, 2007).

The average annual transition of land from one forest stratum to another must be estimated for the historical reference period. The historical reference period may be further broken down into two or more time periods. Conditions on selecting the time points in the historical reference period are given Section 223.

The transition must be estimated by mapping the change from one stratum to another, including both forest and non-forest strata, during one of the time periods and calculating the rate of annual transition in each of the stratum as follows:

[9] Adapted from Arlid Angelsen, 2007. Forest Cover Change in Space and Time: Combining the von Thünen and Forest Transition Theories, CIFOR and UMB, World Bank Policy Research Working Paper 4117

$$LT(1 \rightarrow 2)_{y2-y1} = (LC1_{y1} \rightarrow LC2_{Y2})/(y2 - y1)$$ Equation **1**

Where:

$LT(1\text{-}2)_{y2\text{-}y1}$	= Annual average land transition from stratum 1 to stratum 2 from time-point y_1 to time-point y_2 (ha)
$LC1_{y1} \rightarrow LC2_{Y2}$	= Total land classified as stratum LC1 (ha) in time point y1 which has undergone transition to land classified as stratum LC2 (ha) in time point y2 (ha)
Y_1	= Year of first time-point in the land transition analysis
Y_2	= Year of second time-point in the land transition analysis

From this value, the average annual rate of shift from one stratum to another (expressed as a percentage) is also estimated as follows:

$$LT(1 \rightarrow 2)_{y2-y1,rate} = (LT(1 \rightarrow 2)_{y2-y1}/LC1_{Y1}) * 100$$ Equation 2

Where:

$LT(1\text{-}2)_{y2\text{-}y1,\ rate}$	= rate of annual average land transition from stratum 1 to stratum 2 from time-point y_1 to time-point y_2 (%)
$LT(1\text{-}2)_{y2\text{-}y1}$	= Annual average land transition from stratum 1 to stratum 2 from time-point y_1 to time-point y_2 (ha)
$LC1_{y1}$	= Total land classified as stratum LC1 (ha) in time point y1 (ha)

This estimate must be conducted for each of the historical time-points selected for analysis of land transitions. Where more than four historical time-points are considered, the rate of transition from one stratum to another may be developed using regression equations. In the case of three time-points, the average rate of transition may be considered to estimate the overall rate of transition of forest from one stratum to another over the historical reference period. For estimation of baseline emissions, the rate of change of one stratum to another for the entire historical reference period must be estimated.

The same rate of change in the reference region must be applied to the project area. Models of forest scarcity must be applied appropriately to ensure that the rate of change of land from one stratum to another does not result in its complete loss before the end of the project crediting period. If it does, then emissions must be accounted for by:

1) Not accounting for emissions from those strata from that time point at which they will undergo complete transition to other strata; or
2) Applying a discounting factor to evenly distribute the estimated emissions in the entire project crediting period. The discounting factor may be calculated as the ratio of the time taken for the stratum to completely undergo the change to the total crediting period.

The discount factor referenced in (2) above must be calculated as follows:

$$N_{LT} = yLT(j), trans/\ y\ crediting\ period \qquad \text{Equation 3}$$

Where:

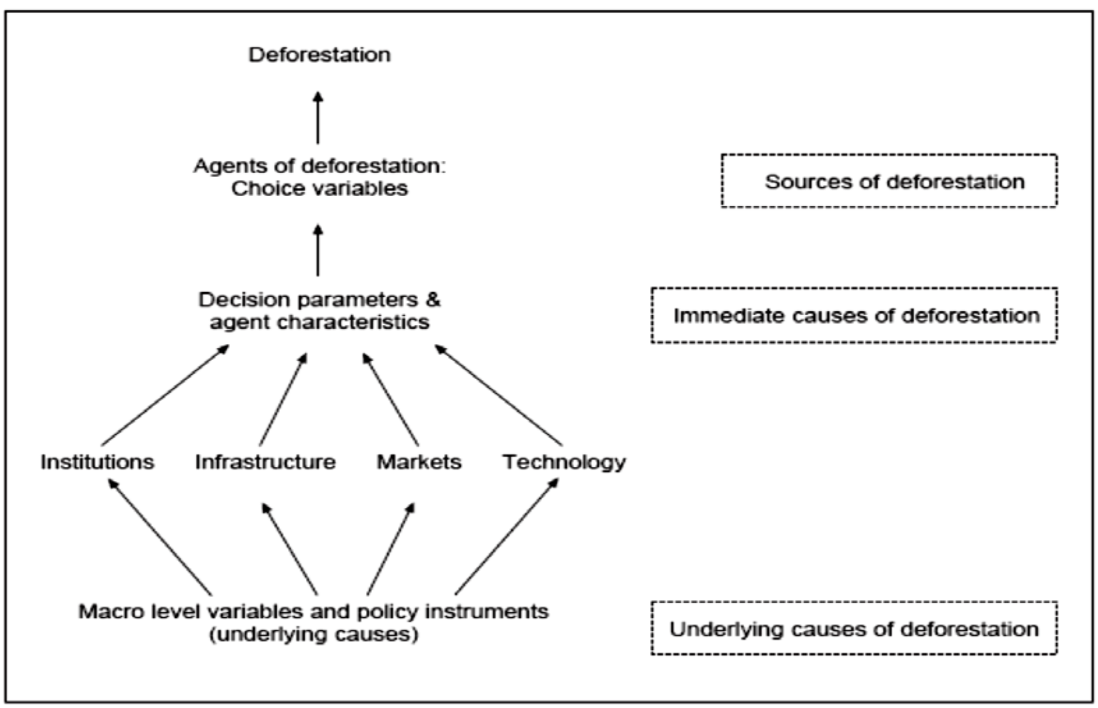
N_{LT}	= land transition discounting factor due to scarcity of land
$y_{LT(i),trans}$	= time taken for the stratum(i) to completely undergo transition to other strata (years)
$y_{crediting\ period}$	= project crediting period (years)

8.1.7 Analyzing Drivers of Forest Change (DoFC)

The project proponent must analyze the DoFC by considering and addressing the points given below:

1) National level driver analysis must be used for the project where available.
2) Where national level driver analysis is not available, or where it can be justified by the project proponent that national level driver analysis is not appropriate for use by the project, the project proponent must conduct a detailed analysis of drivers of forest change. This may be based on internationally accepted norms, such as the five factors proposed by David Kaimowitz and Arild Angelsen (1998) as described in Figure 10 below:

Figure 10: A Framework of Different Types of Variables Affecting Deforestation[10]



[10] Adapted from Kaimowitz, 1998

The project proponent must use the five simplified factors as detailed by David Kaimowitz and Arild Angelsen (1998) on which the analysis of DoFC depends, as given below:

1) **Magnitude and location of deforestation:** Assessed through RS analysis and field surveys.
2) **Agents of deforestation (sources of deforestation):** Analyze the major agents acting and involved in the region causing the forest change (e.g. individual, community, companies).
3) **Choice drivers/variables (sources of DoFC):** Determine the drivers and variables that result in the forest change activities undertaken by the agents (e.g., a community will clear land for agriculture activity or will encroach into the forest for NTFP extraction, whereby a community is an agent, agriculture activity and NTFP extraction are variable). Examples of this include, but are not limited to, the following:
    - Land allocation
    - Labour allocation and migration
    - Capital allocation
    - Consumption
    - Other technological and management decisions
4) **Agent decision parameters (immediate cause of deforestation):** These variables directly influence agents' decisions with respect to the choice variables, but are external to individual agents. This parameter decides the amount of forest change. Examples of this include, but are not limited to, the following:
    - Labor costs,
    - Other factor (input) prices,
    - Accessibility,
    - Available technology and information,
    - Risk,
    - Property regimes,
    - Government restrictions
    - Other constraints on factor use,
    - Environmental factors (physical).
5) **Macro-level variables and policy instruments or the underlying cause:** The impact of these variables are not direct on the agents. However, they impact forest change by affecting and influencing the agents' decision parameters. Examples of this include, but are not limited to, the following:

- Population growth/density of a country,
- Forest dependency ratio,
- Government policies,
- Tariffs,
- Tax rate,
- International exchange rate.

The estimation of the area affected and magnitude of DoFC is done through RS analysis. However, the estimation of land specific values for a given parameter and variables relies heavily on field sampling, which is frequently done through national forest inventories (Tier 2) and project measurement (Tier 3) data. REDD is not only associated with carbon and forest canopy, but also involves social, environmental and economic dimensions.

Based on the historical evidence collected from remote sensing analysis and socio-economic mapping, the project proponent must analyze the relationship between the main agent groups, key drivers, and underlying causes, and explain the sequence of events that typically leads to deforestation and degradation.

Table 5: Approach for Assessing and Evaluating the Socioeconomic Impacts of REDD

Methods of socioeconomic analysis		Stakeholder consultation	Prediction based on stakeholders' views	Use existing data	Collect own data
Primary data	Participatory Rural Appraisal	✓	✓	X	✓
	Household Survey	✓	✓	✓	✓
	Key informant interviews	✓	X	X	✓
	Focus group discussions	✓	X	X	✓
Secondary data	Population census, published scientific literature	X	X	✓	X

The design of survey tools must be made in a way that makes the understanding of natural resource management easier, leading to development and effective implementation of intervention activities. It must also provide information between the decision making system of the government, and the trends and priorities of the local communities. Similarly, information on community based institutions and their role in sustainable conservation of natural resources must be obtained which may be useful in understanding land tenure and rights. Socioeconomic assessments are therefore an efficient and cost effective tool for understanding the social, economic, cultural and political aspects of all the involved stakeholders. However, certain tools are more effective in mapping certain DoFC, which is detailed in the Table 7 below. The same must be demonstrated at the time of validation.

Table 6: Effectiveness of Selected Socio-Economic Tool in Evaluating the DoFC

Socio-economic tool	Drivers							
	Unsustainable extraction of Fuel-wood	Unsustainable extraction of NTFP	Uncontrolled grazing and fodder collection	Expansion of subsistence agriculture by conversion of forestland	Unplanned timber harvesting	Anthropogenic Forest fire	Encroachment	Unplanned mining and quarrying
Participatory Rural Appraisal (semi-structured focus group discussions)	Yes	Yes	Yes	Yes	NA	Yes	Yes	Yes
Household Survey	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA
Key informant interviews	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Focus group discussions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Government census and records.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This methodology allows different tools to collect socio-economic data, *inter alia*, including, but not limited to:

1) Detailed survey questionnaire
2) Checklist
3) Interviews and discussion notes
4) Interviews and discussion with audio and video records
5) Observation notes
6) Records of earlier surveys and studies

The frequency of conducting surveys must be at least once before every baseline update.

A statistically sound sampling design must be applied or any national/sub-national methodology or standard that is applied for government surveys also may be used. For example, 10 percent with 90 percent confidence level may be considered. Adequate geographical representation also must be appropriately considered in the sampling design.

8.1.7.1 Quantification of Carbon Stock Changes

Data regarding extraction from forests must be derived from the surveys on DoFC mentioned above. These changes in carbon stock and associated emission factors must be computed, and must also be used for back-calculations in assessing the robustness of changes in carbon stock resulting from spatial analysis.

8.1.8 Baseline Emissions from REDD Activities

Deforestation is the change of forest land into other land uses. The change in carbon stock must be derived directly in two GIS approaches: fractional downscaling, and using microwave applications such as SAR analysis and associated algorithms. Ground validation involves estimation of the carbon stock of each of the identified strata.

Stratification must be based on national guidelines. In the absence of national guidelines, forest must be classified into different forest types as per established international ecological norms. The carbon stock of each type of forest must be estimated from ground ecological data collected from each stratum. Carbon stock in each of the identified carbon pools must be estimated in each stratum. Where a national standard exists on forest inventory, the same may be followed. In the absence of such guidance, the requirements below must be followed.

Forest lands in the reference region must be divided into appropriate strata, based on forest types, and other sub-strata as applicable (such as aspect and slope). The carbon pools must then be identified and listed. The carbon pools considered in this methodology are detailed in Section 3 above. AGB measurement involves quantification of the carbon content of trees.

A statistically significant sampling methodology must be applied based on the IPCC GPGLULUCF or CDM tool on sampling. The size of the sample plots must be at least 0.25 ha for quantification of AGB. A smaller plot may be chosen based on regional or national guidance or other accepted international norms. A detailed inventory of all trees must be prepared with data and parameters collected which includes DBH and the height of the trees. The total living biomass carbon content of the strata is computed on a per hectare basis for each stratum.

Where the project proponent is including the SOC (i.e., the case where the baseline scenario is annual crop), the most recent version of the CDM methodological tool *Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities* must be applied.

Carbon content per hectare of a stratum must be estimated from the carbon estimations from the sample plots. Carbon stock in each of the pools must be estimated separately. Regional and national volume equations and allometric equations may be used for estimating AGB. Biomass Expansion Factors (BEF) may be sourced from IPCC GPG LULUCF. Wood density specific to the species of trees may be sourced from regional/national specific sources. Standard root to shoot ratios may be used for estimating BGB. Nationally applicable methodologies or techniques from peer reviewed publications will be applied for estimation of SOC, carbon content in deadwood, litter and other carbon pools.

$$\mathrm{C} - St_i \;=\; \Sigma(\mathrm{C})_{c-pool,i,SP} * 1/\mathrm{SP} \qquad \text{Equation 4}$$

Where:

$C\text{-}St_i$	= Carbon stock per hectare of stratum i (tC/ha)
$(C)_{C\text{-}pool,I,SP}$	= Carbon stock in each of the carbon pool in the sample plot in stratum i (tC/sample plot)
SP	= Area of sample plot (ha)

Change in carbon stock due to degradation must be based on fractional downscaling or other such algorithm based analysis using SAR or LIDAR technology. In the absence of such technology, each forest type must be further divided based on the canopy cover. A minimum of 4 strata based on canopy cover must be established based on national approaches. In the absence of any national approach, or where it is better suited for the analysis, the forest canopy must be divided in such a way that each canopy density class is separated by at least 10 percentage points. Carbon stock of each of the stratum must be measured as explained in the section on deforestation. Emission factor matrices must be developed for each of the forest type, where the changes in carbon stock must be detailed where there is a change in the canopy classes.

This quantification must give details of carbon change in forests due to degradation in forest lands. From this data, an emission factor matrix on deforestation is developed which must give the emission factors for change from forest land to non-forest land. A second emission factor matrix must be developed based on changes from one forest type to another. These two matrices may be integrated into the same matrix depending on the techniques applied.

$$\mathrm{EF}\ (LT)(1 \rightarrow 2)_{y2-y1} = (CSt1_{y1} \rightarrow CSt1_{y2}) \quad \text{Equation } \mathbf{5}$$

Where:

EF(LT)(1→2) = Change in carbon stock associated to transition from stratum 1 to stratum 2 (tC/ha)

CSt1 = Carbon stock in stratum 1 (tC/ha)

CSt2 = Carbon stock in stratum 2 (tC/ha)

From the net change in the carbon stock in the baseline scenario, the trend in change in the carbon stock is developed. This may be a linear regression projection or an average of each time point in case there are only three time points in the analysis. The total loss of carbon stock from the project area in the baseline scenario is computed as:

$$\mathrm{BSL}_{C,si} = \mathrm{EF(LT)(1{\rightarrow}2)} * \left((LT(1-2)_{y2-y1,rate}\right) * S_{REDD,i} \quad \text{Equation 6}$$

Where:

$BSL_{c,si}$ = Change in carbon stocks due to land transitions in the baseline in the REDD project area (tC/ha)

EF(LT)(1→2) = Change in carbon stock associated to transition from stratum 1 to stratum 2 (tC/ha)

LT(1-2)y2-y1, rate = rate of annual average land transition from stratum 1 to stratum 2 from time-point y1 to time-point y2 (%)

$S_{REDD,i}$ = Area in stratum i within the REDD project area (ha)

The total baseline emissions is estimated using the below equation.

$$\mathrm{BE}_{yREDD} = \sum(BSL_{C.si}) * 44/12 \quad \text{Equation 7}$$

Where:

BE_{yREDD} = Baseline emissions from REDD (tCO_2)

$BSL_{C,si}$ = Net change in carbon stocks due to land transitions in the baseline in the REDD project area (tC)

8.1.8.1 Additional Baseline Emission Sources

Detailed quantification of changes in carbon stock is already provided in previous sections where a full field analysis is conducted. This gives the net change in carbon in the landscape, and must also help in the landscape approaches of measuring changes in carbon stock.

However, the methodology also provides for a safeguard by allowing the project proponent to analyze the changes in land use and land cover in the reference region based on activity data. Based on the regression equations or the average rate of change from one LULC class to another, the rate of change from each LULC class to another is computed. The rate of change from each of the strata to other strata is also computed. Statistically insignificant changes may be ignored. From the emission factor matrices developed, and the LULC pattern within the project area, the baseline emissions in the project area may be computed.

In cases where ARR is involved, the baseline must include existing trees within the project area. Conservatively, the change in carbon stock within the baseline trees may be considered as zero, after application of appropriate tools regarding computing change in carbon stock which are approved under VCS or CDM. However, only living biomass carbon stock is to be considered in ARR components.

The project proponent must clearly record the contribution of each of the drivers to forest change and the effectiveness of the implementation of the intervention activity. This must be reflected in the ex-ante quantification. Ex-post emission reduction estimations are not based on the effectiveness values. The effectiveness of any driver intervention activity depends on local conditions and on probability of adoption of intervention activities. Contribution of each driver in causing emissions may be based on different instruments, such as surveys (FGDs and PRAs) published scientific literature, documented expert opinion, and pilot studies. Effectiveness in implementation must be measured on a scale of 0-1, where 0 is not at all effective and 1 is 100 percent effective. Table 8 provides an example of this below.

Table 7: Contribution of Each Drivers of Deforestation and Forest Degradation

Drivers	Contribution	Effectiveness of the intervention activity	Contribution factor (Con-F) to reductions in emissions
Driver 1	X%	0.a	$Con\text{-}F_1$ = X% * 0.a
Driver 2	Y%	0.b	$Con\text{-}F_2$ = Y% * 0.b
Driver 3	Z%	0.c	$Con\text{-}F_3$ = Z% * 0.c
…	…	…	

Once this is calculated, there is no need to calculate emissions due to each of the driver, except for back calculations and redundancy checks during monitoring and verification. The calculations for major drivers only for the redundancy checks are given below.

Carbon losses due to each of the drivers must be analyzed from the scientific studies in the reference region. This is used to assess and calculate the emission reductions for back-calculations and redundancy checks. The carbon losses due to each of the active and major drivers must be computed. Deforestation and degradation caused due to each of the drivers must be given a weight based on the scientific estimate and surveys, which must be the same as that provided in the Table 8 above. The intervention activities to counter each driver must be detailed. Efficiency of each driver also must be considered. This analysis is not mandated for ex-post estimation as ex-post estimations must be based on the actual stock, irrespective of the drivers and success of the intervention activities planned, but must help in redundancy checks. The major drivers are presented below for the redundancy checks.

Additional baseline emission sources shall be calculated as follows:

$$\mathrm{BE}_{yADD} = L_{fuelwood} + C_{fire} + C_{felling} + C_{ill} \quad \text{Equation 8}$$

Where:

BE_{yADD}	= Total additional baseline emissions (tCO_2)
$L_{fuelwood}$	= Annual carbon loss due to fuelwood gathering, tonnes C. yr^{-1} per species
C_{fire}	= Annual carbon loss due to forest fire, tonnes C. yr^{-1}
$C_{felling}$	= Annual carbon loss due to timber harvesting, tonnes C. yr^{-1}
C_{ill}	= annual carbon loss due to illegal activities C. yr^{-1}

Fuelwood

The total amount of fuelwood consumed must be assessed from surveys. At least three sample weighs from each of stratum must be collected to validate the amount of fuelwood collected. Total fuelwood collected from forests and from other sources must be recorded separately. The values considered must be “air dry” biomass and moisture account for a maximum of 12 percent of the weight (FAO, 2003)[11] is deducted. A survey based assessment is sufficient to estimate consumption at larger spatial scales when logistic limitations make impossible following stocks of hundreds of households (Jones et. al., 2008).[12] Carbon loss from fuelwood assessed from surveys is calculated as follows:

$$L_{fuelwood} = FG_i \times D_i \times BEF \times CF \quad \text{Equation 9}$$

Where:

$L_{fuelwood}$	= annual carbon loss due to fuelwood gathering, tonnes C. yr^{-1} per species
FG_i	= annual volume of fuelwood species i gathered, m^3 yr^{-1}
D_i	= basic wood density of fuelwood species, tonnes d.m. m^{-3}

[11] A Guide for Woodfuel Surveys, 2003. Sustainable Forest Management Programme. FAO, Rome.
[12] http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2008.01487.x/full

BEF = biomass expansion factor for converting volumes of extracted wood to total aboveground biomass (including bark), dimensionless;

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.$^{-1}$)

Where the weight of the fuelwood is directly calculated, the above equation must be ignored, and the weight must be directly extrapolated to calculate the total carbon loss due to fuelwood collection. Carbon loss from fuelwood is directly calculated as follows:

$$L_{fuelwood} = W_{fw} * CF \quad \text{Equation 10}$$

Where:

$L_{fuelwood}$ = annual carbon loss due to fuelwood gathering, tonnes C. yr^{-1}

W_{fw} = annual weight of fuelwood gathering, t yr^{-1}

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.$^{-1}$)

Anthropogenic Forest Fire

Only forest fires that originate due to human induced activities may be considered. All forest fires must be mapped. The cause of forest fires must be ascertained as much as possible. If this is not possible, a perception-based demarcation of cause of forest fires may be done based on FGDs. The following two categories are mandatory:

1) Human induced fires.
2) Fires which are not started by human activity.

Only human induced fires are considered in this methodology. The methodology uses GOFC-GOLD Sourcebook, 2013 equation no. 2.6.2, which is an indirect method of estimating anthropogenic emissions from forest fire of IPCC guidelines. Carbon loss from fires is calculated as follows:

$$C_{fire} = Ax_{fire} \times Fl \times Be \times EF \times 10^{-3} \quad \text{Equation 11}$$

Where:

C_{fire} = annual carbon loss due to forest fire, tonnes C. yr^{-1}

Ax_{fire} = Area lost due to forest fire, ha Yr^{-1}

Fl = Fuel loading per unit area, g m-^{2}

Be = Burning efficiency, dimensionless

EF = Emission factor g kg^{-1}

To quantify emissions from forest fires, the area subject to fire must be characterized and stratified into forest types or ecological zones and further sub-divided in terms of fire characteristics (e.g., crown fires which are primarily uncontrolled, intense fires leading to large losses of forest covers, surface fires burning litter and undergrowth).

The quantification method uses a three-tiered approach. However, the project proponent must apply a Tier 3 or Tier 2 approach (i.e., in the absence of region specific data, country level data may be used). In the absence of any country level data, Tier 1 data may be applied.

To map forest fire, moderate resolution satellite data may be used and must have a spatial resolution not coarser than 100 m pixel size. Sub-hectare mapping of forest fire is not allowed in this methodology. Where the forest fire scars in the mapping are less than one hectare, such must not be considered. Monitoring and mapping the understory fire may need analysis based on SAR and appropriate ground validation. In the absence of country specific directions and procedures on SAR analysis, international sources may be used. GHGs other than CO_2 which may be emitted due to forest fires must also be accounted for if they are found to be significant (more than 5 percent of total emissions due to forest fires). Nationally accepted proxies or IPCC default values may also be used in the absence of any local data.

Unplanned Timber Harvesting

Wood that is harvested directly, without being sold, may not be included in the official statistics and must be estimated by survey. Hence, the project proponent must carefully consider these issues. Also, this activity is essentially linked with the socio-economic and geographical conditions of a particular area, and therefore may only be estimated through a Tier 3 approach. Similarly, the FAO approach used for fuelwood estimation may be applied to quantify timber harvesting by local communities. This estimation information must be incorporated into carbon emission accounting algorithms. Carbon loss from timber harvest is calculated as follows:

$$C_{felling} = HT_i \times D_i \times BEF \times CF \qquad \text{Equation 12}$$

Where:

$C_{felling}$	= annual carbon loss due to timber harvesting, tonnes C. yr^{-1}
HT_i	= annual volume of harvested timber, species i, m^3 yr^{-1}
D_i	= basic wood density of species i, tonnes d.m. m^{-3};
BEF	= biomass expansion factor for converting volumes of extracted wood to total aboveground biomass (including bark), dimensionless;
CF	= carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$

Illegal Mining and Quarrying, Encroachment and Expansion of Subsistence Agriculture by Conversion of Forest Lands

These drivers causing change in forest carbon must be illegal and unplanned, and therefore not accounted for in the national inventories. A Tier 3 approach may be used to assess the changes in the forest carbon stock due to illegal mining and quarrying, encroachment and expansion of subsistence agriculture. Analysis of satellite imagery (LULC change matrix) from the past is an effective way to estimate the carbon stock loss due to these activities. Further, to quantify the carbon emissions due to forest loss as a result of these activities, IPCC GPG LULUCF guideline equation no 3.2.9 must be followed. These losses are calculated as follows:

$$C_{ill} = A_{ill} \times B_w \times (1 - f_{biol}) \times CF \qquad \text{Equation 13}$$

Where:

C_{ill}	= annual carbon loss due to illegal activities C. yr^{-1}
A_{ill}	= forest area affected by illegal activities, ha yr^{-1}
B_w	= average biomass stock of forest areas, tonnes d.m. ha^{-1} (Tables 3A.1.2, 3A.1.3, and 3A.1.4 of IPCC GPG LULUCF)
f_{biol}	= fraction of biomass left to decay in forest (transferred to dead organic matter) (Table 3A.1.11 of IPCC GPG LULUCF)
CF	= carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m. $^{-1}$)

Grazing and Fodder

In order to quantify carbon losses due to grazing and fodder, studies on biomass consumed during grazing or extracted as fodder from forests must be used. In the absence of such studies, pilot studies may be carried out where the amount of biomass lost due to grazing is recorded. Since quantifying loss of biomass due to grazing and fodder collection also must consider different cultural practices, region specific or peer reviewed tools or methods may be applied to quantify this. The generic approach explained below may also be applied. In case the impact is found to be less than 5 percent, carbon losses due to grazing and fodder may be considered *de minimis*.

The total number of livestock grazing in the area must be estimated. Emissions from grazing are to be accounted for only if the total livestock grazing in the project area is more than the carrying capacity as estimated by the government or reported in peer-reviewed literature for the project area, or per unit of a similar landscape (same bio-geological zone), or else nationally recognized data may be used. Dry matter intake of cattle must be calculated based on the body weight of the livestock and estimated dietary net energy concentration of diet as explained in *IPCC Guidelines for National Greenhouse Gas Inventories 2006*. Since some supplementary feed might be given by herders, this must be considered in the quantification method, and must be established from surveys, government reports, or peer reviewed literature. From actual dry matter intake per cattle unit, dry matter intake by all the livestock that graze in the forest land must be calculated.

Available forage of the forest land may be estimated with reference to the past records of stocking rates of the grazing land reported by government agencies or research institutes. If the historical trend of the quality of the grazing land is steady or shows a decline, conservatively, the same stocking rate may be considered or must otherwise be revised. In the absence of any historical rates, available forage of similarly managed forests/grazing lands may be applied or else national data may be applied. From actual dry matter intake per animal and the available stocking rate, carrying capacity may be calculated.

Total carbon content in the intake must then be calculated from the difference of available forage and the dry matter intake of all the livestock that graze in the forest. Carbon fraction of the forage must then be either estimated in laboratory tests or is referred to from peer-reviewed literature including government reports. From carbon emissions due to grazing, carbon added to the forest soil in the form of excreta is discounted to avoid any double counting in instances where SOC is accounted as a carbon pool in the project. The discounting factor may be tier-2 data also based on carbon balance studies in pasture lands. This discount factor is to be conservatively applied.

Non-Timber Forest Produce (NTFP)

Where it is found that extraction of NTFP leads to unsustainable losses in biomass, the resulting emissions must be accounted for. This may be done by listing every NTFP that contributes to at least 5 percent of total extracted NTFPs in the reference region by quantity. This may be established through surveys, expert opinion, key informant interviews and secondary literature studies where the use of the NTFPs and the plant parts are recorded. The damage due to extraction of each of the NTFP must be assessed based on expert opinion, direct observations and recording, and/or surveys in such a way that the extraction practices are taken into account. Where government reports or information from peer reviewed literature is available on the carrying capacity of a particular NTFP, the same may be used. In the absence this, expert opinion on the carrying capacity must be established.

8.1.9 Baseline Emission Removals from ARR Activities

Estimation of baseline emission removals from ARR activities must refer to methodology *AR-AMS0007*, the equations for which are presented below.

The baseline net GHG removals by sinks must be calculated as follows:

$$BE_{ARR} = \Delta C_{TREE\_BSL,t} + \Delta C_{SHRUB\_BSL,t} + \Delta C_{DW\_BSL,t} + \Delta C_{LI\_BSL,t}$$ Equation 14

Where:

$\Delta C_{TREE\_BSL,t}$	=	Change in carbon stock in baseline tree biomass within the project boundary in year *t*, as estimated in the tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*; tCO_2e
$\Delta C_{SHRUB\_BSL,t}$	=	Change in carbon stock in baseline shrub biomass within the project boundary, in year *t*, as estimated in the tool *Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*; tCO_2e
$\Delta C_{DW\_BSL,t}$	=	Change in carbon stock in baseline dead-wood biomass within the project boundary, in year *t*, as estimated in the tool *Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities*; tCO_2e

$\Delta C_{LI\_BSL,t}$ = Change in carbon stock in baseline litter biomass within the project boundary, in year *t*, as estimated in the tool *Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities;* tCO_2e

BE_{ARR} = Total baseline emission removals by sinks, tCO_2e

8.2 Project Emissions (PE)

Project emissions are the emissions which occur inside the project boundary as a result of the project activities.

8.2.1 Project Emissions from REDD Activities

Project emission from REDD activities are provided in Table 9.

Table 8: Sources of Project Emissions

Parameters	Description
Fossil fuel combustion (PE_{ff})	Combustion of all types of fossil fuels associated with the project must be calculated. Activities such as forest patrolling, biomass ground inventory, fire prevention activities, installation of fences, boundary poles, Assisted Natural Regeneration (ANR) activities, introducing and providing intervention activities, eco-tourism (if allowed), NTFP market channel and other activities (as livelihood options) (distance travelled by vehicle type, type of fossil fuel used, type of machine used, quantity of fossil fuel used, inside and outside of the project boundary as a part of the project activity/ies). Reference tool: CDM *Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*
Woody biomass removal for fire prevention activities (PE_{wbf})	Loss of carbon must be accounted for if losses of woody biomass takes place due to activities such as installation of fire breaks, clearing of shrubs, dry and dead wood, invasive species, small trees that may act as fuel for fires, thinning of forests to prevent wildfires, or burning woody biomass. Reference tool: CDM tool for *Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity.*
Woody biomass removal during assisted natural regeneration (ANR) activities (PE_{wbanr})	Loss of carbon must be accounted for if removal of woody biomass such as short trees and shrubs, dead wood, invasive species takes place due to project activities, to allow natural regeneration. Reference tool: CDM tool *Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity* must be applied and the resulting emissions must be accounted.

Increased use of fertilizer (PE_f)	Application of fertilizer causing significant N_2O emission from the project activity must be accounted for. Reference tool: CDM tool for *Estimation of direct nitrous oxide emission from nitrogen fertilization to calculate emission.*
Biomass burning/ Fire from natural disturbance/ Forest fire used for harvesting/ site preparation (PE_{bb})	Emissions from biomass burning in the project scenario, whether due to anthropogenic or natural disturbances or as a part of the project activities, must be accounted for. Reference tool: CDM tool for *Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity* to calculate emission.
Unplanned timber harvesting (PE_{uthy})	Where the socio-economic survey finds that there is no unplanned extraction of timber from the project area, then the emissions from unplanned timber harvesting may be assumed to be zero. Reference tool: PE due to unplanned timber harvesting must be estimated using equation no. 11, Section 8.1.8.1, which is based on IPCC GPG-LULUCF.

All project emissions from REDD activities are calculated using the following equation:

$$PE_{REDDy} = PE_{ffy} + PE_{wbanry} + PE_{fy} + PE_{bby} + PE_{uthy} + PE_{ny} + PE_{wbfy}$$

Equation 15

Where:

PE_{REDDy} = Project emissions from REDD activities in year y; t CO_2e

PE_{ffy} = Project emissions from fossil fuel combustion in year y; t CO_2e

PE_{wbfy} = Project emissions from woody biomass removal for fire prevention activities in year y; t CO_2e

PE_{wbanry} = Project emissions from woody biomass removal during ANR activities in year y; t CO_2e

PE_{fy} = Project emissions from direct use of fertilizer in year y; t CO_2e

PE_{bby} = Project emissions from biomass burning in year y; t CO_2e

PE_{uthy} = Project emissions from unplanned timber harvesting in year y, t CO_2e

PE_{ny} = Project emissions from n activities in year y; t CO_2e

8.2.2 Project Emissions and Sequestration from ARR Activities

Project emissions and sequestration from ARR activities are quantified using CDM methodology *AR-AMS0007*. The net GHG removals by sinks must be calculated as below:

$$PS_{ARR} = \Sigma\Delta C_{c-pool,i,SP} * \frac{1}{\mathrm{SP}} * S_{ARR,i} * 44/12$$ Equation 16

Where:

PS_{ARR}	=	Total project sequestration from ARR, tCO_2e
$\Delta C_{c\text{-}pool,i,sp}$	=	Total carbon content of all the carbon pools within the sample plots in stratum i, (tC/smaple plot)
SP	=	Area of sample plot, ha
$S_{ARR,i}$	=	Area under stratum i in ARR in ha

The project proponent must also include losses of carbon where the ARR project scenario includes harvesting. This loss is in the form of the long-term average GHG benefit. The maximum number of GHG benefit should not exceed the total long-term average GHG benefit. VCUs may be issued until the long-term average is reached.

This calculation must be performed in accordance with the VCS rules.

8.3 Leakage Emissions (LE)

The project may include activities aimed to reduce leakage or provide alternative economic opportunities to the dependent communities in the project area which necessarily result in emissions. Such emissions must be accounted for and deducted from net emission reductions.

Leakage refers to the displacement of GHG emission sources from inside the project area to outside the project area due to emission reduction activities in the project area. The potential for all possible leakage must be identified and quantified and the project proponent must include LMZs as part of the overall project design.

The project proponent must address leakage by minimizing leakage risks through robust design of a project activity implementation to tackle the DoFCs and the inclusion of leakage inducing activities, and then discount the remaining leakage due to the project activity from the net carbon gain.

De minimis emissions from leakage are not required to be accounted for. The significance of leakage may be determined using the CDM A/R methodological tool *Tool for testing significance of GHG Emissions in A/R CDM Project Activities.*

Leakage occurring outside the host country are not required to be accounted for.

8.3.1 Leakage Management Zones

LMZ are assessed using the following steps:

1) LMZs must be estimated in order to assess leakage due to displacement of unplanned DoFC.
2) LMZs must be determined using socio-economic surveys and local intelligence

3) The assessment must be agent-centric and robust monitoring must be conducted to account for leakage.

4) All communities which are dependent on the project area for any kind of need must be monitored periodically or at least once at the time of verification through surveys. This will help in finding out what are the current requirements that are fulfilled with the help of the project activity and what are the remaining requirements for which the community has to depend on some other forest area.

8.3.2 Activity Shifting Leakage (ALEt)

The application of conservation practices in the project area may lead to undesirable and unintended movement of DoFC outside the project area leading to emissions of GHG due to deforestation and forest degradation of those areas. Where the shifting of activities increases the rate of DoFC, the related land use change, carbon stock/density changes and non-CO_2 emissions must be estimated and accounted as leakage.

The magnitude of activity shifting leakage will vary greatly across conservation projects. If neighbouring forested lands are easy to access and the DoFC are mobile, activity-shifting leakage is likely. Where forested land is not easily accessible or the DoFC are not mobile, the risk of activity-shifting leakage may be quite low.

Activity shifting leakage must be determined using the tools in Table 10 below.

Table 9: Sources of Leakage Emissions

Leakage source	Description
Fossil fuel combustion	Leakage due to all type of fossil fuel as a result of project activity must be calculated. Reference tool: CDM *Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*
Shifting of grazing and livestock production	Leakage due to shifting of grazing and livestock production as a result of the project activity must be accounted. Reference tool: CDM tool for the *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*
Shifting of agriculture activities	Leakage due to shifting of agricultural activities as a result of the project activity must be accounted. Reference tool: CDM tool for the *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*
Increased use of fertilizer	Leakage due to application of fertilizer causing significant N_2O emission from the project activity must be accounted. Reference tool: CDM tool for the *Estimation of direct nitrous oxide emission from nitrogen fertilization*

Unplanned timber harvesting	Leakage emission due to unplanned timber harvesting are required to be accounted. However, if the socio-economic survey found that there is no unplanned extraction of timber from the project area, then the leakage emissions from unplanned timber harvesting may be assumed to be zero. Reference tool: Through the selected socio-economic survey option and expert reviews
Biomass Collection	As per the general guidance on leakage in biomass project activities "the project participant must evaluate *ex-ante* if there is a surplus of the biomass residues in the region of the project activity, which is not utilised. If it is demonstrated (e.g., using published literature, official reports, surveys) at the beginning of each crediting period that the total/aggregated quantity of available biomass residues in the region (e.g., 50 km radius), is at least 25 per cent larger than the quantity of biomass residues that are utilised in the region including the project activity, then this source of leakage may be neglected. Otherwise, this leakage must be estimated and deducted from the emission reductions. Projects with more than one biomass residue type may, in principle, treat all relevant biomass residues as one type of biomass residue when estimating the surplus of the biomass in the region."[13]

8.3.3 Market Leakage (CLEt)

Market leakage must be quantified where, due to the conservation practices inside the project area, there is an impact on the supply chain of forest products which result in a shift of production of forest products elsewhere to fulfil the demand supply chain.

Market leakage emissions must be quantified by multiplying the net change in carbon stock with a leakage discount factor as follows:

$$CLE_y = LF_{md} \times \Delta C_{net,bsl,t} \qquad \text{Equation 17}$$

Where:

CLE_y,	=	Total market leakage as a result of REDD+ activities, in the year y since the start of the project activity, tCO_2e;
LF_{md}	=	The dimensionless leakage factor for market-effects calculations
$\Delta C_{net.bsl,y}$	=	Net greenhouse gas emissions in the baseline scenario in the year y since the start of the project activity, tCO_2e.

[13] http://cdm.unfccc.int/filestorage/e/x/t/extfile-20140515165832305-SSCWG44_annex11_Guideline_Leakage_in_biomass_ver04.0.pdf/SSCWG44_annex11_Guideline_Leakage%20in_biomass_ver04.0?t=b0R8bmZtejR5fDDWHSaVyD4kxwXkvvKoLsBw

Market leakage must be accounted for where unplanned timber harvesting is considered in the baseline emissions. Restriction to timber extraction may result in leakage. This may be attributed to (i) identified agents or (ii) unidentified agents.

In the case of identified agents, where timber extraction is/was a part of planned deforestation, the agent will have right over the forest land within the project area. All other forest land within the same management practice must be part of leakage management plan in such cases. If appropriate management plans exist to ensure no leakage occurs and it is demonstrated that there have been no marked increase in timber extraction in lands within the LMZ managed by the agent, leakage may be considered as zero. In case there is a marked increase in timber extraction from the forest lands within the LMZ (more than 5% as compared to the land management plan may be considered to be as a departure), then leakage must be calculated from the records of the actual activity on ground. In the absence (or difficulty in collection) of such information, the leakage discount factors that is to be used in case of unidentified agents (as explained in the next paragraphs) may be applied.

In the case of unidentified agents, comparable market leakage figures (from same forest type within the host country or comparable timber species within the host country) may be applied from scientific peer reviewed journals. As an alternative, a discount factor, which is estimated *ex-post* and revised along with baseline, may be applied to the net GHG changes associated with countermeasures that decrease timber harvest.

The leakage discount factor is estimated on the basis of a comparison between the ratio of merchantable biomass to total biomass across all strata in the project area in base year, and the ratio of merchantable biomass to total biomass within the area from where harvesting would likely be displaced to. The following discount factors may be applied for market leakage:

1) Countermeasures to decrease drivers have no or minimal effect on total timber harvest volume – apply discount factor 0%.
2) Countermeasures that decrease occurrences of harvesting (such as a moratorium), but eventually causing minimal reduction in harvested timber in the long run – apply discount factor 0.1.
3) In the case of countermeasures that substantially reduces harvest level permanently, three discount factors may be applied based on the availability of biomass which is of comparable use and quality in the LMZ as the mercantile biomass within the project area. The three discount factors are as follows:
    - If ratio of merchantable biomass to the total biomass in the leakage area is higher than that of the project area (more than 15%) - discount factor 0.2.
    - If ratio of merchantable biomass to the total biomass in the leakage area is similar to that of project area (within +/-15%) - discount factor 0.4.

- If ratio of merchantable biomass to the total biomass in leakage area is lower than the project area (less than 15%) - discount factor 0.7.

The leakage factor is determined by considering where due to the conservation project activity in the project area the country logging will be increased as a result of the decreased supply of the timber caused by the project. The market leakage may be neglected if it may be demonstrated that no market-effects leakage will occur within national boundaries, due to market leakage and annual extracted volumes increase is negligible within existing national boundary (emission is less than 5% of the total project's GHG emission reduction (i.e., *de minimis*) and illegal logging is absent in the project host country.

Leakage outside the host country is not required to be accounted.

8.3.4 Total Leakage

Total leakage is calculated as follows:

$$LE_y = CLE_y + ALE_y + LK_y \quad \text{Equation 18}$$

Where:

LE_y = Leakage emissions in year y, tCO_2e

CLE_y = Total market leakage emissions as a result of REDD+ activities, in the year y since the start of the project activity, tCO_2e;

ALE_y = Activity shifting leakage emissions in year ytCO_2e

LK_y = GHG emissions due to leakage of ARR activities, in year *y*; t CO_2-e

ARR project emissions due to activities such as vehicular emissions and fodder application are not to be accounted for. In line with *AR-AMS0007*, leakage emissions must be estimated as follows:

$$LK_y = LK_{AGRIC,y} \quad \text{Equation 19}$$

Where:

LK_y = GHG emissions due to leakage, in year *y*; t CO_2-e

$LK_{AGRIC,y}$ = Leakage due to the displacement of agricultural activities in year *y*, as calculated in the CDM tool *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*; t CO_2-e

8.4 Calculation of Uncertainty

In every step of GHG emission quantification of a project activity, the level of uncertainty must be determined. Uncertainty includes measurement errors in the sample collection, inventory and laboratory processing. The project proponent must clearly state the uncertainty associated with the project activity and describe how much uncertainty must be addressed at what confidence level and must use the 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, AFOLU for uncertainty analysis. Tables 11 and 12 provide the appropriate guidance.

Table 11: Assessing Uncertainty While Accounting for Degradation

Accounting Type	Guidance Document
Assessing uncertainty while accounting degradation	2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, AFOLU, Chapter 4, Section 4.2 or nationally accepted standard

Table 12: Assessing Uncertainty While Accounting for Deforestation

LULC Class	Guidance document
Forest land to cropland	2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, AFOLU, Chapter 5, Section 5.3
Forest land to grassland	2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, AFOLU, Chapter 6, Section 6.3
Forest land to settlement	2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, AFOLU, Chapter 8, Section 8.3
Forest land to other lands	2006 *IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 4, AFOLU, Chapter 9, Section 9.3

Where uncertainty is found to be less than zero, (i.e., if there is any possibility of NERs being underestimated) the uncertainty factor (UF) must be considered to be zero. In all other cases $UF_{projectREDD}$ is calculated using the guidances in tables 11 and 12 above.

8.5 Net GHG Emission Reduction and Removals

Net GHG emission reductions and removals are calculated as follows:

REDD

Net GHG emission reductions are removals from REDD activities are calculated using the following equation:

$$ER_{yREDD} = (BE_{yREDD} + BE_{yADD} - PE_{yREDD} - LE_y)(1 - \mathrm{UF}_{\mathrm{projectREDD}})$$ **E**quation 20

Where:

ER_{yREDD} = Total GHG emissions reductions and removals in year y; tCO_2e
BE_{yREDD} = Baseline emissions from REDD activities in year y; tCO_2e
BE_{yADD} = Total additional baseline emissions in year y; tCO_2
PE_{yREDD} = Project emissions from REDD activities in year y; tCO_2e
LE_y = Leakage in year y; tCO_2e
$UF_{projectREDD}$ = Uncertainty (REDD)

ARR

Net GHG emission reductions and removals from ARR activities are calculated using the following equation:

$$ER_{yARR} = BE_{ARR} - PS_{ARR} - LK_t$$ Equation 21

Where:

ER_{yARR}	=	Net GHG removals by sinks, in year *t*; t CO_2-e
BE_{ARR}	=	Baseline net GHG removals by sinks, in year *t*; t CO_2e
LK_t	=	GHG emissions due to leakage, in year *t*; t CO_2e
PS_{ARR}	=	GHG emissions reductions and removals in year y; tCO_2e

Net GHG Emission Reductions/Removals

$$\mathrm{NER_y} = \mathrm{ER_{yREDD}} + \mathrm{ER_{yARR}}$$ Equation 22

Where:

NER_y = Net GHG emissions reductions and removals in year y; tCO_2e
ER_{yREDD} = GHG emissions reductions and removals by REDD project activities in year y; t CO_2e
ER_{yARR} = GHG emissions reductions and removals by ARR project activities in year y; t CO_2e

Buffer Contribution

Buffer credits are set aside to address risks of non-permanence and are determined using the net change in carbon stocks and the risk rating determined using the *AFOLU Non-Permanence Risk Tool*, using the following equations:

$$\mathrm{Buffer_y} = \Delta C_y \times \mathrm{RR_y}$$ Equation 23

$$\mathrm{VCU_y} = \mathrm{NER_y} - \mathrm{Buffer_y}$$ Equation 24

Where:

VCU_y = VCUs eligible for issuance in year y; tCO_2e

NER_y = Net GHG emissions reductions and removals in year y; tCO_2e

$Buffer_y$ = Buffer credits to be deposited in the AFOLU Pooled Buffer Account in year y; t CO_2e

ΔC_y = Net change in carbon stocks for REDD and ARR project activities in year y; t CO_2e

RR_y = Risk rating determined in year y

9 MONITORING

9.1 Data and Parameters Available at Validation

Data / Parameter	$BEF_{2,j}$
Data unit	Dimensionless
Description	Biomass expansion factor for conversion of stem biomass to above ground tree biomass for tree species *j*
Equations	4, 11
Source of data	Values from IPCC Good Practice Guidance for LULUCF (2003) Table 3A.1.10. Default values of biomass expansion factors (BEFs)
Value applied	IPCC GPG Default value
Justification of choice of data or description of measurement methods and procedures applied	BEF must be sourced from data on local ecological systems. In case of unavailability of this data, regional, national and international data must be used, in that order.
Purpose of Data	Project emissions and project sequestration
Comments	

Data / Parameter	CF_{Tree}
Data unit	$tC td.m.^{-1}$
Description	Carbon fraction of dry matter for species of type *j*
Equations	4, 8, 9,11, 12
Source of data	Methodological tool: "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Latest version.*

Value applied	A default value of 0.47 is used following the AR CDM methodological tool.
Justification of choice of data or description of measurement methods and procedures applied	To convert the dry biomass into carbon weight
Purpose of Data	Project emissions and project sequestration
Comments	To calculate CO_2 sequestered in equation $C_{Tree,\,t} = 44/12 * B_{Tree,\,t} * CF_{Tree}$ where CF_{Tree} is the carbon fraction and C_{Tree} gives the CO_2 content in tonnes.

Data / Parameter	D_j
Data unit	t d.m. m^{-3}
Description	Density overbark of tree stem for tree species j.
Equations	4, 8, 11
Source of data	Good Practices IPCC Guidelines, 1996 and Published literature
Value applied	To be calculated
Justification of choice of data or description of measurement methods and procedures applied	*Dj* must be sourced from data on local ecological systems. In case of unavailability of this data, regional, national and international data must be used, in that order.
Purpose of Data	Project emissions and project sequestration
Comments	

Data / Parameter	$V_{TREE,j,p,i,t}$
Data unit	m^3
Description	Stem volume of trees of species j in sample plot p of stratum i at time t calculated using a volume Table or volume equation or allometric equations. In case a field analysis such as fractional downscaling has been conducted, this data need not be recorded.
Equations	4

Source of data	Field measurements for tree parameters (i.e. GBH, Height) measured in sample plot p of stratum i at time t. Volume equations of each species were taken from nationally accepted and published data. Not required in cases where fractional downscaling analysis is conducted.
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	$V_{TREE,j,p,i,t}$ must be sourced from data on local ecological systems. In case of unavailability of this data, regional, national and international data must be used, in that order.
Purpose of Data	Project emissions and project sequestration
Comments	

Data / Parameter	R_j
Data unit	Dimensionless
Description	Root-shoot ratio appropriate for biomass stock, for species *j*
Equations	4
Source of data	As per the field data analysis.
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Rj must be sourced from data on local ecological systems. In case of unavailability of this data, regional, national and international data (Values from IPCC Good Practice Guidance for LULUCF (2003) Table 3A.8 "*Average belowground to aboveground biomass ratio (root-shoot ratio, r) in natural regeneration by broad category (tons dry matter/ton dry matter)" may be considered as per the forest type.)* must be used, in that order.
Purpose of Data	Project emissions and project sequestration
Comments	

Data / Parameter	$S_{REDD,i}$
Data unit	Ha
Description	Land area on which REDD activities are planned under the project scenario for year t and in stratum i
Equations	6
Source of data	To be monitored from the records of project implementation and associated records such as KML files, vector files of land-use activities
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Follow the procedures described in Section 8.1.8
Purpose of Data	Project emissions and project sequestration
Comments	

Data / Parameter	$S_{ARR,i}$
Data unit	Ha
Description	Land area on which ARR activities are planned under the project scenario for year t and in stratum i
Equations	16
Source of data	To be monitored from the records of project implementation and associated records such as KML files, vector files of land-use activities
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Follow the procedures described in Section 8.2.2
Purpose of Data	Project emissions and project sequestration
Comments	Only to be included if ARR activities are implemented.

Data / Parameter	EF

Data unit	g kg^{-1}
Description	Emission factor of forest fires
Equations	10
Source of data	At the time of validation of baseline
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Follow the procedure described in Section 8.1.8.1, under Forest Fire
Purpose of Data	Project emissions
Comments	

Data / Parameter	Be
Data unit	Dimensionless
Description	Burning efficiency
Equations	10
Source of data	Surveys and/or government approved reports
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Follow the procedure described in Section 8.1.8.1, under Forest Fire
Purpose of Data	Project emissions
Comments	

9.2 Data and Parameters Monitored

Data / Parameter	$\mathrm{ER}_{\mathrm{yREDD}}$
Data unit	tCO_2e
Description	Net GHG emission reductions in year t. Here only REDD activities are being considered and only sinks based on REDD is to be recorded.
Equations	21

Source of data	Based on field inventories and implementation data. Where applicable data as per the SAR/LIDAR and /or Fractional downscaling is acceptable.
Description of measurement methods and procedures to be applied	Measurement methods involves appropriate stratification and sampling and field data collection of biomass and SOC.
Frequency of monitoring/recording	Before each verification
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of project emission reductions
Calculation method	
Comments	

Data / Parameter	BE_{YREDD}
Data unit	tCO_2e
Description	Baseline GHG emission reductions in year t. Here only REDD activities are being considered and only sinks based on REDD is to be recorded.
Equations	7, 20,
Source of data	Calculated
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Before each verification
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of baseline emission
Calculation method	
Comments	

Data / Parameter	ER_{yARR}
Data unit	tCO_2e

Description	Net GHG removals by sinks, in year t. Here only ARR activities are being considered and only sinks based on ARR is to be recorded.
Equations	21
Source of data	Based on field inventories and implementation data
Description of measurement methods and procedures to be applied	The total stock of new plantations as per ARR activity is calculated. Carbon content in the stock is estimated over time. The rate of change of carbon stock of each stratum is added to arrive at the total change in carbon.
Frequency of monitoring/recording	Before each verification
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project emissiosn and project sequestration
Calculation method	
Comments	

Data / Parameter	PS_{ARR}
Data unit	tCO_2e
Description	Project sequestration of GHG emission reductions in year t. Here only ARR activities are being considered and only sinks based on ARR is to be recorded.
Equations	22
Source of data	Calculated
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Before each verification
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of project emission
Calculation method	
Comments	

Data / Parameter	BE_{ARR}
Data unit	tCO_2e
Description	Baseline GHG emission reductions in year t. Here only ARR activities are being considered and only sinks based on ARR is to be recorded.
Equations	22
Source of data	Calculated
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Before each verification
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of baseline emission
Calculation method	
Comments	

Data / Parameter	$B_{Trees\text{-}ARR}$
Data unit	Number/dimensionless
Description	Number of baseline trees for the ARR component
Equations	16
Source of data	Field survey
Description of measurement methods and procedures to be applied	Data collected from field enumerations. Details of the trees are to be recorded appropriately.
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	To monitor carbon sinks
Calculation method	
Comments	

Data / Parameter	$Fuelwood_{forest}$
Data unit	t/year
Description	Amount of fuelwood collected from forests in a year.
Equations	8, 9
Source of data	Survey records, government documents
Description of measurement methods and procedures to be applied	The fuelwood collection pattern must be based on surveys and government data such as working plan and micorplans which have been approved. Separate fuelwood assessment studies also may be undertaken for this.
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	$Fuelwood_{agri}$
Data unit	t/year
Description	Amount of fuelwood collected from agriculture land in a year.
Equations	8, 9
Source of data	Survey records, government documents
Description of measurement methods and procedures to be applied	The fuelwood collection pattern must be based on surveys and government data such as working plan and micorplans which have been approved. Separate fuelwood assessment studies also undertaken for this.
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	

Comments	

Data / Parameter	FG_i
Data unit	m^3 yr^{-1}
Description	Annual volume of fuelwood species i gathered,
Equations	8, 9
Source of data	Surveys and/or government approved reports
Description of measurement methods and procedures to be applied	The fuelwood collection pattern must be based on surveys and government data such as working plan and micorplans which have been approved. Separate fuelwood assessment studies also may be undertaken for this.
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	HTi
Data unit	m^3 yr^{-1}
Description	Annual volume of harvested timber, species i
Equations	11
Source of data	Surveys and/or government approved reports
Description of measurement methods and procedures to be applied	As per section 8.1.8.1, under the Unsustainable Timber Harvesting
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions

Calculation method	
Comments	

Data / Parameter	Ax_{fire}
Data unit	ha Yr^{-1}
Description	Area lost due to forest fire
Equations	10
Source of data	Surveys and/or government approved reports
Description of measurement methods and procedures to be applied	Area affected by forest fires may be ascertained from government reports. In the absence of such reports, or if these reports are inconclusive, FGDs may be conducted. The FGDs must be conducted of forest managerial staff
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	*Fl*
Data unit	g m-^{2}
Description	Fuel loading per unit area
Equations	8, 9
Source of data	Surveys and/or government approved reports
Description of measurement methods and procedures to be applied	The fuelwood collection pattern must be based on surveys and government data such as working plan and micorplans which have been approved. Separate fuelwood assessment studies also may be undertaken for this.
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.

QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	B_w
Data unit	ha yr-1
Description	Average biomass stock of forest areas
Equations	12
Source of data	Tables 3A.1.2, 3A.1.3, and 3A.1.4 of IPCC GPG LULUCF
Description of measurement methods and procedures to be applied	As per section 8.1.8.1, under Illegal Mining and Quarrying, Encroachment and Expansion of Subsistence Agriculture by Conversion of Forest Lands
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	F_{biol}
Data unit	Dimensionless
Description	Fraction of biomass left to decay in forest (transferred to dead organic matter)
Equations	12
Source of data	Default value to be sourced from table 3A.1.11 of IPCC GPG LULUCF
Description of	Follow the procedure described in Section 8.1.8.1 given

measurement methods and procedures to be applied	under the Illegal Mining and Quarrying, Encroachment and Expansion of Subsistence Agriculture by Conversion of Forest Lands
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emission
Calculation method	
Comments	

Data / Parameter	$Fire\ type$
Data unit	Dimensionless
Description	The cause of forest fire: Major categories being human induced or fire due to natural causes.
Equations	10
Source of data	Surveys and/or government approved reports
Description of measurement methods and procedures to be applied	Cause of forest fires may be ascertained from government reports. In the absence of such reports, or if these reports are inconclusive, FGDs may be conducted. The FGDs must be conducted of forest managerial staff
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	$LC1y1 \rightarrow LC2Y2$
Data unit	ha
Description	Total land classified as stratum LC1 (ha) in time point y1 which has undergone transition to land classified as stratum LC2 (ha) in time point y2
Equations	3

Source of data	Remote sensing analysis
Description of measurement methods and procedures to be applied	Calculate based on the remote sensing classification and stratification procedures, as described under section 8
Frequency of monitoring/recording	At least once before every baseline update
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Determination of baseline scenario
Calculation method	It may be used for producing baseline transition matrix for new instances to be added into the project area.
Comments	

Data / Parameter	N_{LT}
Data unit	$hayr^{-1}$
Description	Land transition discounting factor due to scarcity of land
Equations	3
Source of data	Remote sensing analysis
Description of measurement methods and procedures to be applied	Described under section 8
Frequency of monitoring/recording	At least once before every baseline update
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Determination of baseline scenario
Calculation method	It may be used for producing baseline transition matrix for new instances to be added into the project area.
Comments	

Data / Parameter	$LC1_{Y1}$
Data unit	Ha
Description	Total area of LULC class or forest stratum 1 at time 1

Equations	2
Source of data	Remote sensing analysis
Description of measurement methods and procedures to be applied	Described under section 8.1.6
Frequency of monitoring/recording	At least once before every baseline update
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Project and leakage emissions
Calculation method	
Comments	

Data / Parameter	$area_{projectareawithharvest,projectscenario}(t,i)$
Data unit	ha yr^{-1}
Description	Size of strata i within the project area with harvest activities during year t under the project scenario.
Equations	16
Source of data	Remote sensing analysis
Description of measurement methods and procedures to be applied	This is relevant for ARR and LMZ
Frequency of monitoring/recording	At least once before verification
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of project emissions
Calculation method	
Comments	

Data / Parameter	$FW_{commercial}$
Data unit	m^{3}yr^{-1}
Description	Annual volume of fuel wood gathering for commercial

	sale
Equations	8, 9
Source 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
Description of measurement methods and procedures to be applied	Estimate among participating communities and communities living in the leakage area.
Frequency of monitoring/recording	At the start of the project activity and every five years since the initial verification or before each verification.
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of project emissions
Calculation method	
Comments	

Data / Parameter	LE_y
Data unit	tCO_2e
Description	Leakage emission in year y
Equations	18
Source of data	Surveys and spatial analysis
Description of measurement methods and procedures to be applied	Estimate among participating communities and communities living in the leakage area.
Frequency of monitoring/recording	Before each verification and at the time of baseline update
QA/QC procedures to be applied	Standard SOPs recommended in the methodology must be applied. Review of monitoring records
Purpose of Data	Calculation of leakage emissions
Calculation method	
Comments	

9.3 Description of the Monitoring Plan

9.3.1 Monitoring Plan

Monitoring involves measuring and recording emissions, including carbon sequestered in the project area and any emissions due to leakage in the leakage area.

9.3.2 Methods of Monitoring

The project proponent may either use professional foresters or community members for carrying out monitoring of the carbon stock.

Extensive research on case studies[14] from around the world demonstrate that carbon stock estimates generated by community-based monitoring provide similar levels of uncertainty as estimates generated by an expert study. This demonstrates that trained and equipped members of local communities may collect accurate data. This also provides additional benefits to the project, as it was also found that involving community-based monitoring in REDD project can help in providing the opportunity of getting community members involved in the design and implementation of REDD projects. Additionally, use of technology like smart phones allows for real time data, and will likely also increase the efficiency of data collection.[15]

A further discussion of the benefits and challenges of community-based monitoring can be found in Box 1 below.

[14] http://forestcompass.org/case-studies/assessing-accuracy-and-cost-efficacy-community-based-monitoring-redd
http://forestcompass.org/case-studies/community-monitoring-chico-mendes-extractive-reserve-acre-brazil
http://forestcompass.org/case-studies/community-carbon-accounting-cca-action-research-project-indonesia
http://forestcompass.org/case-studies/community-monitoring-chico-mendes-extractive-reserve-acre-brazil
http://forestcompass.org/case-studies/iges-fpcd-community-based-forest-monitoring-project-papua-new-guinea
http://forestcompass.org/case-studies/community-based-forest-monitoring-north-rupununi-guyana

[15] http://forestcompass.org/case-studies/community-based-forest-monitoring-north-rupununi-guyana

Box 1: Benefits and Challenges of Community-based Monitoring

Community monitoring helps communities take informed decision to participate in REDD policy dialogue, and allows communities to retain control over their forests. This leads to strengthening of forest management through increased coordination among project proponents, forest departments, communities and other relevant stakeholders. Participation will also help in spreading awareness about climate change impacts and mitigation activities. The following are examples of these activities:

- Offering way forward since the customary forest owners will help in generating scientific data; this will help the communities in making decisions related to forest management while retaining their control over land.
- Giving communities a sense of involvement and in assuring the safeguards of their rights providing
- Transparency and effectiveness in forest management;
- Respect for the traditional knowledge and rights of indigenous people;
- Full and effective participation of communities;
- The action which communities are asked and incentivized for is conservation of natural forests, biodiversity and emission reduction.

Through various case studies around the world it was found that the challenges in the community-based monitoring:

- Initial costs in community-based monitoring are high due to technology and capacity building of communities, though with time (i.e., from 2nd or 3rd monitoring period) the cost will considerably decrease. Also, considering travelling, wages and accommodation of costs of professional forestry experts could be outweighed by the capacity building costs.
- Low social cohesion and rights over common resources have been found to be a challenge for assessing drivers of forest change. Additionally, insufficient understanding of monitoring among neighbouring clans has been found to be one of the major challenges to resolve. Moreover, creating a common understanding about the monitoring procedure and benefit sharing within and between stakeholder groups is a time consuming process.
- Logistics for data collection in remote and uninhabited areas and information dissemination is difficult; therefore, it is favourable if community members undertake monitoring of the activity for the project within the proximity of their homes to decrease the logistical challenges.
- Communities may be clearly in a position to collect basic data from the forest, such as tree species, tree count and DBH. However, the measurements may not always be of high quality in the initial years. It is therefore necessary to have a parallel process to supplement the gaps in the basic data quality of the data collected by community(s).

Requirements of Communities for Performing Monitoring Activities

The following are requirements for monitoring activities:

- Well-designed training by forestry professionals.
- Good payment for their service in-cash or in-kind as required by the communities.
- Full and effective involvement of communities in design and implementation of REDD project.
- New and advanced technology like computers and smart phones may help further increase the community management of forest.

QA/QC in Community-Based Monitoring

A detailed project based risk-abatement plan must be developed before the start of the first monitoring activity. This must also be submitted to the verifier at the time of verification. The minimum frequency of monitoring must range from annually to every 5 years at maximum.

QA/QC Requirements of All Monitoring Methods

QA/QC of field data collected must be assured by the following:

- People involved in field measurement must be fully trained in field data collection and data analysis.
- List the names of all the field teams and the project leader and the dates of the training sessions.
- Record which teams have measured the sampling plots, record who was responsible for which 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. Appropriate internal auditing mechanism must be established.

9.3.3 Monitoring Report Components

The following must be included in monitoring reports:

1) Land use change by deforestation
2) Forest degradation
3) Selected carbon pools
4) Biomass increase due to ANR

5) Leakage area
6) Project emissions
7) Loss events

The monitoring report must contain the information on activities listed below:

1) Changes in LULC in the project area, and leakage area, including a description of the remote sensing techniques; methods of analysis; accuracy assessment and validation used for assessing change in forest land i.e. deforestation and expansion of forest area.

2) Changes of forest cover within forest in the project area and leakage are, including a description of the remote sensing or stratification technique analysis method, accuracy assessment and validation to assess changes (increase or decrease) within the forest i.e. degradation.

3) The change in carbon stocks densities in the selected pool from project area in the project area and leakage area, including a description of the tier used, stratification techniques, techniques used for carbon change analysis, accuracy assessment to assess changes (increase or decrease) in the selected carbon pools in the project area.

4) The increase in the ANR area.

5) Project emissions from the selected carbon pools in the project and leakage area.

6) Loss events (if applicable).

7) Intervention activities in the project area and leakage area.

8) Monitoring of grouped project (if applicable).

9.3.4 Monitoring Steps

Changes in forest cover in the project area (and leakage belt for unplanned deforestation) must be measured before each verification as part of monitoring. All types of forest area need to be monitored for each reporting period. If resources are not sufficient to cover wall to wall coverage, a suitable method of sampling is recommended.

In cases where the project area is located within a region the jurisdictional program or any other VCS or UNFCCC registered MRV, the MRV data generated by the jurisdictional program must be used. In any other case, monitoring must be conducted by the project proponent or the outsourced to a third party having sufficient expertise to carry out the monitoring activities of the project.

All variables used at validation must remain the same. Where the project proponent uses new data and variables in the current fixed baseline period, the baseline must be recalculated using the new data and variables.

9.3.4.1 Monitoring LULC Change in the PA

Calculating actual forest change due to deforestation during the monitoring period, the project proponent must quantify and report the land use change due to deforestation in the PA.

Acquire RS data at the time of monitoring and compare it with the last acquired data and use the same procedure of analysis as used in the baseline for analysing LULC and forest cover. A minimum required selection of imagery and coverage, pre-processing (cloud shadow correction, geometric correction and radiometric correction) and classification of data will be as recommended in Section 8 in the methodology.

Several drivers cause forest degradation and loss of carbon stocks within forests but monitoring all of them with high accuracy is always a challenge. However, high resolution RS data and robust socio-economic surveys helps in achieving 90% - 95% of certainty in data collection. As discussed in Section 8, the gaps in the canopy caused by different drivers (unplanned) may be detected in imagery such as using frequently collected imagery through advanced analytical techniques available and acceptable at National level.

9.3.4.2 Drivers, Agents and Underlying Cause

The drivers, agents and underlying cause identified at the time of the start of the project must be re-assessed, verified and reported as discussed in Section 8.1.7 in the methodology.

9.3.4.3 Biomass Stock Density in LULC Class and Degraded Patch

As per the change quantified and reported, the project proponent must calculate the biomass change in the selected carbon pools in the PA as per the given procedures and tools used in Section 8.1.8 in the methodology.

9.3.4.4 Increase in Biomass Due to ARR

The project proponent must calculate the biomass increase in the current monitoring phase from the consecutive baseline or monitoring phase using biomass inventories. The increase in biomass must be calculated and reported against which the project proponent may claim credit. The project proponent must follow the monitoring procedure as described in *AR-AMS0007 A/R Small-scale Methodology: Afforestation and reforestation project activities implemented on lands other than wetlands*.

9.3.4.5 Monitoring of Project Emission

The resulting project emission due to the project activity must be monitored and accounted before each verification period using the same tools and procedures described in Section 8.2.

9.3.4.6 Monitoring of Leakage Area and LMZ

Increases in anthropogenic emission outside the project boundary due to activity shift or market leakage must be monitored and reported at each reporting period. Such emission must be deducted from the emission reduction to determine the net carbon benefit.

Two types of activities need to be monitored:

A) Increase in GHG emission or decrease in carbon stock due to activity shift or Market Leakage in the Leakage Area

Areas selected as leakage areas which are subjected to unplanned deforestation and forest degradation and cause significant decrease in carbon stock must be estimated and monitored before each verification.

B) Increase in GHG emission or decrease in carbon stock due to leakage prevention activities in the LMZ

In areas which are subject to LMZ for leakage prevention measures must be measured and accounted before each verification, this will offset the carbon emission due to the leakage in leakage area.

Monitoring ex-post Land use change and forest cover change in leakage area

Apply the same method used to monitor deforestation and degradation in the PA.

The reason of anthropogenic emission in the leakage area may be due to some external factor and not because of the project activity and if the project proponent may prove this by giving proper justification in the monitoring report, then the project proponent are allowed to adjust the baseline rate of emission reduction. In such case the rate of deforestation and degradation is assessed by calculating the rate in the RR through RS and then using this in the adjusted baseline.

Calculation of Leakage

Project proponent must apply the same procedures and tools used to calculate activity shift and Market leakage in Section 8.3 of the methodology.

In case if the Leakage area is located within a region within the jurisdictional program MRV, the MRV data generated by the jurisdictional program must be used.

In any other case monitoring must be done by the Project proponent or the outsourced third party having sufficient expertise to carry out the monitoring activities of the REDD project.

9.3.4.7 Monitoring intervention activities in the project area and LMZ

Project proponent must monitor and report the intervention activities taking place as a part of emission reduction program of the project activity. The project proponent must monitor and calculate the emission reduction through the approved standard methodologies of CDM or VCS.

The project proponent must exclude the energy efficient intervention activities sources which were already available in the baseline inside the project area and LMZ.

Also, once due to effective implementation of intervention activities or due to any other factor the project area is no longer in danger from the fuel wood emission, the benefit from the energy efficient intervention activities must be excluded. The effectiveness of the intervention activities or in an another word that the biomass stock in the project area is not depleting due to the fuel wood collection may be measured through socio-economic survey or any national data, local statistics, census, FRA reports, RS data, decrease in fuel wood price, trends showing tie and distance travelled by the fuel wood collectors.

9.3.4.8 Monitoring of the Sample Design and Stratification

The carbon stocks are monitored before or at each verification event by conducting a forest inventory using permanent or temporary sample plots. Re-measurement and re-assessment of sample plots is periodically needed and the results must be calculated and reported. Due to any unforeseen natural disaster and deforestation, the permanent sample plots have to be neglected and must not be considered during measurement of carbon stocks. Similarly, in order to measure the increase in forest stock, additional sample plots must be established in order to accurately account the forest carbon stocks. The Project proponent must use latest inventory method and emission factor to calculate ex-post emission reductions and removals.

9.3.4.9 Updates to Baseline Net GHG Removals by Sinks

The baseline must be re-measured and re-assessed after every 10 years and must be validated at the subsequent verification as per the VCS AFOLU Requirements.

9.4 Procedures for Managing Data Quality

The following are procedures that must be followed for managing data quality:

- The data collected must be documented and archived for a period of at least two years after the end of the last crediting period of the project activity.
- The PD must contain description about the Standard Operating Procedure (SOP)
- The SOP of field measurement and reporting must describe each step of field carbon and socio-economic measurement.
- The SOP document must contain the QA/QC procedure of field data measurement, monitoring steps and parameters and how to collect information and data with accuracy.

- Remedial action must be taken including:
  - Errors in the measurement procedure
  - Errors in stratification of forest
  - Effectiveness of intervention

QA/QC must contain (adapted from: MacDonald, 1994):

Precision: precision is a measure of mutual agreement among individual measurements or values of a variable taken under similar conditions.

Accuracy: accuracy is a degree of agreement between a measured value and the true or expected value of the variable.

Completeness: completeness is the percentage of measurement made, that are judged to be valid.

Representativeness: is the degree to which data accurately and precisely represent a characteristic of a population, variations at a sampling point, or an environmental condition. The program must be designed so that the samples collected are as representative as possible of the habitat or populations and a sufficient number of samples are collected.

Comparability: is a measure of the confidence with which one data set may be compared to another. Comparability is not quantifiable. However, it must be considered when designing sampling plans, analysis procedures, quality control and data reporting. Employing consistent data forms and survey protocols will maximize comparability.

- SOPs and QA/QC procedures for inventory operations, including field data collection and data management, must be calculated, recorded and used. SOPs from published handbooks at National level or from the "IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003" Section 3.2.6,[16] is recommended.
- Data requirement may be found in the recommended tools in the methodology
- Data and parameters obtained from measurement must be monitored as required in the tools.

For further guidance on monitoring QA/QC, the project proponent may also consult:

- IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry.
- GOFC-GOLD Sourcebook (FAO, 2013) A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals caused by deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation. Report COP19, Ver. 2, 2013.

[16] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

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10 REFERENCES

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DOCUMENT HISTORY

Version	Date	Comment
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