REVISIONS TO VCS AVOIDING UNPLANNED DEFORESTATION AND/ORDEGRADATION METHODOLOGIES

Title	Revisions to VCS Avoiding Unplanned Deforestation and/or Degradation (AUDD) Methodologies
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1 INTRODUCTION

As announced by Verra in August 2022, VCS Avoiding Unplanned Deforestation and Degradation (AUDD) projects have the option to use revised versions of methodologies VM0006, VM0007, VM0009, VM0015, and VM0037 until Verra transitions REDD accounting to a jurisdictional allocation approach by the end of 2025. This document details the changes that will apply across all current AUDD methodologies to allow for public comment on these changes before methodologies are revised and undergo VVB assessment.

This document is not a standalone methodology nor does it comprise standalone sections of a methodology. Rather, it describes the common requirements and updates that will be incorporated to fit within VM0006, VM0007, VM0009, VM0015, and VM0037. The revised methodologies will be updated such that as much as possible of the original methodologies is retained intact. As such, the specific parameters will differ among methodologies, and the edits will differ greatly within each methodology to fit with the existing equations. However, the overarching requirements on baseline setting and other elements will be fully aligned to ensure comparability of resulting emission reduction and removal estimates.

2 DEFINITIONS

Calibration period
The time period between the forest cover maps that represent the beginning and the midpoint of the historical reference period

Confirmation period
The time period between the forest cover maps that represent the midpoint and the end of the historical reference period

Factor maps
Maps in the spatial dataset used to project deforestation risk, including maps of spatial features, distances, and other maps that may represent continuous or categorical variables

Reference region
The boundaries of an administrative unit or group of units that form the reference for analysis of deforestation rate and location of deforestation

Risk map
A risk map shows, for each pixel location, the risk of deforestation over the baseline validity period, on a numerical scale

3 APPLICABILITY CONDITION

Although methodologies previously had applicability conditions limiting usage to mosaic deforestation circumstances, these applicability conditions will be removed. All projects will be required to model and allocate deforestation risk across a jurisdictional reference region that includes the project area and leakage belt.

4 PROCEDURES

4.1 Definition of Boundaries

Spatial Boundaries

4.1.1 Reference regions shall be either national boundaries or the first or second-level subnational jurisdiction boundaries within which the project is located, including the project area and leakage belt and all other registered REDD+ project areas and leakage belts.

4.1.2 The same reference region shall apply for projecting deforestation rate and location of deforestation.

4.1.3 Areas of planned deforestation must be identified and excluded from the reference region where deforestation is legally permissible and has a significant probability of occurring.[1]

4.1.4 Where subnational jurisdictions are used, the following applies:

1) If any part of the project area is located within 50 kilometers of the boundary of a jurisdiction, the reference region shall also include the relevant neighboring subnational jurisdiction(s) of the same subnational level.

2) If the boundary of the sub-national jurisdiction is a national boundary, requirement 4.1.4(1) does not apply. Where project boundaries are within five kilometers of the national boundary and it may be demonstrated that the agents of deforestation from the neighboring country do not face significant barriers to crossing national boundaries, a project may include a 15-kilometer zone from the project boundary extending into the neighboring country as part of its reference region.

3) The project proponent shall demonstrate that the selection of subnational jurisdictions is not engineered to inflate baseline emissions nor to prioritize the project area for the projection of the location of future deforestation.

[1] For example mining concessions, industrial agriculture, large-scale public works.

4) If the project is focused on the conservation of a unique forest type (e.g., mangroves or peat forest), then the subnational jurisdiction selected for the reference region shall contain at least as much of this type of forest as the project area, otherwise the reference region shall default to national boundaries.

4.1.5 The forested project area shall be continuous without arbitrary exclusions of forests located in the same geography (e.g., excluding forests next to villages around which deforestation is likely to occur).

4.1.6 The spatial extent of the leakage belt shall be based on delineating the forest area within a 10-kilometer wide buffer around the project area, excluding other active VCS AFOLU project areas and areas outside the host country (unless included in the reference region). "Active" VCS AFOLU project areas are those that have undergone verification or validation within the five years immediately preceding the establishment of the leakage belt boundaries.

4.1.7 Where the project area includes non-contiguous forest patches, each patch is considered a separate project area segment for the purpose of leakage belt delineation. Ten-kilometer buffers shall be delineated around each segment excluding other active project area segments that fall within the buffer.

