## 1. Forest and Natural Resources Conservation/Afforestation

### 1. Typical Project Outline

The project intends to increase CO₂ sink through afforestation of non-forest lands including degraded, pasture or agricultural lands. For reducing emissions from deforestation and forest degradation (REDD), refer to “2. Forest Preservation”.

### 2. Applicability

- This project is not applicable to the lands defined as forests in the target country.
- AR-CDM defines afforestation lands as non-forests for the past 50 years and reforestation lands as non-forests since 1990, respectively. Formulas presented below are to estimate the amount of GHG emission reduction as the outcome resulted from afforestation regardless of time constraints.
- The forests should be sustainably managed after afforestation with appropriate management tasks including thinning in place.

### 3. Methodology of GHG reduction calculation

Since trees absorb and fix carbons in atmosphere for growth in photosynthesis, they are regarded as the carbon dioxide (or carbon) reservoirs. Thus, the net anthropogenic GHG absorption through afforestation is calculated as the difference between increase in carbon dioxide sink in forested lands (or reduction due to thinning and harvesting) (project absorption) and assumed increase (or decrease) in carbon dioxide sinks without afforestation project (baseline absorption) plus GHG emission associated with the afforestation project (project emission) in a certain period after the project.

\[
ER_{AR,y} = \Delta C_{PRJ,y} - \Delta C_{BSL,y} - GHG_{PRJ,y}
\]

- \( ER_{AR,y} \) : Net anthropogenic GHG absorption with afforestation project in Year y (t-CO₂/y)
- \( \Delta C_{PRJ,y} \) : Annual GHG absorption with afforestation project in year y (t-CO₂/y)(Project absorption)
- \( \Delta C_{BSL,y} \) : Annual GHG absorption without afforestation project in year y (t-CO₂/y)(Baseline absorption)
- \( GHG_{PRJ,y} \) : GHG emission associated with afforestation project in Year y (t-CO₂/y)(Project emission)

where

\[
\Delta C_{PRJ,y} = \frac{C_{PRJ,y} - C_{PRJ,y-t}}{t}
\]

\[
\Delta C_{BSL,y} = \frac{C_{BSL,y} - C_{BSL,y-t}}{t}
\]

- \( C_{PRJ,y} \) : CO₂ absorbed by planted trees until year y (CO₂ sink of forested lands in year y)(t-CO₂/y)
- \( C_{PRJ,y-t} \) : CO₂ absorbed by planted trees until year y-t (CO₂ sink of forested lands in year y-t)(t-CO₂/y)
- \( C_{BSL,y} \) : GHG absorbed by non-woody plants without afforestation project until year y (CO₂ stock in year y)(t-CO₂/y)
- \( C_{BSL,y-t} \) : GHG absorbed by non-woody plants without afforestation project until year y-t (CO₂ stock in year y-t)(t-CO₂/y)

The difference of CO₂ sink in the forested lands 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 absorption can be calculated by dividing the calculated GHG absorption by t years.

To simplify and generalize descriptions here, t is assumed as 1 year.

Then, the cumulative net anthropogenic GHG absorption stored after the project implementation until year y can be expressed in the following formula.

\[
cumER_{AR} = \sum_{y}^{y} ER_{AR,y}
\]

The figure below illustrates the above-mentioned concept (formula).
As shown in the figure above, each of project absorption (t-CO₂/y), baseline absorption (t-CO₂/y), and project emission (t-CO₂/y) changes along the time scale.

- Project absorption is obtained as the difference of carbon dioxide stocks in the forested land between year y and year y-1.
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- Baseline absorption is obtained as the difference of carbon dioxide stocks in the project area before year \( y \) and the year earlier \( (y-1) \) assumed without afforestation project. If the vegetation originally grown in the land is reproduced in the same cycle over years, \( \Delta C_{BSL,y} = 0 \) is derived as the baseline absorption as \( B_{y,BSL,l} = B_{y-1,BSL,l} = \text{constant} \), thus \( C_{BSL,y} = C_{BSL,y-1} = \text{constant} \).
- Project emission includes dinitrogen monoxide (N\(_2\)O) emission due to fertilization (nitrogen fertilizer, caustic lime) and GHG emission due to clearing grasses, crops and trees originally grown on the project area. The former is usually negligibly small, thus treated as zero here. The latter is limited only to the initial stage to prepare for afforestation, however, it is not always negligible.

The figures below show changes and cumulative (carbon dioxide stocks in the forested land, t-CO\(_2\)) of project absorption (t-CO\(_2\)/y), baseline absorption (t-CO\(_2\)/y), and project emission (t-CO\(_2\)/y) along the time scale in a typical afforestation project. In this afforestation project, seedlings were planted in 2010 and trees are harvested in 2020. Subsequently planting and harvesting will be repeated in the cycle of 10 years. The figure on the left shows the overall view, while the figures on the right are enlarged versions.

In 2010, project emission should be considered for clearance of the afforestation land. From 2012 to 2020, project absorption is expected along with tree growth, however, as trees are harvested in 2020, project absorption turned to negative. Baseline absorption remains at zero throughout the project period.

On the other hand, the cumulative shown on the left bottom shows constant increase of carbon dioxide stocks absorbed by original vegetation from 1987 to 2009. After 2010 until 2020, cumulative project absorption continues to increase along with tree growth in a sigmoid curve. Once trees are harvested in 2020, the cumulative absorption reduces to the baseline level. Cumulative baseline absorption and project emission level off from 2010 when project emission occurred. The difference between cumulative project absorption and cumulative project emission represents cumulative net anthropogenic GHG absorption or the carbon dioxide stocks in the forested land until the specific year.

(1) Boundary and land use of afforestation land

Afforestation in lands with low CO\(_2\) stocks (degraded/pasture land) may effectively increase CO\(_2\) absorption. In this regard, the boundary and historical land use need to be accurately understood using the following means.
- Arial photos or satellite images that show historical land use in the target area.
- Documents that provide land use information, i.e., land use map, vegetation map or land cover map

In developing countries where the afforestation land usually extends in a wider area (or scattered in a wider extent)
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and land cover and/or land use are not well-documented, satellite images from LANDSAT, ASTER, SPOT, ALOS, or QuickBird will provide useful data.

3. Methodology of GHG reduction calculation (cont’d)

(2) Calculation of project absorption

Annual project absorption after project implementation can be obtained as the difference of carbon dioxide stocks in the afforested area between Year \( y \) and the year earlier \((y-1)\). Carbon dioxide stocks can be obtained by multiplying the forested tree biomass (dry matter) by the forested acreage and CO\(_2\) conversion factor for carbon.

\[
\Delta C_{PRJ,y} = C_{PRJ,y} - C_{PRJ,y-1}
\]

\[
C_{PRJ,y} = \sum_i (N_{y,i} \times A_{PRJ,i} \times 44 / 12)
\]

\[
C_{PRJ,y-1} = \sum_i (N_{y-1,i} \times A_{PRJ,i} \times 44 / 12)
\]

<table>
<thead>
<tr>
<th>Type</th>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>( \Delta C_{PRJ,y} )</td>
<td>Project absorption: Annual GHG absorption by planted trees in Year ( y ) after project implementation (t-CO(_2)/y)</td>
</tr>
<tr>
<td>Input</td>
<td>( N_{y,i} )</td>
<td>Carbon stocks in strata in Year ( y ) after project implementation (t-C/ha)</td>
</tr>
<tr>
<td></td>
<td>( A_{PRJ,i} )</td>
<td>Forested acreage of stratum ( i ) (ha)</td>
</tr>
<tr>
<td></td>
<td>44/12</td>
<td>CO(_2) conversion factor for carbon</td>
</tr>
</tbody>
</table>

Note: Strata represent forest growth attributes such as species, density, forested year, degree (grade of land fertility) in the forested land. All attribute data are required per stratum. Since there is no standardized stratification, strata can be specifically defined in each project. In the land with uniform degree, the required stratum may be species only even in a wide area. More numbers of strata are required in lands with diverse species and degrees. The past projects registered in CDM typically defined 2 -16 strata. Stratification can be simplified, for example, trees can be roughly classified into 3 strata based on growth rate where diverse species are found. Annex table A-7 shows the sample stratification.

**Determination of \( N_{y,i} \)**

Carbon stocks acquired through afforestation are calculated for aboveground and belowground, respectively.

\[
N_{y,i} = \left( N_{A,y,i} + N_{B,y,i} \right)
\]

\( N_{A,y,i} \) : carbon stock in aboveground (t-C/ha)
\( N_{B,y,i} \) : carbon stock in belowground (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), respectively, by tree carbon fraction.

\[
N_{A,y,i} = T_{A,y,i} \times CF_i
\]

\[
N_{B,y,i} = T_{B,y,i} \times CF_i
\]

\( T_{A,y,i} \) : Aboveground biomass (t-dm/ha: ton dry matter/ha)
\( T_{B,y,i} \) : Belowground biomass (t-dm/ha)
\( CF_i \) : Carbon fraction

Aboveground biomass is calculated by multiplying the tree volume by the biomass expansion factor and bulk
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\[ T_{A,y,j} = SV_{y,i} \times BEFi \times WD_i \]

- \( SV_{y,i} \): Tree volume (m³/ha)
- \( BEFi \): Biomass expansion factor (-)
- \( WD_i \): Bulk density (t-dm/m³)

- Tree volume \((SV_{y,i})\) means the stem volume. Based on “the yield table” listing the average tree volumes in relation to species and tree ages, develop “the yield projection table” for the project. The yield table shows the course of tree growth under the standard management for a specific region/species/degree. Use the country-specific table if available.

- If the yield table is not available, measure the breast-height diameter and tree height to calculate tree volumes in the tree volume equation.

- Biomass expansion factor \((BEFi)\) is the factor to expand the tree volume to the whole tree including branches, leaves, and roots. One should apply factors specific to species and ages. Preferably the country-specific factor should be applied, however, values in Table 3A.1.10 (Annex Table A-1) in IPCC Good Practice Guidance (GPG) for Land Use, Land Use Change, and Forestry (LULUCF) are also applicable where no specific factor is available in the country.

- Bulk density is the coefficient to convert volume into weight. Various coefficients are available specific to species. Preferably the country-specific coefficient should be applied, however, values in Table 3A.1.9 (Annex Table A-2) are also applicable where no specific coefficient is available in the country.

- Carbon fraction \((CFi)\) is the carbon ratio to the whole tree weight. Preferably the country-specific ratio should be applied, however, values in Table 4.3 (Annex Table A-3) in IPCC Guidelines for National Greenhouse Gas Inventories (GNGGI), Volume 4. Agriculture, Forestry, and Other Land Use are also applicable where no specific rate is available in the country.

- Aboveground biomass can be obtained based on the tree volume (indirect approach) as well as the allometry formula (direct approach). If these approaches are not applicable, values in Table 3A.1.6 in IPCC GPG for LULUCF (Annex Table A-4) is also applicable.

Belowground biomass can be obtained in the following formula.

\[ T_{B,y,j} = R_i \times T_{A,y,j} \]

- \( R_i \): Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-)

- The ratio of belowground biomass to aboveground biomass is specific to species. Preferably, the country-specific values should be applied, however, values in Table 3A.1.8 of IPCC GPG for LULUCF (Annex Table A-5) are also applicable where no specific value is available.

(3) Baseline absorption calculation

Baseline absorption would be zero under the assumption that the vegetation grows in the same cycle over years without afforestation project.

Baseline absorption can be obtained as the difference of carbon dioxide stocks in vegetation originally grown on the afforestation land between year \( y \) when afforestation is implemented and the year earlier \( (y-1) \). Carbon dioxide stocks are calculated by multiplying biomass such as grasses (dry matter) by the acreage and CO₂ conversion factor
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\[ \Delta C_{\text{BSL},y} = C_{\text{BSL},y} - C_{\text{BSL},y-1} \]

\[ C_{\text{BSL},y} = \sum_j (B_{y,j} \times A_{\text{BSL},j} \times 44/12) \]

\[ C_{\text{BSL},y-1} = \sum_j (B_{y-1,j} \times A_{\text{BSL},j} \times 44/12) \]

<table>
<thead>
<tr>
<th>Type</th>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>( \Delta C_{\text{BSL},y} )</td>
<td>Baseline absorption CO(_2) absorption by original vegetation in Year ( y ) without afforestation project (t-CO(_2)/y)</td>
</tr>
<tr>
<td>Input</td>
<td>( B_{y,j} )</td>
<td>Carbon stock in stratum ( j ) in year ( y ) (t-C/ha)</td>
</tr>
<tr>
<td></td>
<td>( A_{\text{BSL},j} )</td>
<td>Acreage of stratum ( j ) (ha)</td>
</tr>
<tr>
<td></td>
<td>( 44/12 )</td>
<td>CO(_2) conversion factor for carbon</td>
</tr>
</tbody>
</table>

**Determination of \( B_{y,j} \)**

Carbon stocks in vegetation without afforestation project are calculated for aboveground and belowground, respectively.

\[ B_{y,j} = (B_{\text{A},y,j} + B_{\text{B},y,j}) \]

\( B_{\text{A},y,j} \): Aboveground carbon stocks (in grasses, crops)(t-C/ha)
\( B_{\text{B},y,j} \): Belowground carbon stocks (in grasses, crops)(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), respectively, by carbon fraction for vegetation.

\[ B_{\text{A},y,j} = M_{\text{A},y,j} \times 0.5 \]
\[ B_{\text{B},y,j} = M_{\text{B},y,j} \times 0.5 \]

\( M_{\text{A},y,j} \): Aboveground biomass (t-dry matter/ha)
\( M_{\text{B},y,j} \): Belowground biomass (t-dry matter/ha)
\( 0.5 \): Carbon fraction for vegetation

Belowground biomass is calculated in the following formula.

\[ M_{\text{B},y,j} = R_j \times M_{\text{A},y,j} \]

\( R_j \): Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-)

**Baseline absorption \( \Delta C_{\text{BSL},y}=0 \)**

In the land without afforestation project, under the assumption that the vegetation grows in the same cycle over
1. Forest and Natural Resources Conservation/Afforestation

...years, baseline absorption would be \( \Delta C_{BSL,y} = 0 \) as \( B_{i,j} = B_{i,j-1} = \text{constant} \), thus \( C_{BSL,y} = C_{BSL,y-1} = \text{constant} \).

(4) Project emission calculation

Project emission may include emission of dinitrogen monoxide (N\(_2\)O) associated with fertilization and GHG emission associated with clearing grasses and crops to prepare for afforestation.

\[
GHG_{PRJ,y} = N2O_y + C_{RMF,y}
\]

<table>
<thead>
<tr>
<th>Type</th>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>( GHG_{PRJ,y} )</td>
<td>Project emission CO(_2) emission after project implementation (t-CO(_2)/y)</td>
</tr>
<tr>
<td>Input</td>
<td>( N2O_y )</td>
<td>N(_2)O emission associated with fertilization (t-CO(_2)/ha)</td>
</tr>
<tr>
<td></td>
<td>( C_{RMF,y} )</td>
<td>Carbon stocks in vegetation to be cleared for afforestation (t-C/ha)</td>
</tr>
</tbody>
</table>

**Emission of dinitrogen monoxide associated with fertilization**

This emission is usually negligibly small compared to CO\(_2\) absorption after project implementation, thus disregarded. CO\(_2\) emission resulted from fertilizing are listed in Annex Table A-6 in CDM registered projects for your reference. Therefore,

\[
N2O_y = 0
\]

**GHG emission associated with clearing vegetation originally grown on the afforestation land**

This GHG emission corresponds to carbon stocks in vegetation originally grown on the afforestation land. It can be calculated by multiplying biomass (dry matter) such as grasses before the project by the acreage and CO\(_2\) conversion factor for carbon. Note that this emission is calculated for the year of clearance for afforestation only.

\[
C_{RMF,y} = \sum_j (O_{py,j} \times A_{orj,j} \times 44/12)
\]

- \( O_{py,j} \): Carbon stocks in stratum j in the year of clearance for afforestation (t-C/ha)
- \( A_{orj,j} \): Acreage of stratum j (ha)
- \( 44/12 \): CO\(_2\) conversion factor for carbon

**Determination of \( O_{py,j} \)**

Carbon stocks in vegetation cleared in the afforestation land are calculated for aboveground and belowground, respectively.

\[
O_{y,j} = (R_{Apy,j} + R_{Bpy,j})
\]

- \( R_{Apy,j} \): Aboveground carbon stocks in the year of clearance (year py)(t-C/ha)
- \( R_{Bpy,j} \): Belowground carbon stocks in the year of clearance (year py)(t-C/ha)

Aboveground and belowground carbon stocks are calculated by multiplying aboveground biomass (dry matter stem and leaves) and belowground biomass (dry matter roots), respectively, by carbon fraction for vegetation.
Belowground biomass is calculated in the following formula.

\[ V_{B,y,i} = R_j \times V_{A,y,j} \]

- Preferably, the country-specific ratio of belowground biomass to aboveground biomass \((R)\) should be used; however, values in Table 6.1 of PCC-GNGGI are also applicable where specific values are not available.

\[ R_j : \text{Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground)} \]

**Vegetation in scope of biomass calculation**

Among vegetation in pasture or agricultural lands, perennial plants are included in carbon stock calculation. Perennial plants prefer to grow in pasture lands. In addition, shrubs grown on pasture lands are also in scope of calculation. Among crops on agricultural lands, perennial orchards and horticultural trees such as gum trees and date palms are also in scope of calculation. Annual crops (vegetables, corns and cottons) are grown and harvested in a year, thus contribution to carbon stocks would be almost zero.

**CO₂ stock calculation per land use**

Biomass in pasture and agricultural lands is preferably calculated for aboveground and belowground, respectively. However, biomass per land use issued in the target country can be used to estimate CO₂ stocks per hectare. The tables below show some samples.

<table>
<thead>
<tr>
<th>Land use category</th>
<th>Biomass (t-dm/ha)</th>
<th>Carbon fraction (t-C/t-dm)</th>
<th>Conversion factor from carbon to carbon dioxide</th>
<th>CO₂ stock (t-CO₂/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before conversion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural land</td>
<td>Paddy</td>
<td>0.00</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Upland</td>
<td>0.00</td>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Orchard</td>
<td>30.63</td>
<td>0.5</td>
<td>56.16</td>
</tr>
<tr>
<td>Pasture</td>
<td></td>
<td>13.50</td>
<td>0.5</td>
<td>24.75</td>
</tr>
<tr>
<td>Wetland, developed land, others</td>
<td>0.00</td>
<td></td>
<td></td>
<td>0.00</td>
</tr>
</tbody>
</table>

Extracted from “Report of Greenhouse Gas Inventory of Japan”
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<table>
<thead>
<tr>
<th>Land use category</th>
<th>Biomass (t-dm ha)</th>
<th>Carbon fraction (t-C/t-dm)</th>
<th>Conversion factor from carbon to carbon dioxide</th>
<th>CO₂ stock (t-CO₂/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Glass land</td>
<td>11</td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>2. Glass land with shrubs</td>
<td>16</td>
<td>0.5</td>
<td>44/12</td>
<td>29</td>
</tr>
<tr>
<td>3. Annual crops/low land (slash and burn)</td>
<td>0</td>
<td>0.5</td>
<td>44/12</td>
<td>0</td>
</tr>
<tr>
<td>4. Perennial crops</td>
<td>24</td>
<td></td>
<td></td>
<td>44</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description of Data</th>
<th>Data Acquisition method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline Absorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before project</td>
</tr>
<tr>
<td><strong>Acreage</strong> ($A_i$)</td>
<td>Forested acreage after project (ha)</td>
<td>(Not required; out of the scope of calculation)</td>
</tr>
<tr>
<td><strong>Aboveground biomass</strong> ($T_{ai}$)</td>
<td>Biomass of planted trees (t-C/ha)</td>
<td>(Not required; out of the scope of calculation)</td>
</tr>
<tr>
<td><strong>Tree volume</strong> ($S_{vi}$)</td>
<td>Tree volume after project (t-dm/ha)</td>
<td>(Not required; out of the scope of calculation)</td>
</tr>
<tr>
<td><strong>Biomass expansion factor</strong> ($BEFi$)</td>
<td>Biomass expansion factor of planted trees</td>
<td>Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-1)</td>
</tr>
<tr>
<td><strong>Bulk density</strong> ($WDi$)</td>
<td>Bulk density of planted trees (t-dm/m$^3$)</td>
<td>(Not required; out of the scope of calculation)</td>
</tr>
<tr>
<td><strong>Carbon fraction</strong> ($CF_i$)</td>
<td>Carbon ratio to the total tree weight (-)</td>
<td>(Not required; out of the scope of calculation)</td>
</tr>
</tbody>
</table>
## 1. