VCS Module

VMD0010

Estimation of emissions from activity shifting for avoiding unplanned deforestation and avoiding unplanned wetland degradation (LK-ASU)

Version 1.2

08 September 2020

Sectoral Scope 14

Module developed by:

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1 SOURCES

This module is one of numerous modules that constitute VCS methodology *VM0007 REDD+ Methodology Framework (REDD+ MF)*.

This module uses the latest versions of the following tools and modules:

- CDM tool *Estimation of direct N_2O emissions from nitrogen application (E-NA)*
- *VMD0001 Estimation of carbon stocks in the above- and belowground biomass in live tree and non-tree pools (CP-AB)*
- *VMD0007 Estimation of baseline carbon stock changes and greenhouse gas emissions from unplanned deforestation and unplanned wetland degradation (BL-UP)*
- *VMD0013 Estimation of greenhouse gas emissions from biomass and peat burning (E–BPB)*
- *VMD0016 Methods for stratification of the project area (X-STR)*
- *VMD0015 Methods for monitoring of greenhouse gas emissions and removals in REDD project activities (M-REDD)*

2 SUMMARY DESCRIPTION OF THE MODULE

This module provides methods for estimating emissions from displacement of unplanned deforestation and unplanned wetland degradation (leakage due to activity shifting).

This module provides methods to determine the net greenhouse gas emissions due to activity shifting leakage for projects preventing unplanned deforestation ($\Delta C_{LK\text{-}AS,unplanned}$) and/or unplanned wetland degradation ($GHG_{LK\text{-}WRC\text{-}AS,unplanned}$).

This module was originally developed for AUDD project activities. It is also mandatory for use in stand-alone AUWD project activities.

3 DEFINITIONS

In addition to the definitions set out in the VCS Program document *Program Definitions* and VCS methodology VM0007 *REDD+ MF*, the following definitions apply to this methodology:

Active Management
Under a specific ownership which has management plans and actively defends lands against invasion by squatters

Protected Forest
Forests with active protection in place including forest guards and policies to evict squatters

Road
A maintained open public way for the passage of vehicles, people and animals

River
A waterway flowing along a definite course, usually into the sea, fed by tributary streams and navigable by vessels able to transport people and animals

4 APPLICABILITY CONDITIONS

This module is applicable for estimating carbon stock changes and greenhouse gas emissions related to the displacement of activities that cause deforestation of lands or wetland degradation outside the project area due to avoiding unplanned deforestation or avoiding unplanned wetland degradation in the project area.

Activities subject to potential displacement are conversion of forest land to grazing lands, crop lands, and other land uses, or conversion of intact or partially degraded wetlands to drained or degraded wetlands.

The module is mandatory if module *BL-UP* has been used to define the baseline and the applicability conditions in module *BL-UP* must be complied with in full.

5 PROCEDURES

5.1 5.1 REDD Project Activities

5.1.1 General

Activities that deforestation agents would implement inside the project area in the absence of the REDD project activity could be displaced outside the project boundary as a consequence of the implementation of the REDD project activity.

Where this displacement of activities increases the rate of deforestation, the related carbon stock changes and non-CO_2 emissions must be estimated and counted as leakage.

Two different groups of deforestation agents may be displaced:

1. **Local Deforestation Agents.** Agents obtaining their livelihood inside or near the project area since the start of the REDD project activity. This will be the main agent group in most cases of mosaic deforestation. This group will also be present in some cases of frontier deforestation.

   The risk of displacing activities of local agent groups must be addressed in the design of the REDD project activity using one or both of the following two approaches:

   - Exclusion from the project area of the forest locations that are likely to be deforested by these groups during the implementation of the REDD project activity. Changes in the rate of deforestation in these areas, compared to the baseline case, must be counted as leakage; and

- Implementation of leakage prevention measures to maintain or increase the agents' livelihoods, such as, but not limited to, the creation of alternative sources of fuelwood, improved crop or animal production systems, and employment[1].

2. **Immigrant Deforestation Agents.** Agents expected to encroach into the project area in future periods. This will be the main agent group in most cases of frontier deforestation. This group will also be present in some cases of mosaic deforestation.

   Influencing the land-use decisions of this deforestation agent groups will not be possible in most cases, particularly if the agents are coming from distant locations and are driven by economic reasons. Leakage prevention measures may not be sufficient to avoid some level of activity displacement from happening.

Definition of the Boundary of the Leakage Belt

A leakage belt is a critical component of the analysis of leakage for unplanned deforestation. Module *BL-UP* must be used to establish the boundary of the leakage belt.

The basic steps to estimate displacement of unplanned deforestation are:

Step 1. Estimation of baseline carbon stock changes and GHG emissions in the leakage belt

Step 2. Estimation of the proportions of area deforested by immigrant and local deforestation agents in the baseline

Step 3. Estimation of unplanned deforestation displaced from the project area to the leakage belt

Step 4. Estimation of unplanned deforestation displaced from the project area to outside the leakage belt

Step 5. Emissions from activity shifting resulting in peatland drainage

Step 6. Emissions from leakage prevention activities

Step 7. Estimation of total leakage due to the displacement of unplanned deforestation

5.1.2 Step 1: Estimation of Baseline Carbon Stock Changes and GHG Emissions in the Leakage Belt

A baseline for the leakage belt must be estimated in order to assess leakage due to displacement of unplanned deforestation.

For methods to define the baseline of the leakage belt refer to Module *BL-UP*.