Temporal Boundaries

4.1.8 The start date of the historical reference period shall be 10 years (plus or minus two years when there is lack of data availability, using the most conservative period). The end date of the historical reference period shall be the same as the project start date.

4.1.9 The baseline shall be renewed every six years after the start of the project.

4.2 Estimation of Annual Areas of Unplanned Deforestation

Analysis of Historical Deforestation

4.2.1 New data may be collected to enable mapping of historical deforestation. Where already-interpreted data of adequate spatial and temporal resolution and accuracy are available that meet the requirements defined by the methodology, these may be used instead of new data.

4.2.2 Historical deforestation data for the reference region shall be divided into polygons[2] representing "forest" land and "non-forest" land at different dates in the past within the historical reference

[2] Data formats may be either raster or vector (polygon). Data in raster format may be converted to vector format and vice versa.

period[3] (forest cover maps) as well as land that was "deforested" (deforestation maps) at different time periods in the past (within the historical reference period).

4.2.3 Forest cover maps shall be developed for a minimum of three distinct years representing the beginning, midpoint, and end of the historical reference period. All of the following apply to the project's forest cover maps:

1) Intervals between forest cover maps should be as similar in duration as data availability allows.

2) To allow for subdivision of the historical reference period into a calibration period and a confirmation period (see Section 4.3), an odd number of forest cover maps shall be utilized.

3) Good practice in remote sensing analysis shall be followed in any case.[4]

4) Where possible, deforestation maps shall identify areas of planned and unplanned deforestation.[5]

5) Where relevant, deforestation maps shall identify areas of mangrove and peat forest.

4.2.4 To analyze historical deforestation, the following shall be calculated:

1) The area of forest at the beginning and end of the historical reference period, and

2) The number of hectares deforested in each interval of the historical reference period (requirement 4.2.3).

Gross (rather than net) deforestation shall be measured. Areas of planned deforestation, where these are evident on the maps, shall be excluded from the calculation of historical deforestation. Where relevant, the number of hectares deforested for each interval of the historical reference period shall be calculated separately for areas of mangrove and peat forest.

4.2.5 A verifiable accuracy assessment of the maps produced under requirement 4.2.3 is necessary to produce a credible estimate of the historical deforestation area.[6] The minimum overall map accuracy shall be 90 percent for each of the "forest" and "non-forest" classes over the whole

[3] For the purpose of this document, mapping forest and non-forest land is sufficient. However, project proponents may consider dividing these two classes into subclasses representing different carbon densities, as long as it is possible to accurately map such classes using the data collected under requirement 4.2.1 and such mapping is useful for other methodology steps.
[4] For example GOFC-GOLD (2016); GFOI-MGD 3.0 (2020), Klemas (2013), Kuenzer et al. (2011), Kumar & Patnaik (2013), Rundquist et al. (2001).
[5] For example mining concessions, industrial agriculture, large-scale public works.
[6] See Chapter 5 of IPCC (2003) *Good Practice Guidance*, Chapter 3A.2.4 of IPCC (2006) *Guidelines for National Greenhouse Gas Inventories Vol. 4 AFOLU*, and Section 2.1 of GOFC-GOLD (2016) for guidance on mapping deforestation and performing accuracy assessments.

historical reference period. The estimated user's and producer's accuracy[7] of the deforestation class shall be at least 70 percent over the whole historical reference period.

Area Bias Correction of Historical Deforestation Area

4.2.6 A historical reference period forest change map shall be available with the following land cover change categories: forest remaining forest, forest to non-forest (deforestation), non-forest remaining non-forest, and non-forest to forest. Where relevant, the forest to non-forest category shall be separated into planned and unplanned deforestation.

4.2.7 An accuracy assessment shall be undertaken for the map (e.g., relying on visual sampling of high-resolution imagery as a reference). The requirements for the accuracy assessment are as follows:

1) The accuracy assessment shall address all map classes, with a focus on deforestation classes. Locations that transition from forest to non-forest within any interval of the overall historical reference period shall be mapped as deforestation in the historical reference period forest change map, regardless of any subsequent non-forest to forest transition.

2) High-resolution (≤5-meter resolution) imagery shall be used where available.

3) The accuracy assessment shall follow detailed standard operating procedures (which shall be made available to the VVB and Verra) that describe, among other things, how classification errors are quantified and minimized.

4) The results of the accuracy assessment shall be analyzed using standard best practice methods which shall be described in the standard operating procedures. (Refer to GFOI (2016). *Methods and Guidance from the Global Forest Observations Initiative v2.0*, page 134, Section 5.1.5 or *v3.0* (2020), page 176, Section 4.2.3 for examples.[8])

4.2.8 Estimation of land cover change areas shall result in mean estimates of areas, each with an uncertainty estimate representing sampling error as a two-sided 90 percent confidence interval. The uncertainty estimates shall be reported in hectares, and as a percentage of the area estimate.

4.2.9 Area of land cover change must be bias-corrected to account for the proportion of land cover change observed within each mapped land cover change category in the accuracy assessment dataset. Area estimates shall not be derived from uncorrected pixel-counts of land cover change maps. This step produces a bias-corrected historical deforestation area.

[7] User's accuracy shows false positives, or errors of commission (Type 1 errors), where pixels are incorrectly classified as a known class when they should have been classified as something else. Producer's accuracy shows false negatives or errors of omission (Type 2 errors). Producer's accuracy indicates how accurately the classification results meet the expectation.
[8] Available at: https://www.fs.usda.gov/treesearch/pubs/56461 and https://www.reddcompass.org/mgd/resources/GFOI-MGD-3.1-en.pdf, respectively.

4.2.10 The uncertainty-discounted historical unplanned deforestation area is calculated as follows:

1) The estimate of the bias-corrected historical unplanned deforestation area shall be conservatively discounted in order to reduce the risk of overestimation.

   Conservatively discounted unplanned deforestation area = *bias-corrected area estimate* × (1 − *discount factor*)

2) The discount factors shall be based on the uncertainty, U%, of the estimate to be discounted (i.e., the half-width of the two-sided 90 percent confidence interval as a percentage of the mean estimate). The discount factors are given by the following:

   a) If the uncertainty is less than or equal to 10 percent of the mean, then the discount factor is 0 percent.

   b) If the uncertainty is equal to or more than 100 percent, the project is not eligible for crediting.

   c) If the uncertainty is more than 10 percent and less than 100 percent of the mean, then:

$$DF = (U\%/t_{\alpha=10\%}) \cdot t_{\alpha=66.6\%}$$

Where:

DF	Discount factor (%)
U%	Percentage uncertainty of the area of the reference region classified as unplanned deforestation through plot sampling (i.e., the half width of the 90 percent confidence interval as a percentage of the mean estimate) (%)
t	Values from the t-distribution ($t_{\alpha=10\%}$ is the t-value for the two-sided 90 percent confidence interval, approximately 1.6449; $t_{\alpha=66.6\%}$ is the t-value for a one-sided 66.66 percent confidence interval, approximately 0.4307) (dimensionless)

Estimation of the Annual Areas of Unplanned Baseline Deforestation in the Reference Region

4.2.11 By default, the projected annual area of deforestation in the reference region shall be calculated as the historical average annual deforestation area across the historical reference period, conservatively corrected for uncertainty. The calculated mean annualized area shall then be used for each year of the baseline period.

An exception may be applied in cases where the existence of a significant trend in unplanned

deforestation over the historical reference period is demonstrated. A simple linear regression model shall be fitted (using ordinary least-squares) to a 10-year long annual deforestation time series (see Section 4.1.8 for more detail). A significant trend is present when the fitted slope value (b) is significantly different from zero (as judged based on a two-tailed Student's t test with $\alpha < 0.05$), with determination coefficient $r^2 > 0.6$. Standard equations for estimating uncertainties in regression forecasting should be applied, and the VCS guidance for uncertainty discounting (refer to the *VCS Methodology Requirements*) shall be used.

Where a significant downward trend exists, this trend shall be used for projected annual area of deforestation. Where a significant increasing tend exists, this trend may be used for projected annual area of deforestation. When the trend is not significant, the projected annual area of deforestation shall be defined as the historical average described above.

4.2.12 A project may elect to utilize a smaller annual area of unplanned baseline deforestation for the reference region than that calculated from the discounted historical average annual deforestation where this lower (thus conservative) area is derived from national-level REDD+ program reporting.

