02. Forest/Countermeasures for Deforestation and Forest Degradation

1. Typical Project Outline

・ Countermeasures for deforestation and forest degradation.

2. Applicability

(1) Land in the project area has satisfied as forests as per host countries definitions of forest.

(2) Forests are managed sustainably during the project.

3. Methodology of Emission Reduction Calculation

CO_2 emission reduction and increase in CO_2 sink of forests are determined based on the changes of carbon stocks of the forests. Thus, the net anthropogenic GHG reduction through countermeasures for deforestation and forest degradation is calculated as the difference between changes of carbon dioxide stock in the case of without project activities (baseline emission), changes of carbon dioxide stock in the case of project (project emission) and GHG emissions associated with the project activities (leakage).

$$ER_y = \Delta \mathrm{C}_{\mathrm{BL,y}} - \Delta \mathrm{C}_{\mathrm{PJ,y}} - \Delta C_{LK,y}$$

$\mathrm{ER_y}$: Net anthropogenic GHG emission reduction by the project in year y (t-CO_2e/y)

$\Delta \mathrm{C}_{\mathrm{PJ,y}}$: Annual GHG emission with the project in year y (t-CO_2e/y)

$\Delta \mathrm{C}_{\mathrm{BL,y}}$: Annual GHG emission without the project in year y (t-CO_2e/y)

$\Delta \mathrm{C}_{\mathrm{LK,y}}$: Net GHG greenhouse gas emissions due to leakage in year y (t-CO_2e/y)

Here,

$$\Delta C_{BL,y} = (C_{BL,y} - C_{BL,y-t})/t$$

$$\Delta C_{PJ,y} = (C_{PJ,y} - C_{PJ,y-t})/t$$

$\mathrm{C}_{\mathrm{BL,y}}$: CO_2 stock in the absence of the project in year y (t-CO_2e/y)

$\mathrm{C}_{\mathrm{BL,y-t}}$: CO_2 stock in the absence of the project in year y-t (t-CO_2e/y)

$\mathrm{C}_{\mathrm{PJ,y}}$: CO_2 stock by the project in year y (t-CO_2e/y)

$\mathrm{C}_{\mathrm{PJ,y-t}}$: CO_2 stock by the project in year y-t (t-CO_2e/y)

The difference of CO_2 stock in forest can be obtained as the difference between year y and the year earlier (y-1) as well as between year y and year y-t (i.e., t=3 or 5 years). Per year GHG emission can be calculated by dividing the differences of carbon stock by time t.

t is assumed as 1 year for simplicity .

Then, the cumulative net anthropogenic GHG emission reduction after the project implementation until year Y can be expressed in the following formula.

$$ER_Y = \sum_{y}^{Y} ER_y$$

For leakage $(\Delta \mathrm{C}_{\mathrm{LK,y}})$ it is considered that residents and/or farming activities (cultivation, animal husbandry) need to be migrated in the course of project implementation, loss of carbon stocks (leakage) might be a concern in relation to deforestation out of the project boundary. Although pasture and agricultural lands are in scope of afforestation in this estimation formula, migration of many farmers and farming activities out of the project boundary is not assumed in the course of the project implementation. Therefore, leakage is deemed as zero. However, migration of residents and farming activities (cultivation, animal husbandry) needs to be counted as a concern, 15% of anthropogenic GHG reduction is calculated as leakage for simplicity.

(1) Calculation of Baseline Emission

Annual baseline emission is generally obtained as the differences of carbon dioxide stocks of carbon pools (soil, litter, dead, aboveground and belowground biomasses) in associated with planned deforestation, unplanned deforestation and unplanned forest degradation. In this methodology, carbon dioxide stocks changes in past years only for carbon pools of aboveground and belowground biomasses is concerned.

The carbon dioxide stocks change can be obtained as the average of several data of the carbon dioxide stocks changes in past years in the project area and the data to be used should be at least several points from last 10 years of the project, and it should be an average value of at least 3 points as shown in the following formula.

$$\Delta C_{BL,y} = \frac{\sum_i C_{ybi} - C_{ybi+1}}{\sum_i yb_{i+1} - yb_i}$$

C_{yb} : Carbon stocks of the forest in year yb in teh baseline. (t- CO_{2e})

yb_i : year of baseline

Carbon dioxide stocks can be obtained by multiplying per hectare carbon stock of the forest with the acreage of the forest and CO_2 conversion factor of carbon.

$$C_{ybi} = \sum_k (BT_{ybi,k} \times A_{ybi,k} \times 44/12)$$

$$C_{ybi+1} = \sum_k (BT_{ybi+1,k} \times A_{ybi+1,k} \times 44/12)$$

$BT_{ybi,k}$: Per hectare carbon stocks in the stratum k in year ybi in the baseline (t-C/ha)

$BT_{ybi+1,k}$: Per hectare carbon stocks in the stratum k in year ybi+1 in the baseline (t-C/ha)

$A_{ybi,k}$: Acreage of the stratum k in year ybi (ha)

$A_{ybi+1,k}$: Acreage of the stratum k in year ybi+1 (ha)

$44/12$: CO_2 conversion factor of carbon

A stratum represents forest growth attributes such as forest types, species, climate belts, terrain and management forms of the forested land. All attribute data are required per stratum. Appendix table A-12 shows examples of stratification[1].

Determination of $BT_{y,k}$:

[1] It provides examples of stratification having applied in REDD surveys supported by JICA and NEDO.

Generally, carbon stocks include above ground biomass, below ground biomass, dead wood, litter and soil organic carbon. For the methodology carbon stocks through the project are mainly calculated based on the aboveground and belowground biomasses for simplicity and conservativeness.

$$BT_{ybi,k} = BT_{A,ybi,k} + BT_{B,ybi,k}$$

$BT_{A,ybi,k}$: Per hectare carbon stock of aboveground biomasses in the stratum k in year yb (t-C/ha)

$BT_{B,ybi,k}$: Per hectare carbon stock of belowground biomasses in the stratum k in year yb (t-C/ha)

Aboveground and belowground carbon stocks are calculated by multiplying aboveground biomass (dry matter stem, branches, and leaves) and belowground biomass (dry matter roots) with carbon fraction of trees, respectively.

$$BT_{A,ybi,k} = TT_{A,ybi,k} \times CF_k$$

$$BT_{B,ybi,k} = TT_{B,ybi,k} \times CF_k$$

$TT_{A,ybi,k}$: Per hectare aboveground biomass in the stratum k in year yb (t-dm/ha: ton dry matter/h*a*)

$TT_{B,ybi,k}$: Per hectare belowground biomass in the stratum k in year yb (t-dm/ha)

CF_k : Carbon fraction of trees in the stratum k

Aboveground biomass is calculated by multiplying the tree volume with the biomass expansion factor of trees and bulk density of the forest.

$$TT_{A,ybi,k} = SV_{ybi,k} \times BEF_k \times WD_k$$

$SV_{ybi,k}$: Per hectare tree volume in the stratum k in year yb (m^3/ha)

BEF_k : Biomass expansion factor of trees in the stratum k

WD_k : Bulk density of the stratum k (t-dm/m^3)

On the other hand, the belowground biomasses are calculated as follows.

$$TT_{B,ybi,k} = TT_{A,ybi,k} \times R_k$$

R_k : Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground)

In addition to the above-mentioned method for obtaining the amount of biomass on the ground from the tree volume, biomass expansion factor, and bulk density, default values may be used in Attached Tables A-4 to A-8. .

(2) Calculation of Project Emission

Project emission is the CO_2 stock changes by project activities such as avoiding planned deforestation, unplanned deforestation and forest degradation. Project emission can be obtained based on the monitored acreage change of the forest and per hectare as carbon stocks of the forest.

In detail, CO_2 stock differences between year y and the year later (y+1) in the project are calculated as per the following equation.

Carbon dioxide stocks are calculated by multiplying per hectare carbon stock of the forest with the acreage of the forest and CO_2 conversion factor of carbon.

$$\Delta C_{PJ,y} = C_{PJ,y} - C_{PJ,y+1}$$

$$C_{PJ,y} = \sum_{k} (NT_{y,k} \times A_{PJ,y,k} \times 44/12)$$

$$C_{PJ,y+1} = \sum_{k} (NT_{y+1,k} \times A_{PJ,y+1,k} \times 44/12)$$

$NT_{y,k}$: Carbon stock in the stratum k in year y (t-C/ha)

$NT_{y+1,k}$: Carbon stock in the stratum k in year y+1 (t-C/ha)

$A_{PJ,y,k}$: Acreage of the stratum k in year y (ha)

$A_{PJ,y+1,k}$: Acreage of the stratum k in year y+1 (ha)

$44/12$: CO_2 conversion factor of carbon

Determination of $NT_{y,k}$:

It is determined as follows.

$$NT_{y,k} = NT_{A,y,k} + NT_{B,y,k}$$

$NT_{A,y,k}$: Per hectare aboveground biomass carbon stocks in the stratum k in year y (t-C/ha)

$NT_{B,y,k}$: Per hectare belowground biomass carbon stocks in the stratum k in year y (t-C/ha)

Aboveground and belowground biomass carbon stocks are calculated by multiplying aboveground biomass (dry matter stem, branches, and leaves) and belowground biomass (dry matter roots) with carbon fraction of trees, respectively.

$$NT_{A,y,k} = TT_{A,y,k} \times CF_k$$

$$NT_{B,y,k} = TT_{B,y,k} \times CF_k$$

$TT_{A,y,k}$: Per hectare aboveground biomass in the stratum k in year y (t-dm /ha)

$TT_{B,y,k}$: Per hectare belowground biomass in the stratum k in year y (t-dm /ha)

CF_k : Carbon fraction of trees in stratum k (t-C/t-dm)

Belowground biomass is calculated based on the following formula.

$$TT_{A,y,j} = SV_{y,k} \times BEF_k \times WD_k$$

$SV_{y,k}$: Per hectare tree volume in the stratum k (m^3/ha)

BEF_k : Biomass expansion factor of the stratum k

WD_k : Bulk density of the stratum k (t-dm/m^3)

$$TT_{B,y,j} = TT_{A,y,k} \times R_k$$

R_k : Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground)

4. Data and Parameters Estimated and Need Monitoring

Data	Description	Data Sources			
		For baseline emission calculation		For project emission calculation	
		Ex-ante	Ex-post	Ex-ante[2]	Ex-post
$A_{ybi,k}$	Acreage of the stratum k in the forest in the year yb in the case of without project (ha)	A predicted value (Prediction is conducted as per past trend analysis based on the remote sensing and land use statistics data having gained prior to project implementation)		N/A	N/A
$A_{Bybi+1,k}$	Acreage of the stratum k in the forest in the year yb+1 in the case of without project (ha)	A predicted value (Prediction is conducted as per past trend analysis based on the remote sensing and land use statistics data having gained prior to project implementation)		N/A	N/A
$A_{PJ,y,k}$	Acreage of the stratum k in the forest in the year y in the case of project (ha)	N/A		A planned value	A monitored value
$A_{PJ,y+1,k}$	Acreage of the stratum k in the forest in the year y+1 in the case of project (ha)	N/A		A planned value	A monitored value
$TT_{A,y,k}$	Per hectare aboveground biomass in the stratum k (t-dam/ha)	A IPCC default value (Table A-4, 6 Appendix) Or, can be calculate by using following Volume of trees（$SV_{y,k}$）, Biomass expansion factor (BEF_k) and Bulk density (WD_k). However, if there is no default value applied or if there is another appropriate value, that value may be used.			
$SV_{y,k}$	Volume of trees in the stratum k (m^3/ha)	A monitored value prior to project implementation		A monitored value prior to project implementation	A monitored value
BEF_k	Biomass expansion factor for the stratum k	A IPCC default value (Table A-1, Appendix) However, if there is no default value applied or if there is another appropriate value, that value may be used.			
WD_k	Bulk density of the stratum k (t-dm/m^3)	A IPCC default value (Table A-2, Appendix) However, if there is no default value applied or if there is another appropriate value, that value may be used.			
CF_k	Carbon fraction of trees in stratum k (t-C/t-dm)	A IPCC default value (Table A-3, Appendix) However, if there is no default value applied or if there is another appropriate value, that value may be used.			
R_k	Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground)	A IPCC default value (Table A-9, Appendix) However, if there is no default value applied or if there is another appropriate value, that value may be used.			

5. Others

(1) Project Boundary

The project boundary is the forests where conservations and management being conducted.

[2] It refers to a value for ex-ante calculation of project emissions.

(2) Leakage

Although pasture and agricultural lands are in scope of afforestation in this estimation formula, migration of many farmers and farming activities out of the project boundary is not assumed in the course of the project implementation. Therefore, leakage is deemed as zero. However, migration of residents and farming activities (cultivation, animal husbandry) needs to be counted as a concern, 15% of anthropogenic GHG reduction is calculated as leakage for simplicity.

(3) Monitoring

In the case of countermeasures for deforestation and forest degradation, it is required to monitor a change of acreage of a stratum in the forest and per hectare carbon stock of that stratum. For monitoring of acreage changes, remote sensing technology such as Landsat TM, ETM+/SPOT-4,5/ALOS AVNIR-2 are useful. On the other hand, for grasping of per hectare carbon stocks of forests, there are two methods are considered. They are the fixed plot survey and the regression model. If there is data of (NFI) national forest resources survey or if the national forest resources and data biomass estimation models are available, it helps to calculate carbon stocks of forests.

(4) Comparison with existing CDM methodologies

There are methodologies that can be reference for the methodology such as VCS (Verified Carbon Standard), JCM and J-VER. Among them REDD Methodology Modules provide different modules according to different baseline scenarios. However, this methodology focuses on the ultimate carbon stock changes in the forest caused by the project activities and applies the same estimation approach (acreage of a stratum in forest * per hectare of carbon stock in the stratum) with JCM methodology （Joint Crediting Mechanism Guidelines for Developing Proposed Methodology for Reducing Emissions from Deforestation and Forest Degradation, and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries (REDD-plus)） for calculation of emission reduction.