[1] Note the applicability condition above that precludes leakage prevention activities that cause greater than *de minimis* increases in emissions.

5.1.3 Step 2: Estimation of the Proportions of Area Deforested by Immigrant and Local Deforestation Agents in the Baseline

Randomly sample communities living within 2 km of the boundaries of the leakage belt and project area (defined in Module *BL-UP* – Part 1). At least 10% of communities must be sampled. If 10% of communities is less than 10 communities then the sample size must be set as 10 (or 100% of the communities). If 10% is more than 30 communities then the sample size must be set as 30.

Using a participatory rural appraisal (PRA) approach, existing studies and other verifiable sources of information, determine the proportion of area deforested by the population that has been resident in and around the leakage belt and project area for ≥ 5 years ($PROP_{RES}$) and the proportion of area deforested by population that has migrated into the area in the last 5 years ($PROP_{IMM}$).

This assessment must be repeated at least every 5 years and the estimated proportions will be assumed to be representative for up to five future years.

5.1.4 Step 3: Estimation of Unplanned Deforestation Displaced from the Project Area to the Leakage Belt

5.1.4.1 A *Ex-ante* Assessment

Based on the expected effectiveness of the proposed REDD project activities, conservatively estimate the carbon stock changes and greenhouse gas emissions in the leakage belt that are expected to occur due to the implementation of the REDD project activity and that would not occur in the baseline case. This must be done by multiplying the estimated baseline carbon stock changes and greenhouse gas emissions for the project area by a factor < 1.0 representing the % of deforestation expected to be displaced into the leakage belt[2].

The result is added to the estimated baseline for the leakage belt (Step 1) to estimate carbon stock changes and greenhouse gas emissions in the leakage belt under the project scenario. The difference between project and baseline carbon stock changes and greenhouse gas emissions in the leakage belt is the *ex-ante* estimated leakage due to displacement of unplanned deforestation from the project area to the leakage belt.

5.1.4.2 B *Ex-post* Assessment

Measure the area deforested in the project area ($A_{PA,unplanned,t}$) and leakage belt ($A_{LK,unplanned,t}$). Follow instructions and guidance in Module *M-REDD*.

Leakage in the leakage belt is estimated as follows:

$$\Delta C_{LK\text{-}ASU\text{-}LB} = \Delta C_{P,LB} - \Delta C_{BSL,LK,unplanned} \quad (1)$$

[2] If no leakage prevention activities are planned the factor must be equal to 1. Where leakage prevention activities are implemented the factor must be equal to the proportion of the baseline agents estimated to be given the opportunity to participate in leakage prevention activities. Leakage prevention activities must be planned to fully replace income, product generation and livelihood.

Where:

$\Delta C_{LK\text{-}ASU\text{-}LB}$	Net CO_2 emissions due to unplanned deforestation displaced from the project area to the leakage belt up to year t^* (t CO_2e)
$\Delta C_{BSL,LK,unplanned}$	Net CO_2 emissions in the baseline from unplanned deforestation in the leakage belt up to year t^* (t CO_2e)
$\Delta C_{P,LB}$	Net greenhouse gas emissions within the leakage belt in the project case up to year t^* (t CO_2e)

If $\Delta C_{LK\text{-}ASU\text{-}LB}$ as calculated is <0 then $\Delta C_{LK\text{-}ASU\text{-}LB}$ must be set equal to 0 (to prevent positive leakage).

5.1.5 Step 4: Estimation of Unplanned Deforestation Displaced from the Project Area to Outside the Leakage Belt

Immigrants prevented from migrating into and deforesting the project area are conservatively assumed to migrate to an alternative forest area and to cause deforestation, and where applicable, peatland drainage, in the alternative area. The alternative forest area could be within the leakage belt or it could be elsewhere in the country.

The proportion migrating to the leakage belt is calculated as the area of the leakage belt as a proportion of the total available forest area nationally.

5.1.5.1 Define the total available national forest area (i.e., the total forest area in the country (*TOTFOR*)). This can be assessed with a coarse-scale imagery (e.g., using MODIS imagery or similar), or with official government statistics on forest area. The total national forest area should be reduced to just the area of forest within 5 km of a road or river that is suitable for conversion to agriculture or raising livestock. If boundaries are available, then area of protected forests[3] (*PROTFOR*) and the area of managed forests[4] (*MANFOR*) may be excluded from the total forest area calculated in this step.

$$AVFOR = TOTFOR - PROTFOR - MANFOR \quad (2)$$

Where:

AVFOR	Total available national forest area for unplanned deforestation (ha)
TOTFOR	Total available national forest area (ha)
PROTFOR	Total area of fully protected forests nationally (ha)
MANFOR	Total area of forests under active management nationally (ha)

5.1.5.2 Calculate the area of forest in the leakage belt as a proportion of the total available national forest area. Note that if areas of protected forests and/or areas of managed forests are

[3] The effectiveness of protection must be demonstrable for areas to be excluded from total available forest area.
[4] The effectiveness of active management for preventing deforestation must be demonstrable for areas to be excluded from total available forest area

excluded from the total available national forest area they must also be excluded from the leakage belt forest area (*LBFOR*).

$$PROP_{LB} = LBFOR / AVFOR \quad (3)$$

Where:

$PROP_{LB}$	Area of forest available in the leakage belt for unplanned deforestation as a proportion of the total national forest area available for unplanned deforestation (proportion)
LBFOR	Total available forest area for unplanned deforestation in the leakage belt (ha) (calculated from the *Leakage Belt Forest Cover Benchmark Map*)
AVFOR	Total available national forest area for unplanned deforestation (ha)

5.1.5.3 Stratify *AVFOR* by carbon stock. The stratification must use peer-reviewed assessments of forest carbon stocks across the country in combination with coarse forest type maps. An initial stratification should be derived from biophysical parameters (e.g., soil type, elevation, precipitation regime, temperature, slope and aspect, tree species composition, age class/disturbance history). Carbon stocks data must be associated with each of the strata either through limited field measurements or through values derived from the peer-reviewed literature. Carbon stock must include only live above-ground tree biomass (C_{AB_tree} – see Module *CP-AB*). *AVFOR* must be separated into different strata where contiguous areas of at least 100 ha differ in stocks by ≥20%.[5] Take the area-weighted average carbon stock across the leakage belt (C_{LB}) and the area-weighted average carbon stock for all available forest area outside the leakage belt (C_{OLB}). The proportional difference in stocks is calculated by dividing the stock outside the leakage belt by the stock inside the leakage belt.

$$PROP_{CS} = C_{OLB} / C_{LB} \quad (4)$$

Where:

$PROP_{CS}$	The proportional difference in carbon stocks between areas of forest available for unplanned deforestation both inside and outside the leakage belt (proportion)
C_{OLB}	Area-weighted average aboveground tree carbon stock for forests available for unplanned deforestation outside the leakage belt (t CO_2e ha^{-1})
C_{LB}	Area-weighted average aboveground tree carbon stock for forests available for unplanned deforestation inside the leakage belt (t CO_2e ha^{-1})

5.1.5.4 The proportional leakage for areas with immigrating populations would then be equal to the immigrating proportion multiplied by the proportion of available national forest area outside the leakage belt multiplied by the proportional difference in stocks between forests inside and outside the leakage belt.

[5] At validation the source national datasets/maps must be presented alongside the stratification of AVFOR and any divergence must be explained

$$LK_{PROP} = PROP_{IMM} \times \left(1 - PROP_{LB}\right) \times PROP_{CS} \quad (5)$$

Where:

LK_{PROP}	Proportional leakage for areas with immigrating populations (proportion)
$PROP_{IMM}$	Estimated proportion of baseline deforestation caused by immigrating population (proportion)
$PROP_{LB}$	Area of forest available for unplanned deforestation in the leakage belt as a proportion of the total national forest area available for unplanned deforestation (proportion)
$PROP_{CS}$	The proportional difference in stocks between areas of forest available for unplanned deforestation both inside and outside the leakage belt (proportion)

5.1.5.5 *Ex ante*, leakage due to the proportion of the baseline deforestation actors who are displaced to areas outside the leakage belt would therefore be equal to the change in stocks in the leakage belt the baseline scenario minus the change in stocks in the leakage belt in the project scenario multiplied by the proportional leakage factor for areas with immigrating populations:

$$\Delta C_{LK\text{-}ASU,OLB} = (\Delta C_{BSL,LK,unplanned} - \Delta C_{P,LB}) \times LK_{PROP} \quad (6)$$

Where:

$\Delta C_{LK\text{-}ASU,OLB}$	Net CO_2 emissions due to unplanned deforestation displaced outside the leakage belt up to year t^* (t CO_2e)
$\Delta C_{BSL,LK,unplanned}$	Net CO_2 equivalent emissions in the baseline from unplanned deforestation in the leakage belt up to year t^* (t CO_2e)
$\Delta C_{P,LB}$	Net CO_2 equivalent emissions within the leakage belt in the project case up to year t^* (t CO_2e)
LK_{PROP}	Proportional leakage for areas with immigrating populations (proportion)

In each monitoring period, measure the area deforested in the project area ($A_{DefPA,i,t}$) and leakage belt ($A_{DefLB,i,t}$). Use Module *M-REDD*.

5.1.5.6 *Ex post*, as deforestation in the project area and leakage belt will be measured, $\Delta C_{LK\text{-}ASU,OLB}$ is estimated as follows:

1. *Ex post,* the proportion of the total area deforested by immigrant agents in the project scenario must be determined from the same proportion calculated in the baseline data. The proportional area deforested by immigrant agents in the baseline and project scenarios is assumed to remain the same.

   $$A_{LK\text{-}IMM,t} = PROP_{IMM} \times A_{BSL,PA,unplanned,t} \quad (7)$$

Where:

$A_{LK\text{-}IMM,t}$	Total area deforested by immigrant agents in the baseline and project scenario in year *t* (ha)
$PROP_{IMM}$	Proportion of area deforested by immigrant agents in the leakage belt and project area (proportion)
$A_{BSL,PA,unplanned,t}$	Projected area of unplanned baseline deforestation in the project area in year *t* (ha)
t	*1, 2, 3 …t** time elapsed since the start of the project activity (year)

2. Calculate the area deforested by immigrants in the project area and leakage belt under the project scenario as follows:

$$A_{LK-ACT-IMM,t} = PROP_{IMM} \times \left(\sum_{i=1}^{M} A_{DefPA,i,t} + A_{DefLB,i,t} \right) \quad (8)$$

Where:

$A_{LK\text{-}ACT\text{-}IMM,t}$	Area deforested by immigrants in the project area and leakage belt under the project scenario in year *t* (ha)
$PROP_{IMM}$	Proportion of area deforested by immigrant agents in the leakage belt and project area[6] (proportion)
$A_{DefPA,i,t}$	Area of recorded deforestation in the project area in the project case in stratum i in year t (ha)
$A_{DefLB,i,t}$	Area of recorded deforestation in the leakage belt in the project case in stratum i in year t (ha)
i	1, 2, 3 …*M* strata
t	*1, 2, 3 …t** time elapsed since the start of the project activity (year)

3. Calculate the area deforested by immigrants outside the leakage belt and project area:

$$A_{LK\text{-}OLB,t} = A_{LK\text{-}IMM,t} - A_{LK\text{-}ACT\text{-}IMM,t} \quad (9)$$

Where:

$A_{LK\text{-}OLB,t}$	Area deforested by immigrants outside the leakage belt and project area under the project scenario in year *t* (ha)
$A_{LK\text{-}IMM,t}$	Total area deforested by immigrant agents in the baseline and project scenario in year *t* (ha)
$A_{LK\text{-}ACT\text{-}IMM,t}$	Area deforested by immigrants in the project area and leakage belt under the project scenario in year *t* (ha)
t	*1, 2, 3 …t** time elapsed since the start of the project activity (year)

[6] Note: this proportion is estimated at least every 5 years.

4. Determine whether leakage outside the leakage belt has occurred:

   If: $A_{LK\text{-}OLB,t} \leq 0$ → Leakage outside the leakage belt has not occurred.

   If: $A_{LK\text{-}OLB,t} > 0$ → Leakage outside the leakage belt has occurred.

5. If leakage outside the leakage belt has not occurred:

$$\Delta C_{LK-ASU,OLB} = 0 \quad (10)$$

   Where:

$\Delta C_{LK\text{-}ASU,OLB}$	Sum of carbon stock changes and greenhouse gas emissions due to unplanned deforestation displaced outside the leakage belt (t CO_2e)

6. If leakage outside the leakage belt has occurred:

$$\Delta C_{LK-ASU,OLB} = C_{OLB} \times (\sum_{t=1}^{t^*} A_{LK-OLB,t}) \quad (11)$$

   Where:

$\Delta C_{LK\text{-}ASU,OLB}$	Net CO_2 emissions due to unplanned deforestation displaced outside the leakage belt up to year t^* (t CO_2-e)
C_{OLB}	Area-weighted average aboveground tree carbon stock for forests available for unplanned deforestation outside the leakage belt (t CO_2-e ha^{-1})
$A_{LK\text{-}OLB,t}$	Area deforested by immigrants outside the leakage belt and project area under the project scenario in year t (ha)
t	*1, 2, 3 …t** time elapsed since the start of the project activity (year)

5.1.6 Step 5: Emissions from Activity Shifting Resulting in Peatland Drainage or Tidal Wetland Degradation

The total available national forest area for unplanned deforestation (*AVFOR*) identified in Step 2 may contain undrained peatland or intact or partially degraded tidal wetland, to be determined using official data, where available, or recent (i.e., less than 5-year old) remote sensing products. In such cases, the project proponent must account for possible emissions from peatland drainage or tidal wetland degradation linked to activity shifting activities to the leakage belt and outside the leakage belt and project area.

Activity shifting to peatland or tidal wetland areas may happen regardless of whether the project area contains peatland or tidal wetland or not. Therefore, all projects located in countries with peatland or tidal wetlands must carry out the estimations presented in this step. However this is not required if it can be demonstrated that peatland or tidal wetland areas in the country are not suitable for the baseline deforestation activities (i.e., that *AVFOR* does not contain peatland or tidal wetland areas) or that baseline deforestation agents do not usually drain peatlands or degrade tidal wetlands in the country in order to carry out their activities (i.e., that the historical data used to construct the deforestation baseline can demonstrate that the identified

deforestation agents have never carried out their activities on drained peatland or tidal wetlands, or that such activities cannot by their nature be developed on drained peatland or tidal wetlands).

Determine whether leakage outside the leakage belt has occurred similar with step 4 above. If leakage outside the leakage belt has not occurred ($A_{LK\text{-}OLB,t} \leq 0$), $A_{LK\text{-}OLB,t}$ in Equations 12 and 13 is set to 0.

Total emissions from peatland drainage due to activity shifting leakage are estimated as:

$$\Delta C_{LK\text{-}ASU\text{-}PEAT} = (PROP_{PEAT\text{-}LB} \times LK_{PEAT\text{-}EF\text{-}LB} \times \sum_t^{t^*} A_{LK,unplanned,t}) + (PROP_{PEAT\text{-}OLB} \times LK_{PEAT\text{-}EF\text{-}OLB} \times \sum_t^{t^*} A_{LK-OLB,t}) \quad (12)$$

Total emissions from tidal wetland degradation due to activity shifting leakage are estimated as:

$$\Delta C_{LK\text{-}ASU\text{-}TW} = (PROP_{TW\text{-}LB} \times LK_{TW\text{-}EF\text{-}LB} \times \sum_t^{t^*} A_{LK,unplanned,t}) + (PROP_{TW\text{-}OLB} \times LK_{TW\text{-}EF\text{-}OLB} \times \sum_t^{t^*} A_{LK-OLB,t}) \quad (13)$$

Where:

$\Delta C_{LK\text{-}ASU\text{-}PEAT}$	Net GHG emissions due to peatland drainage from unplanned deforestation displaced from the project area up to year t^* (t CO_2e)
$PROP_{PEAT\text{-}LB}$	Proportion of undrained peatland areas in the leakage belt with respect to the total area of the leakage belt (unitless)
$LK_{PEAT\text{-}EF\text{-}LB}$	Emission factor from peat loss at peat depletion time (PDT) in the leakage belt (t CO_2e ha^{-1})
$\Delta C_{LK\text{-}ASU\text{-}TW}$	Net GHG emissions due to tidal wetland degradation from unplanned deforestation displaced from the project area up to year t^* (t CO_2e)
$PROP_{TW\text{-}LB}$	Proportion of intact or partially degraded tidal wetland areas in the leakage belt with respect to the total area of the leakage belt (unitless)
$LK_{TW\text{-}EF\text{-}LB}$	Emission factor from soil organic carbon loss at soil organic carbon depletion time (SDT) in the leakage belt (t CO_2e ha^{-1})
$A_{LK,unplanned,t}$	Area of recorded deforestation in the leakage belt in the project case in year t (ha)
$PROP_{PEAT\text{-}OLB}$	Proportion of undrained peatland areas in the area outside the leakage belt and project area with respect to the total area outside the leakage belt and project area (unitless)
$LK_{PEAT\text{-}EF\text{-}OLB}$	Emission factor from peat loss at peat depletion time in the area outside the leakage belt and project area (t CO_2e ha^{-1})
$PROP_{TW\text{-}OLB}$	Proportion of intact or partially degraded tidal wetland areas in the area outside the leakage belt and project area with respect to the total area outside the leakage belt and project area (unitless)
$LK_{TW\text{-}EF\text{-}OLB}$	Emission factor from soil organic carbon loss at soil organic carbon depletion time (SDT) in the area outside the leakage belt and project area (t CO_2e ha^{-1})

$A_{LK\text{-}OLB,t}$	Area deforested (for AUWD or WRC-AUWD project activities) or area with degraded wetland (for stand-alone AUWD project activities) by immigrants outside the leakage belt and project area under the project scenario in year *t* (ha)
t	*1, 2, 3 …t** time elapsed since the start of the project activity (year)

The use of PDT and SDT generates a conservative outcome because the total peat loss at PDT or the total soil organic carbon loss at SDT is an instant loss.

The proportion undrained peatland area or the intact or partially degraded tidal wetland area of the total area of the leakage belt represents the probability of leakage affecting such areas and is estimated as follows:

$$PROP_{PEAT\text{-}LB} = A_{PEAT\text{-}LB}/A_{LB} \quad (14)$$

$$PROP_{TW\text{-}LB} = A_{TW\text{-}LB}/A_{LB} \quad (15)$$

Where:

$PROP_{PEAT\text{-}LB}$	Proportion of undrained peatland area in the leakage belt with respect to the total area of the leakage belt (unitless)
$A_{PEAT\text{-}LB}$	Total undrained peatland area found within the leakage belt (ha)
$PROP_{TW\text{-}LB}$	Proportion of intact or partially degraded tidal wetland area in the leakage belt with respect to the total area of the leakage belt (unitless)
$A_{TW\text{-}LB}$	Total intact or partially degraded tidal wetland area found within the leakage belt (ha)
A_{LB}	Total area of the leakage belt (ha)

The emission factor from peat drainage or tidal wetland degradation in the leakage belt is determined as the amount of carbon that would be lost at PDT or SDT from undrained peatland area or intact tidal wetland area found within the leakage belt:

$$LK_{PEAT\text{-}EF\text{-}LB} = C_{loss\text{-}PDT\text{-}LB} \quad (16)$$

$$LK_{TW\text{-}EF\text{-}LB} = C_{loss\text{-}SDT\text{-}LB} \quad (17)$$

$$C_{loss\text{-}PDT\text{-}LB} = (C_{t0\text{-}LB} - C_{PDT\text{-}LB}) \times 44/12 \quad (18)$$

$$C_{loss\text{-}SDT\text{-}LB} = (C_{t0\text{-}LB} - C_{SDT\text{-}LB}) \times 44/12 \quad (19)$$

Where:

$LK_{PEAT\text{-}EF\text{-}LB}$	Emission factor from peat loss at t_{PDT} in the leakage belt (t CO_2-e ha^{-1})
$LK_{TW\text{-}EF\text{-}LB}$	Emission factor from soil organic carbon loss at t_{SDT} in the leakage belt (t CO_2-e ha^{-1})
$C_{loss\text{-}PDT\text{-}LB}$	Cumulative peat loss in the leakage belt at t_{PDT} (t CO_2-e ha^{-1})

$C_{loss\text{-}SDT\text{-}LB}$	Cumulative soil organic carbon loss in the leakage belt at t_{SDT} (t CO_2-e ha^{-1})
$C_{t0\text{-}LB}$	Soil organic carbon stock in the leakage belt at t_0 (t C ha^{-1})
$C_{PDT\text{-}LB}$	Soil organic carbon stock in the leakage belt at t_{PDT} (t C ha^{-1})
$C_{SDT\text{-}LB}$	Soil organic carbon stock in the leakage belt at t_{SDT} (t C ha^{-1})
t_{PDT}	Peat Depletion Time (years)
t_{SDT}	Soil organic carbon Depletion Time (years)

t_{PDT} can be taken from $t_{PDT\text{-}BSL,i}$ or t_{SDT} can be taken from $t_{SDT\text{-}BSL,i}$ in Section 5.5 and 5.6, respectively, of Module *X-STR*[7] or by using default values derived from the peer-reviewed literature, including default factors, where available.

$C_{t0\text{-}LB}$ must be quantified using Module *X-STR* (See $C_{BSL,i,t0}$ in Section 5.4.1). $C_{PDT\text{-}LB}$ and $C_{SDT\text{-}LB}$ (whichever is relevant) must be quantified using Module *X-STR* (See $C_{BSL,i,t100}$ in Section 5.4.1, substituting t_{PDT} or t_{SDT} for t_{100}).

$A_{LK,unplanned,}$ is the area of recorded deforestation (for AUWD or WRC-AUWD project activities) or area with degraded wetland (for stand-alone AUWD project activities) in the leakage belt in the project case in year *t* (ha). *Ex ante*, it is equal to the area used to estimate *ex-ante* project-case emissions in Step 3A above (i.e., by multiplying the estimated baseline area of deforestation or wetland degradation in the project area by a factor < 1.0 representing the % of deforestation or wetland degradation expected to be displaced into the leakage belt); *ex post*, it is obtained by applying Module *M-REDD*.

$PROP_{PEAT\text{-}OLB,}$ $LK_{PEAT\text{-}EF\text{-}OLB}$, $PROP_{TW\text{-}OLB,}$ $LK_{TW\text{-}EF\text{-}OLB}$ and $A_{LK\text{-}OLB,t}$ are estimated using the best available official or peer-reviewed data from the area outside the leakage belt and project area instead of data from the leakage belt. *Ex ante*, the value of $A_{LK\text{-}OLB,t}$ is based on the area value used to estimate $\Delta C_{P,LB}$ in Step 4 above; *ex post*, use the value of $A_{LK\text{-}OLB,t}$ estimated in Equation 9.

5.1.7 Step 6: Emissions from Leakage Prevention Activities

Where leakage prevention activities are implemented, the emissions from biomass burning and fertilizer usage must be counted and conservatively included in their entirety as emissions caused by project implementation. Stratification of leakage prevention activities must be on the basis of biophysical parameters.[8]

$$GHG_{LK,E} = \sum_{t=1}^{t^*}\sum_{i=1}^{M}\left(E_{BiomassBurn,i,t} + N_2O_{direct-N,i,t}\right) \quad (20)$$

[7] Noting that similarity in peat depth (for PDT) or soil organic carbon content (for SDT) and land use with stratum *i* referred to must be demonstrated; t_{PDT} and t_{SDT} may be assumed to exceed the project crediting period and are limited to t=100.
[8] E.g., soil type, elevation, precipitation regime, temperature, slope and aspect

Where:

$GHG_{LK,E}$	Greenhouse gas emissions as a result of leakage prevention activities up to year t^* (t CO_2-e)
$E_{biomassburn,i,t}$	Non-CO_2 emissions due to biomass burning in stratum i in year t (t CO_2e)
$N_2O_{direct\text{-}N,i,t}$	Direct N_2O emission as a result of nitrogen application on the alternative land use in stratum i in year t (t CO_2e)
i	1, 2, 3 …M strata
t	$1, 2, 3 \ldots t^*$ time elapsed since the start of the project activity (years)

5.1.8 Step 7: Estimation of Total Leakage Due to the Displacement of Unplanned Deforestation

$$\Delta C_{LK\text{-}AS,unplanned} = \Delta C_{LK\text{-}A\ SU\text{-}LB} + \Delta C_{LK\text{-}ASU\text{-}OLB} + GHG_{LK,E} \quad (21)$$

$$GHG_{LK\text{-}WRC\text{-}AS,unplanned} = \Delta C_{LK\text{-}ASU\text{-}PEAT} + \Delta C_{LK\text{-}ASU\text{-}TW} \quad (22)$$

Where:

$\Delta C_{LK\text{-}AS,unplanned}$	Net greenhouse gas emissions due to activity shifting leakage for projects preventing unplanned deforestation Net CO_2 emissions up to year t^* (t CO_2e)
$\Delta C_{LK\text{-}ASU\text{-}OLB}$	Net CO_2 emissions due to unplanned deforestation displaced outside the leakage belt up to year t^* (t CO_2e)
$\Delta C_{LK\text{-}ASU\text{-}LB}$	Net CO_2 emissions due to unplanned deforestation displaced from the project area to the leakage belt up to year t^* (t CO_2e)
$GHG_{LK,E}$	Greenhouse gas emissions as a result of leakage prevention activities up to year t^*; see Equation 18 (t CO_2-e)
$GHG_{LK\text{-}WRC\text{-}AS,unplanned}$	Net GHG emissions due to wetland degradation from unplanned deforestation displaced from the project area up to year t^* (t CO_2e)
$\Delta C_{LK\text{-}ASU\text{-}PEAT}$	Net GHG emissions due to peatland drainage from unplanned deforestation displaced from the project area up to year t^* (t CO_2e)
$\Delta C_{LK\text{-}ASU\text{-}TW}$	Net GHG emissions due to tidal wetland degradation from unplanned deforestation displaced from the project area up to year t^* (t CO_2e)

5.2 CIW Project Activities

For stand-alone CIW project activities, the procedures provided in Section 5.1.6 and 5.1.7 can be applied here, *mutatis mutandis*, noting that:

- $A_{LK,unplanned,t}$ represents Area of recorded degradation of wetland in the leakage belt in the project case in year t (ha); and

- Direct N_2O emission as a result of nitrogen application on the alternative land use do not occur as per the applicability conditions for WRC in *REDD+ MF*.

$$GHG_{LK\text{-}WRC\text{-}AS,unplanned} = \Delta C_{LK\text{-}ASU\text{-}PEAT} + \Delta C_{LK\text{-}ASU\text{-}TW} + GHG_{LK,E} \quad (23)$$

Where:

$GHG_{LK\text{-}WRC\text{-}AS,unplanned}$	Net GHG emissions due to wetland degradation from unplanned wetland degradation displaced from the project area up to year *t** (t CO_2e)
$\Delta C_{LK\text{-}ASU\text{-}PEAT}$	Net GHG emissions due to peatland drainage from unplanned deforestation displaced from the project area up to year *t** (t CO_2e)
$\Delta C_{LK\text{-}ASU\text{-}PEAT}$	Net GHG emissions due to tidal wetland degradation from unplanned deforestation displaced from the project area up to year *t** (t CO_2e)
$GHG_{LK,E}$	Greenhouse gas emissions as a result of leakage prevention activities up to year *t**; see Equation 18 (t CO_2-e)

6 PARAMETERS

6.1 Data and Parameters Available at Validation

Data / Parameter	$\Delta C_{BSL,LK,unplanned}$
Data unit	t CO_2e
Description	Net CO_2 emissions in the baseline from unplanned deforestation in the leakage belt
Equations	1, 6
Source of data	Module *BL-UP*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module *BL-UP*
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	C_{LB}
Data unit	t CO_2e ha^{-1}
Description	Area-weighted average aboveground tree carbon stock for forests available for unplanned deforestation inside the leakage belt

Equations	4
Source of data	Literature, field surveys
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Calculate from field measurements using Module *CP-AB*. As forests in the leakage belt are deforested, the area weighted average must be recalculated at each monitoring period.
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	C_{OLB}
Data unit	t CO_2e ha^{-1}
Description	Area-weighted average aboveground tree carbon stock for forests available for unplanned deforestation outside the leakage belt
Equations	4
Source of data	Literature, field surveys
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Either: 1. Calculate directly from field measurements using Module *CP-AB* 2. Use numbers derived from peer-reviewed literature that are nationally or at least regionally appropriate Areas included in the calculation of C_{OLB} must be limited to areas demonstrated to be suitable for agriculture or livestock ranching. Demonstration must be through existing areas of agriculture or livestock ranching on adjacent lands with the same soil type and climate. Areas unsuitable for agriculture or livestock such as areas that are excessively dry, flooded or nutrient poor must be excluded. The available national forest area and *MANFOR* and *PROTFOR* will change over time. The area-weighted average must be recalculated at least every 5 years.
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$A_{BSL,PA\text{-}unplanned,t}$
Data unit	ha
Description	Projected area of unplanned baseline deforestation in the project area in year *t*
Equations	7
Source of data	Module *BL-UP*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module *BL-UP*
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$A_{PEAT\text{-}LB}$
Data unit	ha
Description	Total undrained peatland area found within the leakage belt
Equations	14, 16
Source of data	Module *M-REDD*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	For mapping $A_{PEAT\text{-}LB}$, see procedures in Module *M-REDD* for the *Leakage Belt Wetland Benchmark Map.* As peatlands in the leakage belt are drained, the area must be recalculated at each monitoring period.
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	$A_{TW\text{-}LB}$
Data unit	ha
Description	Total intact or partially degraded tidal wetland area found within the leakage belt
Equations	15, 17
Source of data	Module *M-REDD*
Value applied	N/A

Justification of choice of data or description of measurement methods and procedures applied	For mapping $A_{TW\text{-}LB}$, see procedures in Module *M-REDD* for the *Leakage Belt Wetland Benchmark Map.* As peatlands in the leakage belt are drained, the area must be recalculated at each monitoring period.
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter	A_{LB}
Data unit	ha
Description	Total area of the leakage belt
Equations	15, 17
Source of data	Module *M-REDD*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	For mapping A_{LB}, see procedures in Module *M-REDD* for the *Leakage Belt Wetland Benchmark Map.* As tidal wetlands in the leakage belt are degraded, the area must be recalculated at each monitoring period.
Purpose of Data	Calculation of leakage emissions
Comments	N/A

Data / Parameter:	*Leakage Belt Forest Cover Benchmark Map / Leakage Belt Wetland Benchmark Map*
Data unit:	
Description:	Map showing the location of forest land or wetland within the leakage belt area at the beginning of each monitoring period. Only applicable where leakage is to be monitored in a leakage belt
Equations	3, 14, 15
Source of data:	Module *M-REDD*
Description of measurement methods and procedures to be applied:	See Module *M-REDD*
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.

Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

6.2 Data and Parameters Monitored

Data / Parameter:	*MANFOR*
Data unit:	ha
Description:	Total area of forests under active management nationally
Equations	2
Source of data:	Official data, peer reviewed publications and other verifiable sources
Description of measurement methods and procedures to be applied:	A demonstration is required that areas will be protected against deforestation. Such a demonstration must include the existence of forest guards in sufficient numbers to prevent illegal colonization and an active management plan detailing harvest plans and return intervals, and/or evidence that the concession owner has previously evicted illegal colonists/squatters from the forest areas. *Ex-ante* it can be assumed that *MANFOR* must remain constant.
Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	*PROTFOR*
Data unit:	ha
Description:	Total area of fully protected forests nationally
Equations	2
Source of data:	Official data, peer reviewed publications and other verifiable sources
Description of measurement methods	A demonstration is required that areas will be protected against deforestation. Such a demonstration must include either:

and procedures to be applied:	1. Designation as a UNESCO World Heritage Site, or 2. Management by an international NGO, or 3. Evidence that the government has immediately acted to evict any and all illegal squatters *Ex ante* it can be assumed that *PROTFOR* must remain constant.
Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	*TOTFOR*
Data unit:	ha
Description:	Total available national forest area
Equations	2
Source of data:	Official data, peer reviewed publications, remotely sensed imagery (coarse scale imagery is appropriate) or cadastral maps and other verifiable sources
Description of measurement methods and procedures to be applied:	Limited to forest areas within 5 km of roads and rivers suitable for conversion to agriculture / livestock *Ex ante* it can be conservatively be assumed that *TOTFOR* must remain constant for the baseline period.
Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$\Delta C_{P,LB}$
Data unit:	t CO_2e
Description:	Net greenhouse gas emissions within the leakage belt in the project case
Equations	1, 6
Source of data:	Module *M-REDD*
Description of measurement methods and procedures to be applied:	See Module *M-REDD*
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Chapter 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$PROP_{IMM}$
Data unit:	Proportion
Description:	Estimated proportion of baseline deforestation caused by immigrating population
Equations	5, 7, 8
Source of data:	The source of data must be chosen with priority from higher to lower preference as follows: 1. Official (government) data 2. Peer-reviewed published sources 3. Other verifiable sources 4. PRA
Description of measurement methods and procedures to be applied:	Estimated as proportion of the area deforested in the past 5 years by population that migrated into the leakage belt and project area in the past 5 years (all areas within 2 km of the boundaries of the project area and the leakage belt must be considered here)

Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event. *Ex ante* it can be assumed that $PROP_{IMM}$ will remain constant during the baseline period.
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$PROP_{RES}$
Data unit:	Proportion
Description:	Estimated proportion of baseline deforestation caused by population that has been resident for ≥5 years
Equations	N/A
Source of data:	The source of data must be chosen with priority from higher to lower preference as follows: 1. Official (government) data 2. Peer-reviewed published sources 3. Other verifiable sources 4. PRA
Description of measurement methods and procedures to be applied:	Estimated as proportion of the area deforested in the past 5 years by population resident in the leakage belt and project area for ≥5 years (all areas within 2km of the boundaries of the project area and the leakage belt must be considered here). *Ex ante* it can be assumed that $PROP_{RES}$ will remain constant during the baseline period
Frequency of monitoring/recording:	Must be monitored at least every 5 years or if verification occurs on a frequency of less than every 5 years examination must occur prior to any verification event
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$A_{DefLB,i,t}$
Data unit:	ha
Description:	Area of recorded deforestation in the leakage belt in the project case in stratum *i* in year *t*
Equations	8
Source of data:	Module *M-REDD*
Description of measurement methods and procedures to be applied:	See Module *M-REDD*
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$A_{DefPA,i,t}$
Data unit:	ha
Description:	Area of recorded deforestation in the project area in the project case in stratum *i* in year *t*
Equations	8
Source of data:	Module *M-REDD*
Description of measurement methods and procedures to be applied:	See Module *M-REDD*
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$E_{biomassburn,i,t}$
Data unit:	t CO_2e
Description:	Non-CO_2 emissions due to biomass burning in stratum *i* in year *t*
Equations	12
Source of data:	Module *E-BPB*
Description of measurement methods and procedures to be applied:	See module *E-BPB*
Frequency of monitoring/recording:	See module *E-BPB*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$N_2O_{direct\text{-}N,i,t}$
Data unit:	t CO_2e
Description:	Direct N_2O emission as a result of nitrogen application in stratum *i* in year *t*
Equations	12
Source of data:	Module *E-NA*
Description of measurement methods and procedures to be applied:	See module *E-NA*
Frequency of monitoring/recording:	See module *E-NA*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	C_{PDT-LB}
Data unit:	t C ha^{-1}
Description:	Soil organic carbon stock in the leakage belt at t_{PDT}
Equations	18
Source of data:	Module *X-STR*
Description of measurement methods and procedures to be applied:	Refer to $C_{BSL,i,t100}$ in Section 5.4.1 in Module *X-STR*, and substitute t_{PDT} for t_{100}
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	C_{SDT-LB}
Data unit:	t C ha^{-1}
Description:	Soil organic carbon stock in the leakage belt at t_{SDT}
Equations	19
Source of data:	Module *X-STR*
Description of measurement methods and procedures to be applied:	Refer to $C_{BSL,i,t100}$ in Section 5.4.1 in Module *X-STR*, and substitute t_{SDT} for t_{100}
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	C_{t0-LB}
Data unit:	t C ha^{-1}
Description:	Soil organic carbon stock in the leakage belt at t_0

Equations	18, 19
Source of data:	Module *X-STR*
Description of measurement methods and procedures to be applied:	Refer to $C_{BSL,i,t0}$ in Section 5.4.1 in Module *X-STR*
Frequency of monitoring/recording:	See Module *M-REDD*
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of leakage emissions
Calculation method:	N/A
Comments:	N/A

7 REFERENCES

None.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version
v1.1	9 March 2015	The module was updated to include activities on peatlands.
v1.2	8 Sep 2020	The module was updated to include activities on tidal wetlands.