4.3 Location and Quantification of Threat of Unplanned Deforestation

4.3.1 The model or software used to project the location of future deforestation[9] shall:

1) Be transparent (include no black box calculations). The modeling system shall provide feedback on the relative contribution of explanatory variables and assess model fit through comparisons with empirical data.

2) Be able to project location of future deforestation.

4.3.2 In applying the model/software, project proponents shall provide clear documentation and justification for all model inputs and assumptions.

4.3.3 Spatial variables that explain the pattern of deforestation in the reference region shall be identified. The following classes shall be considered: distance to existing deforestation, landscape factors (e.g., topography and vegetation type[10]), accessibility factors (e.g., road, railway), and factors related to land tenure and management.

4.3.4 Risk maps shall be created and shall show, for each pixel location, the risk of deforestation on a numerical scale (e.g., from 0 = minimum risk to some upper limit representing the maximum).

[9] Many models exist, including GEOMOD and Land Change Modeler (both now part of the TerrSet suite available at http://www.clarklabs.org/); these are given as examples only and are neither required nor pre-approved for use.
[10] Where unique forest types exist in the reference region (e.g., mangrove forests or peat forests) then vegetation type shall always be included.

Algorithms of internationally peer-reviewed modeling tools are eligible for preparation of deforestation risk maps provided they are shown to conform with the methodology at time of validation. In preparing deforestation risk maps, multiple simulations (at least tens of computer runs) of the model shall be run using different numbers and combinations of factor maps, to produce a number of risk maps.

4.3.5 Calibration and confirmation shall be conducted by comparing a "confirmation period risk map" to observed unplanned deforestation within the confirmation period. The confirmation period risk map for the reference region must be developed using only factor maps representing the historical changes and state of the landscape through the end of the calibration period as inputs.

4.3.6 For each variant of the confirmation period risk map, project proponents shall prepare a confirmation period prediction map by overlaying the confirmation period risk map with locations that were deforested during the confirmation period. The prediction map with the best fit shall be selected and the risk map that was used to produce it shall be identified.

4.3.7 When using artificial neural networks to determine the model that best fits (has the lowest error), project proponents shall apply the following:

1) For the calibration period, a minimum of 5,000 samples (pixels) of the "transition" category (forest to non-forest) and 5,000 samples (pixels) of the "persistence" category (locations that do not transition but remain as forest) shall be randomly selected and used for training and testing.

2) A minimum of 10,000 iterations of the model shall be run before selecting the model that best fits.

4.3.8 The map with the best fit shall be the map that best reproduces actual deforestation in the confirmation period. The best fit shall be statistically assessed[11] and used as the criterion for selecting the most accurate deforestation risk map to be used for predicting future deforestation.

4.3.9 Following the selection of the most suitable confirmation period risk map, a new risk map is generated using the same model algorithms, landscape factors, and factor weights as the confirmation period risk map, but using the history and the state of the landscape through the end of the confirmation period as the model's starting state. The resulting map is termed the baseline risk map.

4.3.10 Future unplanned deforestation is assumed to occur proportionally to the relative rate of deforestation per modeled risk category observed in the historical reference period. The following steps are required to determine the locations of future deforestation:

1) Spatially bin the confirmation period risk map into 30 equal-area risk strata. The resulting map is termed the stratified confirmation period risk map.

2) Overlay the map representing actual observed deforestation within the confirmation period against the stratified confirmation period risk map. Calculate from this overlay the number of pixels of observed deforestation per risk stratum and the proportion of total observed deforestation in each risk stratum.

3) Create a stratified baseline risk map through replicating the creation of the 30-equal area risk strata in the baseline risk map.

4) Take the proportion of total observed deforestation in each risk stratum calculated from the stratified confirmation period risk map and apply to the calculated total baseline deforestation in each year of the crediting period to determine the annual loss area per risk stratum.

5) Overlay the stratified baseline risk map with the forest stratification maps of the project area and leakage belt and calculate the area of each risk stratum within each forest stratum. Use the area of risk stratum per forest stratum to calculate an area-weighted deforestation rate for each forest stratum within the project area and leakage belt. This area-weighted rate is "allocated" to the forest stratum and taken as the baseline rate of deforestation over the baseline validity period.

