

VMD0036

GLOBAL COMMODITY LEAKAGE MODULE: EFFECTIVE AREA APPROACH (LM-EA)

Version 1.0

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Sectoral Scope 14

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1 SOURCES

The following have informed the development of the module:

- VCS Leakage Working Group
- VCS document *AFOLU Requirements*
- VCS document *JNR Requirements*
- VCS document *Program Definitions*

2 SUMMARY DESCRIPTION OF THE MODULE

This module estimates the global commodity leakage value that is expected to result from REDD+ activities in the jurisdiction. The global commodity leakage value, expressed as a percentage, is used to determine the global commodity leakage deduction within the VCS *JNR Leakage Tool* (ie, a 4 percent global commodity leakage value results in a leakage deduction of 4 for the global commodity leakage category in the tool).

The global commodity leakage value is calculated based on the amount of land on which deforestation (and degradation, where relevant)¹ is avoided, and whether the loss of production is compensated for by increasing production elsewhere in the jurisdiction without contributing to deforestation (and degradation). This module focuses on the effective area of production which represents the difference between the production (or area and yields) observed during the program crediting period and an estimated baseline of production within the jurisdiction. The effective area is compared to the area on which deforestation (and degradation) is avoided to estimate the potential area subject to leakage. This approach considers the aggregate levels of production of relevant global commodities within the jurisdiction rather than on units of production of every commodity that might have occurred on that land. The underlying premise behind this approach is that the land is a limited resource but commodity production can be reallocated across the land base in a variety of different ways. Therefore, this approach does not require data about commodity-specific production lost from areas of reduced deforestation (and degradation), and it allows aggregation across different commodities with different units. It also reflects that the effective area of production in a jurisdiction can be increased by increasing yields or agricultural intensification as well as bringing new land into agricultural production.

The potential area of production subject to leakage is used to estimate the leakage emissions resulting from displaced deforestation (and degradation) outside the jurisdiction but within the country. First, an econometric factor is applied to estimate how much of the foregone production will result in increases in supply outside of the jurisdiction due to market effects. The increased area of supply is used to calculate how much of the supply will be made up through new land

¹ For the purposes of this module, degradation is relevant where the jurisdictional program scope includes accounting for reducing emissions from forest degradation. All "(and degradation)" references throughout the document should be read as, "(and degradation, where relevant)".

being brought into production. The module then determines how much of the new land brought into production will result in deforestation.

Since global commodities are linked to international markets, this method assumes that such commodity production will shift to areas outside the jurisdiction both domestically and internationally. The final step of the leakage module is to estimate how much of this deforestation (and degradation) will occur within the country but outside of the jurisdiction. This follows UNFCCC policy that a country is only responsible for accounting for GHG emissions occurring within the country. The module determines the share of leakage that remains in the country based on either the share of recent global deforestation (and degradation) emissions occurring within the country, or the share of global forest carbon stocks at-risk of deforestation (and degradation) existing within the country, whichever is greater. These factors are then applied to estimate the percentage of the area of deforestation (and degradation) that would result in leakage emissions to other forests within the country. The amount of deforestation (and degradation) already accounted for by other jurisdictional REDD+ programs within the country is also considered. Finally this approach applies the average carbon stocks of forests within the country to estimate the global commodity leakage value. This global commodity leakage value can then be used in coordination with the *VCS JNR Leakage Tool*.

This module was developed with a working group composed of leading practitioners and experts on jurisdictional REDD+ and has undergone peer review and public consultation, including review and testing by jurisdictional governments that are applying the VCS JNR framework.²

3 DEFINITIONS

For the purpose of this module, the definition below applies. See VCS documents *Program Definitions*, *JNR Requirements* and *AFOLU Requirements*, and *VCS JNR Leakage Tool*, for further specification on terms and definitions used within this document.

Effective Area

The difference between the area of production observed within the jurisdiction and the area required to maintain the projected baseline levels of production

4 APPLICABILITY CONDITIONS

This module is applicable to jurisdictional programs seeking to estimate a global commodity leakage value as referenced by the *VCS JNR Leakage Tool*.

The module is applicable under the following conditions:

- The jurisdictional program applies a Scenario 2 or Scenario 3 approach (see VCS document *JNR Requirements* for a description of the scenarios).

² VCS JNR Leakage Working Group members can be found at: <http://www.v-c-s.org/node/620>

- The jurisdictional program is subnational in scope, or the jurisdictional program is national and the tool is being used to estimate and address leakage within the country.
- The jurisdictional program affects the production of relevant global commodities.

5 PROCEDURES

Where the jurisdictional program only includes activities that reduce emissions from deforestation, estimate the leakage emissions from commodities driving deforestation. Where the jurisdictional program includes activities that reduce emissions from deforestation and degradation, estimate the leakage emissions from both deforestation and degradation. Unless otherwise noted, when applying this module to calculate a global commodity leakage value for degradation, deforestation should be read as degradation. The module must be run separately for leakage resulting from deforestation and for leakage resulting from avoided degradation (where relevant). This will result in one global commodity leakage value for deforestation and one for degradation for each year in the monitoring period.

Where this module is applied to determine a global commodity leakage value for both deforestation and degradation, the analysis must consider whether relevant global commodities drive deforestation and/or degradation. For example, forest or plantation crops driving degradation (eg, palm oil or coffee production) that degrade forests but maintain a forest land use should be considered in the analysis of degradation. Agricultural crops and livestock that drive deforestation (ie, that maintain a non-forest land use) should be considered during the deforestation analysis. Where a relevant global commodity drives both deforestation and degradation, such commodity must conservatively be included in the analysis for both deforestation and degradation.

5.1 Area of Production Subject to Leakage

This section evaluates whether, and to what extent, the jurisdiction has experienced a net decline in land area suitable for commodity production as a result of the jurisdictional program. This is achieved by monitoring the number of hectares of avoided deforestation over the monitoring period (as reported in the jurisdictional monitoring report) and evaluating whether the jurisdiction has made up an amount of production equivalent to the amount that would have been produced on that area for each year during this period (ie, the effective area), as calculated in Section 5.1.4.

All areas of agricultural commodity production are treated as equivalent for the purpose of mitigating leakage given that agricultural land is fungible across different uses within a globally linked market. For example, where deforested land would have been used to produce 1000 hectares of agricultural commodity X, the leakage pressure from avoiding this deforestation and thus the agricultural production on that land can be equivalently mitigated if the jurisdictional

program adds an additional 1000 hectares of commodity X or of any other commodity Y somewhere else within its borders.³

This analysis must be conducted for, at minimum, each relevant global commodity j associated with driving deforestation within the jurisdiction, identified using the procedures in the VCS *JNR Leakage Tool*. Global commodities include agricultural products, forest product and livestock products that are linked to international markets. A commodity is considered linked to international markets where a significant amount of the country's production of that commodity is traded on international commodities markets, given as more than 5 percent of the country's total production of a given commodity being traded on international commodities markets. Since this module is designed to assess the shifts from one commodity to another, other global commodities that may be substituted for relevant global commodities should also be considered. Illegal commodities (eg, coca) must not be included within this analysis, as set out in the VCS *JNR Leakage Tool*. The procedures in Section 5.1.3 describe how such relevant global commodities should be summed to calculate the total effective area for the jurisdictional program.

5.1.1 Baseline Amount of Production

Evaluating jurisdictional market leakage requires estimating the baseline amount of production for each relevant global commodity within the jurisdiction. Production for each crop, livestock or forest commodity j at time t and the planted acreage must be considered to evaluate commodity yields. It is important to use data specific to the jurisdiction in order to be able to demonstrate performance. Apply annual data from each year included in the historical reference period used to develop the jurisdictional baseline to determine a baseline amount of production. Where annual data is not available throughout the historical reference period, provide justification that the years in which data is available are representative of such period. The commodity yield is defined as total production divided by total acreage, as set out in equation 1 below:

$$y_{j,t} = \frac{p_{j,t}}{a_{j,t}} \quad \text{or} \quad \bar{y}_{j,h} = \frac{\bar{p}_{j,h}}{\bar{a}_{j,h}} \quad (1)$$

Where:

$y_{j,t}$ = Commodity yield for commodity j at time t (tonnes / ha)

$p_{j,t}$ = Production for commodity j at time t (tonnes)

$a_{j,t}$ = Area of production for commodity j at time t (ha)

$y_{j,h}$ = Commodity yield for commodity j in year h of the historical reference period (tonnes / ha)

$\bar{p}_{j,h}$ = Production of commodity j in year h of the historical reference period (tonnes)

$\bar{a}_{j,h}$ = Area of production for commodity j in year h of the historical reference period (ha)

³ In practice, given that all land is not equally suitable for all agricultural uses, the chain of causality is likely to be more complex such that, for example, by producing commodity Y, this frees up land elsewhere to produce another commodity Z, which in turns frees up the land somewhere to produce commodity X.

Historical production data is used to estimate baseline commodity production. The method to estimate the baseline commodity production depends on the method applied by the jurisdictional program to develop the most plausible jurisdictional baseline scenario. The baseline scenario may be developed based on a historical annual average or a historical trend of GHG emissions or removals and the baseline may include modeled adjustments (as set out in VCS document *JNR Requirements*).

Where the jurisdictional baseline is developed using the historical annual average GHG emissions or removals (without modeled adjustments), estimate the level of production required to maintain existing production within the jurisdiction using either the historical annual average amount of production or the historical trends in production (as set out in the VCS *JNR Leakage Tool*). Procedures for conducting the historical annual average analysis are provided in the corresponding sub-section below.

Where the jurisdictional baseline is developed using the historical annual average with modeled adjustments or historical trend of GHG emissions or removals, estimate the level of production required to maintain the existing trend of production within the jurisdiction using the historical trend in production (as set out in the VCS *JNR Leakage Tool*). Such historical trend of production is projected throughout the program crediting period to estimate increases in yield and/or planted acreage. Procedures for conducting the historical trend analysis are provided in the corresponding sub-section below.

Historical Annual Average Analysis

Where the jurisdictional baseline is developed using the historical annual average GHG emissions or removals, a historical annual average of production for each commodity j may be applied to calculate baseline production, based on a historical record of total annual production within the jurisdiction. The baseline level of production for each commodity j in year t is defined in equation 2 below. This baseline level of production will be the same for every year during the program crediting period.

$$\bar{p}_{j,t} = \frac{\sum_{h=1}^H (\bar{p}_{j,h})}{H} \quad \text{or} \quad \bar{p}_{j,t} = \frac{\sum_{h=1}^H (\bar{a}_{j,h} * \bar{y}_{j,h})}{H} \quad (2)$$

Where:

- $\bar{p}_{j,t}$ = Baseline production of commodity j in year t (tonnes)
- $\bar{p}_{j,h}$ = Production of commodity j in year h of the historical reference period (tonnes)
- H = Number of historical reference years
- $\bar{a}_{j,h}$ = Area of production for commodity j in year h of the historical reference period (ha)
- $\bar{y}_{j,h}$ = Commodity yield for commodity j in year h of the historical reference period (tonnes / ha)

The baseline production of commodity j must be calculated using data from the same historical reference period used to develop the jurisdictional baseline. Where data for total production of relevant global commodities within the jurisdiction during the historical reference period ($\bar{p}_{j,h}$) is not available, data on the area under production and commodity yields for such commodities may be used to calculate the baseline production of commodity j at time t .

Historical Trend Analysis

Where the jurisdictional baseline is developed using the historical annual average with modeled adjustments or historical trend of GHG emissions or removals, a historical trend in production for each relevant global commodity j must be applied to calculate baseline production, based on the historical annual average production within the jurisdiction and a growth rate. Where the jurisdictional baseline is developed using the historical annual average GHG emissions or removals, a historical trend analysis may also be applied to calculate baseline production.

The baseline level of production for each commodity j at time t is calculated by applying an annual growth rate r_j to the historical annual average production as set out in equation 3 below.

$$\bar{p}_{j,t} = \frac{\sum_{h=1}^H (\bar{p}_{j,h})}{H} * (1 + r_j)^t \quad \text{or} \quad \bar{p}_{j,t} = \frac{\sum_{h=1}^H (\bar{a}_{j,h} * \bar{y}_{j,h})}{H} * (1 + r_j)^t \quad (3)$$

Where:

- $\bar{p}_{j,t}$ = Baseline production of commodity j in year t (tonnes)
- $\bar{p}_{j,h}$ = Production of commodity j in year h of the historical reference period (tonnes)
- H = Number of historical reference years
- r_j = Growth rate of production for commodity j (percent); or the default value (2.5 percent)
- t = Years since program crediting period start date
- $\bar{a}_{j,h}$ = Area of production for commodity j in year h of the historical reference period (ha)
- $\bar{y}_{j,h}$ = Commodity yield for commodity j in year h of the historical reference period (tonnes / ha)

Where data regarding the historical production of relevant global commodities within the jurisdiction is not available, data on the area of production and commodity yields for such commodities can also be used to develop the historical trend in production. Calculate the baseline production of commodity using data from the same historical reference period used to develop the jurisdictional baseline.

This module uses a conservative default growth rate of commodities of 2.5 percent, based on peer reviewed agricultural studies.⁴ Apply the default growth rate, or where data on trends in commodity production within the jurisdiction are available, justify a more accurate jurisdiction-specific growth rate for commodity j based on government-approved or peer-reviewed studies on growth trends within the jurisdiction. Where a jurisdiction-specific growth rate is applied, the

⁴ See Appendix 2 for additional background information.

growth rate must be calculated using data from the same historical reference period used to develop the jurisdictional baseline. Growth rates are expected to increase over time with technological improvements in agriculture.

5.1.2 Change in the Amount of Production

For each relevant global commodity j , estimate the difference between observed production and baseline production (as calculated in Section 5.1.1) for each year included in the monitoring period (eg, a monitoring period that includes data from 2011, 2012 and 2013 will calculate the change in production for each of these years). Where annual data is not available throughout the monitoring period, provide estimates of the production for the years where data was not available and justify that such estimates are appropriate. The change in production⁵ for each relevant global commodity j in year t is calculated as follows:

$$\tilde{p}_{j,t} = p_{j,t} - \bar{p}_{j,t} \quad \text{or} \quad \tilde{p}_{j,t} = a_{j,t}y_{j,t} - \bar{p}_{j,t} \quad (4)$$

Where:

- $\tilde{p}_{j,t}$ = Change in production of commodity j in year t (tonnes)
- $p_{j,t}$ = Observed production of commodity j in year t (tonnes)
- $\bar{p}_{j,t}$ = Baseline production of commodity j in year t (tonnes)
- $a_{j,t}$ = Observed area of production for commodity j in year t (ha)
- $y_{j,t}$ = Commodity yield for commodity j in year t (tonnes / ha)

5.1.3 Effective Area of Production

The change in production (as calculated in Section 5.1.2) must be converted into an area of production using the historical commodity yield to determine the effective area of production for each relevant global commodity. The effective area of production represents the area of production required to produce the change in the production if the observed yields had remained the same as under the baseline. The effective area is calculated as follows:

⁵ This change in production may come from an increase in area or yields. While increasing area might temporarily mitigate leakage, only increasing yields will allow the jurisdiction to continue increasing production in the long term so it is important to keep track of both $a_{j,t}$ and $y_{j,t}$ rather than just $p_{j,t}$.

$$\tilde{a}_{j,t} = \tilde{p}_{j,t} * \frac{H}{\sum_{h=1}^H \bar{y}_{j,h}} \tag{5}$$

Where:

- $\tilde{a}_{j,t}$ = Effective area for commodity j in year t (ha)
- $\tilde{p}_{j,t}$ = Change in production of commodity j in year t (tonnes)
- $\bar{y}_{j,h}$ = Commodity yield for commodity j in year h of the historical reference period (tonnes / ha)
- H = Number of historical reference years

In practice, the change in effective area, $\tilde{a}_{j,t}$, can potentially be positive or negative (or zero). The effective area must be summed across all the relevant global commodities to estimate the total effective area for the jurisdictional program. The total effective area is the summation across the total number of relevant global commodities as follows:

$$\tilde{a}_t = \sum_{j=1}^J \tilde{a}_{j,t} \tag{6}$$

Where:

- \tilde{a}_t = Total effective area in year t (ha)
- $\tilde{a}_{j,t}$ = Effective area for commodity j in year t (ha)
- J = Total number of relevant global commodities

Note that the effective area could increase in aggregate for the jurisdiction at the same time that there is an increase or decrease for individual commodities.⁶

5.1.4 Area of Production Subject to Leakage

The potential area of leakage is the estimated difference between the area where production of relevant global commodities would have occurred (which is conservatively assumed to be equivalent to the area of avoided deforestation) and the total effective area as follows:

⁶ Reallocation of existing land among different crops could also produce changes in effective area in theory, though such changes might not occur on a significant scale in practice. For example, if a jurisdiction has one hectare of low quality land (measured by productivity) producing one unit of crop A and one hectare of high quality land producing one unit of crop B (with the potential to produce two units of A) and the jurisdiction shifts its hectares of high quality cropland producing crop B to produce crop A instead, it would then produce three units of A and zero units of B. This would then represent a 50 percent increase of effective area of production from two to three units. This would capture the shifts that are most likely to occur in terms of leakage mitigation if indeed it is the lowest quality land that is the margin for expansion into the forest, as assumed here.

$$l_t = \tilde{d}_t - \tilde{a}_t \tag{7}$$

Where:

- l_t = Potential area of leakage in year t (ha)
- \tilde{d}_t = Area of avoided deforestation in year t (ha)
- \tilde{a}_t = Total effective area in year t (ha)

The area of avoided deforestation, \tilde{d}_t , includes the total area of deforestation prevented as specified in the monitoring report. This approach conservatively assumes that all deforestation within the jurisdiction is driven by relevant global commodities and that the productivity on land being deforested is equivalent across all land within the jurisdiction.

Where the potential area of leakage in year t is less than or equal to zero (ie, $l_t \leq 0$), there is no potential leakage from the jurisdictional program and the calculation ends. The jurisdiction has more than made up for the maximum potential global commodity leakage effects from REDD+ within its border when the total effective area is greater than the area of forest land within the jurisdiction.

Where the potential area of leakage in year t is greater than zero (ie, $l_t > 0$), there is potential for leakage as the area of production avoided by the jurisdictional program has not been fully replaced within the jurisdiction. Thus there is a net reduction in the area of production within the jurisdiction which will likely shift to areas outside the jurisdiction. Sections 5.2 and 5.3 estimate how much of this potential area of leakage, l_t , will result in deforestation and how much will remain within the country, rather than shifting internationally.

5.2 Deforestation Caused by Leakage

Where the global commodities are linked to international markets and the potential area of leakage in year t (as calculated in Section 5.1.4) is greater than zero (ie, $l_t > 0$), estimate the total increase in deforestation outside the jurisdiction in year t using equation 8.

$$ID_t = l_t * IS * NL * NLD \tag{8}$$

Where:

- ID_t = Increase in deforestation outside the jurisdiction in year t (ha)
- l_t = Potential area of leakage in year t (ha)
- IS = 75 percent; Proportion of leakage resulting in increased supply outside the jurisdiction
- NL = Proportion of increased supply coming from new land brought into production; or the default value (40 percent)
- NLD = Proportion of new land brought into agricultural production resulting in deforestation; or the default value (100 percent)

A brief summary of the default values and the procedures for applying alternative values is provided below. Appendix 2 contains additional background information regarding how the default values were developed.

Amount of Increased Supply

A fundamental premise of market leakage is that where production is decreased by one unit, then production in other locations will replace some, but not all, of the forgone production. This module uses a conservative default value of 75 percent for *IS*, which assumes that 75 percent of the production lost due to the jurisdictional program is made up through increases in supply outside the jurisdiction.

Amount from New Land Brought into Production

The increases in supply of these global commodities due to the jurisdictional program may or may not result in deforestation. Supply increases from bringing new land into production may result in deforestation, while supply increases from agricultural intensification and increases in yields will not lead to deforestation. This module uses a conservative default value of 40 percent for *NL*, which assumes that 40 percent of the increase in supply outside the jurisdictional program is made up through bringing new land into production.

Where the default value is not applied for *NL*, provide evidence justifying the use of a different value for the percent of supply increase coming from new land brought into production within the country. Such evidence may include government-approved or peer-reviewed studies of the amount of production increases coming from new land brought into agricultural production within the country.

Area Resulting in Deforestation

Of the area of new land brought into production, some of this land will be forested land while some will be marginal land with low carbon stocks. This module uses a conservative default value of 100 percent for *NLD*, which assumes that all of the new land brought into production will result in deforestation.

Where the default value is not applied for *NLD*, provide evidence justifying the use of a different value for the percent of new land brought into production that will result in deforestation within the country. Such evidence may include government-approved or peer-reviewed studies of the amount of production increases that result in deforestation within the country. Where equation 8 is applied to calculate the increase in degradation outside the jurisdiction the default value must be applied, as forest degradation can only occur on forested land.

5.3 Domestic Share of Leakage

5.3.1 Domestic Share of At-Risk Forests

After determining the amount of leakage resulting in deforestation, the next step is to estimate how much of this deforestation is likely to occur outside the jurisdiction but within the country. UNFCCC policy establishes that countries are only responsible for their own GHG emissions. As such, a jurisdiction or country reporting GHG emission reductions or removals does not report emission increases that may occur in other countries as a result of the activities of the reporting country. Therefore the jurisdictional program must estimate the domestic share of at-risk forests to determine how much of this global deforestation is likely to occur within the country. The share of at-risk forests can be calculated using one of the following approaches:

- 1) The percentage of global deforestation during the historical reference period that occurred in the country, as a proxy for historical at-risk forests (equation 10); or
- 2) The percentage of global at-risk forest carbon stocks during the historical reference period that are located within the country, as a proxy for future at-risk forests (equation 11).

Conservatively select the metric that yields the highest percentage, as set out in equation 9 (and expanded upon in equations 10 and 11) below:

$$s_t = \max(s_d, s_{cs}) \quad (9)$$

$$s_{d,t} = \frac{d_d}{g_d} \quad (10)$$

$$s_{cs,t} = \frac{d_{cs}}{g_{cs}} \quad (11)$$

Where:

- s = Country's share of global leakage (percent)
- s_d = Country's share of global deforestation (percent)
- s_{cs} = Country's share of global at-risk forest carbon stocks (percent)
- d_d = Area of deforestation within the country (ha)
- g_d = Area of deforestation globally (ha)
- d_{cs} = At-risk forest carbon stocks within the country (tonnes C)
- g_{cs} = At-risk forest carbon stocks globally (tonnes C)

5.3.2 Other REDD+ Programs

Next estimate the share of leakage resulting in deforestation within the country that is outside any other jurisdictional REDD+ program that monitors and accounts for GHG emissions (ie, to estimate unaccounted leakage within the country). This share is evaluated using either the percentage of global deforestation during the historical reference period or the percentage of global at-risk forest carbon stocks, as described above. Where the country does not include any

other jurisdictional REDD+ programs or data is not available, the share of unaccounted leakage within the country can be set conservatively as 100 percent.

Conservatively select the metric that yields the highest percentage, as set out in equation 12 (and expanded upon in equations 13 and 14) below:

$$u = \max(u_d, u_{cs}) \quad (12)$$

$$u_d = \frac{d_d - R_d}{d_d} \quad (13)$$

$$u_{cs} = \frac{d_{cs} - R_{cs}}{d_{cs}} \quad (14)$$

Where:

- u = Share of unaccounted leakage within the country (percent)
- u_d = Share of unaccounted deforestation within the country (percent)
- u_{cs} = Share of unaccounted at-risk forest carbon stocks within the country (percent)
- d_d = Area of deforestation within the country (ha)
- R_d = Area of deforestation accounted for under other jurisdictional programs within the country (ha)
- d_{cs} = At-risk forest carbon stocks within the country (tonnes C)
- R_{cs} = At-risk forest carbon stocks accounted for under other jurisdictional programs within the country (tonnes C)

5.3.3 Domestic Deforestation Caused by the Jurisdictional Program

Using the country's share of global leakage and the share of unaccounted leakage within the country, calculate the increase in domestic deforestation caused by the jurisdictional program following equation 15 below.

$$IDD_t = ID_t * s * u \quad (15)$$

Where:

- IDD_t = Increase in domestic deforestation outside the jurisdiction in year t (ha)
- ID_t = Increase in deforestation outside the jurisdiction in year t (ha)
- s = Country's share of global leakage (percent)
- u = Share of unaccounted leakage within the country (percent)

5.4 Leakage Emissions

Finally, calculate the global commodity leakage value expected to result from deforestation occurring outside the jurisdiction (but within the country) due to forgone production of goods within the jurisdiction.

The global commodity leakage value, expressed as a percent, is calculated using the increase in domestic deforestation outside the jurisdiction in year t (calculated in Section 5.3) and the area of avoided deforestation by the jurisdictional program as shown in equation 16.

$$X_t = \frac{IDD_t}{\tilde{d}_t} \tag{16}$$

Where:

X_t = Global commodity leakage value for deforestation in year t (percent)

IDD_t = Increase in domestic deforestation outside the jurisdiction in year t (ha)

\tilde{d}_t = Area of avoided deforestation by the jurisdictional program in year t (ha)

This module assumes that the carbon stocks per hectare within the jurisdiction are equivalent to the carbon stocks per hectare in forests subject to deforestation outside the jurisdiction but within the country.⁷ The global commodity leakage value, X_t , is expressed as a percentage and may be used to determine the global commodity leakage deduction as set out in the VCS *JNR Leakage Tool*. Where the monitoring period includes multiple years, the global commodity leakage value must be determined for each year included within the jurisdictional monitoring period.

6 PARAMETERS

6.1 Parameters Available at Validation

Data Unit / Parameter	$\bar{p}_{j,h}$
Data unit	Tonnes
Description	Production of commodity j within the jurisdiction in year h of the historical reference period
Equations	1, 2 and 3
Source of data	Officially published agricultural data by the jurisdiction, or peer-reviewed studies

⁷ Areas selected for REDD+ activities are usually selected for high biodiversity, carbon stock and/or customary value, and often have higher carbon stocks than on other forested land within the country. As a result, it is generally conservative to assume that the carbon stocks will be equivalent because it is likely that carbon stocks where deforestation would shift to will be lower. This method also addresses the challenges of determining the average change in carbon stock due to deforestation outside the jurisdiction. Such data is often unavailable or difficult to determine throughout the entire country.

Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	The data must report on production of commodity <i>j</i> within the jurisdiction and be sourced from the same time period used to develop the jurisdictional baseline.
Purpose of data	Calculation of leakage
Any comment	<p>Where data is not available for every year during the historical reference period used to develop the jurisdictional baseline, provide justification that the years in which data is available are representative of such period.</p> <p>Apply the data from the historical reference period determined at validation until the program crediting period is renewed (ie, where the baseline is updated more frequently than every 10 years, the data from the historical reference period should still be applied until the crediting period is renewed). Apply the data provided at validation throughout the program crediting period to ensure that such historical reference period represents production within the jurisdiction before the implementation of jurisdictional activities. Once the crediting period is renewed, use newly calculated data based on an updated historical reference period.</p>

Data Unit / Parameter	$\bar{a}_{j,h}$
Data unit	Hectares
Description	Area of production for commodity <i>j</i> within the jurisdiction in year <i>h</i> of the historical reference period
Equations	1, 2 and 3
Source of data	Officially published agricultural data by the jurisdiction, or peer-reviewed studies
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	The data must report on the area of production for commodity <i>j</i> within the jurisdiction and be sourced from the same time period used to develop the jurisdictional baseline.
Purpose of data	Calculation of leakage

Any comment	<p>Where data is not available for every year during the historical reference period used to develop the jurisdictional baseline, provide justification that the years in which data is available are representative of such period.</p> <p>Apply the data from the historical reference period determined at validation until the program crediting period is renewed (ie, where the baseline is updated more frequently than every 10 years, the data from the historical reference period should still be applied until the crediting period is renewed). Apply the data provided at validation throughout the program crediting period to ensure that such historical reference period represents the area of production within the jurisdiction before the implementation of jurisdictional activities. Once the crediting period is renewed, use newly calculated data based on an updated historical reference period.</p>
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Data Unit / Parameter	$\bar{y}_{j,h}$
Data unit	Tonnes/hectare
Description	Commodity yield for commodity <i>j</i> within the jurisdiction in year <i>h</i> of the historical reference period
Equations	1, 2, 3 and 5
Source of data	Officially published agricultural data by the jurisdiction, or peer-reviewed studies
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	<p>The data must report on the commodity yield for commodity <i>j</i> within the jurisdiction and be sourced from the same time period used to develop the jurisdictional baseline.</p> <p>Where jurisdictional data on commodity yields is not available, use country-wide commodity yield data and justify that such data is appropriate.</p>
Purpose of data	Calculation of leakage

Any comment	<p>Where data is not available for every year during the historical reference period used to develop the jurisdictional baseline, provided justification that the years in which data are available is representative of such period.</p> <p>Apply the data from the historical reference period determined at validation should be applied until the program crediting period is renewed (ie, where the baseline is updated more frequently than every 10 years, the data from the historical reference period should still be applied until the crediting period is renewed). Apply the data provided at validation throughout the program crediting period to ensure that such historical reference period represents commodity yields within the jurisdiction before the implementation of jurisdictional activities. Once the crediting period is renewed, use newly calculated data based on an updated historical reference period.</p>
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Data Unit / Parameter	<i>H</i>
Data unit	Number
Description	Number of historical reference years
Equations	2, 3 and 5
Source of data	Jurisdictional program description or based on data availability
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	<p>The number of historical reference years should include the same number of years in the historical reference period used to develop the jurisdictional baseline.</p> <p>Where data is not available for every year during the historical reference period used to develop the jurisdictional baseline, provide justification that the years for which data is available are representative of such period. Where such justification is provided, the number of historical reference years, <i>H</i>, is the number of years for which data has been provided (eg, if the jurisdictional baseline was developed from 2005 to 2015 but production data was only available in 2006, 2008, 2010, 2012 and 2014 and this is justified, then the jurisdictional program's number of historical reference years, <i>H</i>, is five years).</p>
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	r_j
Data unit	Percent
Description	Growth rate of production for commodity j
Equations	3
Source of data	For jurisdiction-specific growth rates, data from government-approved or publically available peer-reviewed studies on growth trends within the jurisdiction.
Value to be applied	Default value of 2.5 percent or justify a jurisdiction-specific growth rate
Justification of choice of data or description of measurement methods and procedures applied	For background information on the default value see Appendix 2. For jurisdiction-specific values, data from government-approved or publically available peer-reviewed studies on growth trends for individual commodities within the jurisdiction must be used to justify jurisdiction-specific values for individual commodities. Where jurisdictional data is not available, use studies on growth trends for individual commodities within the country and justify that such data is representative of the jurisdiction.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	IS
Data unit	Percent
Description	Proportion of leakage resulting in increased supply outside the jurisdiction
Equations	8
Source of data	
Value to be applied	Default value of 75 percent
Justification of choice of data or description of measurement methods and procedures applied	For background information on the default value see Appendix 2.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	NL
Data unit	Percent

Description	Proportion of increased supply coming from new land brought into production
Equations	8
Source of data	For country-specific values, data from government-approved or publically available peer-reviewed studies.
Value to be applied	Default value of 40 percent or justify a country-specific value
Justification of choice of data or description of measurement methods and procedures applied	For background information on the default value see Appendix 2. For country-specific values, data from government-approved or publically available peer-reviewed studies on the proportion of increased supply coming from new land brought into production within the country may be used to justify a country-specific value. Such studies should distinguish between the increase in supply coming from bringing new land into production and the increase in supply coming from increased commodity yields or agricultural intensification.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	<i>NLD</i>
Data unit	Percent
Description	Proportion of new land brought into agricultural production resulting in deforestation
Equations	8
Source of data	For country-specific values, data from government-approved or publically available peer-reviewed studies
Value to be applied	Default value of 100 percent or justify a country-specific value
Justification of choice of data or description of measurement methods and procedures applied	For background information on the default value see Appendix 2. For country-specific values, data from government-approved or publically available peer-reviewed studies on the proportion of new land brought into agricultural production coming from forest land within the country must be used to justify a country-specific value. Such studies should distinguish between the new land brought into agricultural production that was previously forest land and such land that was previously grassland or marginal land with lower carbon stocks.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	d_d
Data unit	Hectares
Description	Area of deforestation within the country
Equations	10 and 13
Source of data	Data from recognized, credible sources that have been reviewed by an appropriately qualified, independent organization (eg, IPCC, FAO) or appropriate peer review group, or been published by a government agency
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	When available, apply nationally monitored or estimated data. The at-risk forest carbon stocks data must be sourced from a time period within five years of the program crediting period start date, or justification must be provided for use of older data.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	g_d
Data unit	Hectares
Description	Area of deforestation globally
Equations	10
Source of data	Data from recognized, credible sources that have been reviewed by an appropriately qualified, independent organization (eg, IPCC, FAO) or appropriate peer review group, or been published by a government agency
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	Studies on global deforestation must use comparable methods to estimate global deforestation as those used to determine the area of deforestation within the country.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	d_{cs}
Data unit	Tonnes C

Description	At-risk forest carbon stocks within the country
Equations	11 and 14
Source of data	Data from recognized, credible sources that have been reviewed by an appropriately qualified, independent organization (eg, IPCC, FAO) or appropriate peer review group, or been published by a government agency
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	<p>When available, apply nationally monitored or estimated data. The at-risk forest carbon stocks data must be sourced from a time period within five years of the program crediting period start date or justification must be provided for use of older data.</p> <p>Where data on at-risk forest carbon stocks is not available, data on the area of at-risk forest land may be used. Where studies regarding at-risk forest carbon stocks or areas are not available, justify the use of proxies such as the tropical forest carbon stocks as an indicator of the at-risk forest carbon stocks.</p> <p>The same metric (eg, tonnes C or hectares) or proxy must be used to calculate at-risk forest carbon stocks globally.</p>
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	g_{cs}
Data unit	Tonnes C
Description	At-risk forest carbon stocks globally
Equations	11
Source of data	Data from recognized, credible sources that have been reviewed by an appropriately qualified, independent organization (eg, IPCC, FAO) or appropriate peer review group, or been published by a government agency
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	Studies on global deforestation must use comparable methods to estimate global deforestation as those used to determine the area of deforestation within the country.
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	R_d
Data unit	Hectares
Description	Area of deforestation accounted for under any other jurisdictional REDD+ programs with GHG emissions monitoring and accounting outside the jurisdiction and within the country
Equations	13
Source of data	Reports by other jurisdictional REDD+ programs with GHG emissions monitoring and accounting outside the jurisdiction but within the country
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of data	Calculation of leakage
Any comment	Where data from other jurisdictions is not available, then the share of unaccounted leakage within the country should be set at 1.

Data Unit / Parameter	R_{cs}
Data unit	Tonnes C
Description	At-risk forest carbon stocks accounted for under any other jurisdictional REDD+ programs with GHG emissions monitoring and accounting outside the jurisdiction and within the country
Equations	14
Source of data	Reports by other jurisdictional REDD+ programs with GHG emissions monitoring and accounting outside the jurisdiction but within the country
Value to be applied	
Justification of choice of data or description of measurement methods and procedures applied	Determine at-risk forest carbon stocks based on the jurisdictional baseline or reference levels reported by other jurisdictional programs. Where the at-risk forest carbon stock within the country uses a different metric (ie, area of at-risk forests) such metric must be applied based on data from the jurisdictional baseline or reference levels.
Purpose of data	Calculation of leakage

Any comment	Where data from other jurisdictions is not available, then the share of unaccounted leakage within the country should be set at 1.
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6.2 Parameters Monitored

Data Unit / Parameter	$p_{j,t}$
Data unit	Tonnes
Description	Observed production for commodity j within the jurisdiction in year t of the program crediting period
Equations	1 and 4
Source of data	Officially published agricultural data by the jurisdiction, or peer reviewed studies
Description of measurement methods and procedures to be applied	The data must report on production of commodity j within the jurisdiction and be sourced from the same time period used to develop the jurisdictional baseline.
Frequency of monitoring/recording	The data may be monitored once at the end of the monitoring period but should be reported on an annual basis. Where annual data is not available throughout the monitoring period, provide estimates for the years where data was not available and justify that such estimates are appropriate.
QA/QC procedures to be applied	
Purpose of data	Calculation of leakage
Any comment	The parameter $p_{j,t}$ should not be confused with $\bar{p}_{j,t}$, which is the baseline production for commodity j projected in year t of the program crediting period.

Data Unit / Parameter	$a_{j,t}$
Data unit	Hectares
Description	Observed area of production for commodity j within the jurisdiction in year t of the program crediting period
Equations	1 and 4
Source of data	Officially published agricultural data by the jurisdiction, or peer reviewed studies.

Description of measurement methods and procedures to be applied	The data must report on the area of production for commodity <i>j</i> within the jurisdiction and be sourced from the same time period used to develop the jurisdictional baseline.
Frequency of monitoring/recording	The data may be monitored once at the end of the monitoring period but should be reported on an annual basis. Where annual data is not available throughout the monitoring period, provide estimates for the years where data was not available and justify that such estimates are appropriate.
QA/QC procedures to be applied	
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	$y_{j,t}$
Data unit	Tonnes/hectare
Description	Commodity yield for commodity <i>j</i> within the jurisdiction in year <i>t</i> of the program crediting period
Equations	1 and 4
Source of data	Officially published agricultural data by the jurisdiction, or peer reviewed studies
Description of measurement methods and procedures to be applied	The data must report on the commodity yield for commodity <i>j</i> within the jurisdiction and be sourced from the same time period used to develop the jurisdictional baseline. Where jurisdictional data on commodity yields is not available, use country-wide commodity yield data and justify that such data is appropriate.
Frequency of monitoring/recording	The data may be monitored once at the end of the monitoring period but should be reported on an annual basis. Where annual data is not available throughout the monitoring period, provide estimates for the years where data was not available and justify that such estimates are appropriate.
QA/QC procedures to be applied	
Purpose of data	Calculation of leakage
Any comment	

Data Unit / Parameter	\tilde{d}_t
Data unit	Hectares
Description	Area of avoided deforested by the jurisdictional program
Equations	7 and 16
Source of data	Jurisdictional monitoring report
Description of measurement methods and procedures to be applied	As reported with the jurisdictional monitoring report
Frequency of monitoring/recording	The data may be monitored once at the end of the monitoring period but should be reported on an annual basis.
QA/QC procedures to be applied	
Purpose of data	Calculation of leakage
Any comment	

7 REFERENCES

- Alexandratos, N. and Bruinsma, J. 2012. World Agriculture towards 2030/2050: The 2012 Revision. Food and Agricultural Organization Agricultural Development Economics Division. (<http://www.fao.org/docrep/016/ap106e/ap106e.pdf>)
- FAO, 2010. Global Forest Resources Assessment 2010. FAO Forestry Paper 163
- FAPRI, 2012. Food and Agricultural Policy Research Institute – Elasticity Database. Iowa State Univeristy. (<http://www.fapri.iastate.edu/tools/elasticity.aspx>)
- Fuglie, K., and Nin-Pratt, A. 2012. 2012 Global Food Policy Report: Agricultural Productivity: A Changing Global Harvest. International Food Policy research Institute.
- Gibbs, H. et al. 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. Proceedings of the National Academy of Sciences. 107:38 16,732-16,737.
- Murray, B.C., B.A. McCarl, and H. Lee. 2004. Estimating Leakage from Forest Carbon Sequestration Programs. Land Economics 80(1):109-124. (<http://ideas.repec.org/p/uwo/uwowop/20043.html>)
- Roberts, M.J. and Schlenker, W. 2013. Identifying Supply and Demand Elasticities of Agricultural Commodities: Implications for the US Ethanol Mandate. American Economic Review. 103(6): 2265-2295.

APPENDIX 1: DOCUMENT HISTORY

Version	Date	Comment
v1.0	4 Feb 2014	Initial version released.

APPENDIX 2: BACKGROUND INFORMATION ON DEFAULT VALUES

Growth Rate

The default value for growth rates of production has been developed based on reports from the International Food Policy Research Institute (IFPRI) and Food and Agricultural Organization (FAO). Analysis from IFPRI indicates that the average agricultural growth rates in developing countries over the past 40 years have remained less than 2.5 percent for each decade with values ranging from 2.08 percent to 2.42 percent (Fuglie and Nin-Pratt, 2012). Reports from FAO confirm that this is a conservative default value for growth rates. They predict that agricultural growth rates within developing countries will decrease in the coming decades with an average value of 1.6 percent for developing countries from 2007 to 2030 and an average value of 0.9 percent for developing countries from 2030 to 2050 (Alexandratos and Bruinsma, 2012). Therefore 2.5 percent has been selected as a conservative default value for commodity production and jurisdictions are eligible to justify using jurisdiction or country-specific values where such data is relevant and available.

Proportion of Leakage Resulting in Increased Supply

The default value for the proportion of leakage resulting in increased supply outside the jurisdiction was developed using the methods for estimating leakage from Murray, McCall and Lee (2004). This method considers the elasticity of supply and the elasticity of demand to estimate leakage for a given commodity. The analysis for developing the conservative default value used data on elasticity of supply and demand across commodities and countries from peer-reviewed economic studies and the Food and Agricultural Policy Research Institute's Elasticity Database. The elasticity data on agricultural commodities and forest products indicated that no commodities experienced perfectly inelastic supply or demand. Averaging across countries, most commodities losses occurring within the jurisdiction would result in a 40 to 75 percent increase in supply elsewhere. Therefore 75 percent was selected as a conservative default value.

Proportion of Increased Supply coming from New Land Brought into Production

The default value for the increased supply coming from new land brought into production was developed based on data and reports from FAO. Such studies indicate that globally only 10 percent of the increases in production globally will come from new land being brought into production (Alexandratos and Bruinsma, 2012). Some sub-regions such as Latin America and the Caribbean may experience 40 percent of future supply coming from new land being brought into production. While these studies provide predictions regarding the long-term trends in production other studies on short-term trends result in other conclusions. Roberts and Schlenker (2013) provide evidence that shorter-term price shocks do not follow these longer-term trends and the increase in production is primarily made up by bringing new land into production.

The default value has been developed based on the assumption that jurisdictional programs will have longer-term impacts on commodity markets. Based on the FAO data, 40 percent was selected as a conservative threshold for the default value. Such default value could be updated in the future if jurisdictional REDD+ programs are shown to have shorter-term impacts on commodity markets.

Proportion of New Land Brought into Agricultural Production Resulting in Deforestation

The default value for the new land brought into agricultural production resulting in deforestation was developed based on data and reports from FAO and Gibbs et al (2010). These studies indicate that some countries have significant areas of forested land that are suitable for agricultural production and much of the new land brought into agricultural production in the 1980s and 1990s was forested land. Therefore a default value of one was selected to provide the most conservative assumption that all new land brought into agricultural production will come from forested land. However, a lower value may be justified by using country-specific values where such data is relevant and available.