6) Record the cumulative amount of baseline deforestation activity data that is allocated to each forest stratum within the project area and leakage belt from project start, in hectares. If additional allocation to a forest stratum would cause the cumulative allocation to exceed the total remaining size of the forest stratum, that stratum is considered to be "exhausted." Any excess deforestation allocation to an exhausted stratum is instead added to the

[11] For example using Pontius Jr et al. (2007, 2008).

remaining non-exhausted strata in proportion to the amount of new allocation to those non-exhausted strata in the following baseline validity period.

7) The hectares deforested each year will be located within the defined forest strata and must be summed to give the total area of deforestation in the defined stratum in the specified year.

4.4 Estimation of Emission Factors

4.4.1 Emission factor estimation shall result in a mean estimate of average emissions per deforestation area unit in tonnes CO_2e per hectare. The emission factor estimates shall include an uncertainty estimate representing sampling error as a two-sided 90 percent confidence interval.

4.4.2 Deriving the mean estimate of average emissions for deforestation area unit will usually require drawing on multiple input factors (root-shoot ratios, biomass densities, carbon fractions etc.) and combining measurements (for different forest types, for different types of deforestation/forest degradation, for pre-disturbance and post-disturbance biomass etc.). Error propagation equations shall be applied for tracking uncertainty in these calculations.

The following basic equations shall be used:

Function	Standard Deviation of Estimate	Percentage Uncertainty of Estimate
A+B	$S_{A+B} = \sqrt{S_A^2 + S_B^2}$	$U\%_{A+B} = \left(t * \sqrt{S_A^2 + S_B^2}\right)/(A+B)$
A*B	$S_{A*B} = \lvert A*B\rvert * \sqrt{(S_A/A)^2 + (S_B/B)^2}$	$U\%_{A*B} = \left(t * \lvert A*B\rvert * \sqrt{(S_A/A)^2 + (S_B/B)^2}\right)/(A*B)$
A-B	$S_{A-B} = \sqrt{S_A^2 + S_B^2}$	$U\%_{A-B} = \left(t * \sqrt{S_A^2 + S_B^2}\right)/(A-B)$
A/B	$S_{A/B} = \lvert A/B\rvert * \sqrt{(S_A/A)^2 + (S_B/B)^2}$	$U\%_{A/B} = \left(t * \lvert A/B\rvert * \sqrt{(S_A/A)^2 + (S_B/B)^2}\right)/(A/B)$

4.4.3 The estimate of emission factors shall be conservatively discounted to reduce the risk of overestimation.

Conservatively discounted emission factor = *emission factor estimate* × (1 − *discount factor*)

4.4.4 The discount factors shall be based on the uncertainty of the estimate to be discounted (i.e., the half-width of the two-sided 90 percent confidence interval as a percentage of the mean estimate). The discount factors are given by the following:

1) If the uncertainty is less than or equal to 10 percent of the mean, then the discount factor is 0 percent.

2) If the uncertainty is equal to or more than 100 percent of the mean, the project is not eligible for crediting.

3) If the uncertainty is more than 10 percent and less than 100 percent of the mean, then:

$$DF = (U\%/t_{\alpha=10\%}) \cdot t_{\alpha=66.6\%}$$

Where:

DF	Discount factor (%)
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5 SAFETY MECHANISM

At each reporting interval, the rate of deforestation across the reference region and the project area shall be calculated and compared to the active reference level. Where the rate of deforestation is declining more rapidly across the entire reference region than in just the project area, no emission reductions shall be issued for that reporting period.

6 STANDARD INDICATORS

The following values shall be reported, each accompanied with an estimate of uncertainty representing sampling error as a two-sided 90 percent confidence interval.

1) Aggregate annual deforestation area for the historical reference period in the reference region (hectares per year)

2) Aggregate annual planned deforestation for the historical reference period in the reference region (hectares per year)

3) Aggregate annual deforestation area for the verification period in the project area (hectares per year)

4) Aggregate annual deforestation area for the verification period in the leakage belt (hectares per year)

5) Average emission factor for deforestation over all years of the historical reference period and over the whole reference region (tonnes CO_2e per hectare)

6) Aggregate annual emission from deforestation for the reference period and reference region (tonnes CO_2e per year)

7) Aggregate annual emission from deforestation for the verification period and project area (tonnes CO_2e per year)

8) Aggregate annual emission from deforestation for the verification period and leakage belt (tonnes CO_2e per year)

9) Average emission factor for deforestation for the verification period and over the project area (tonnes CO_2e per hectare)

7 REFERENCES

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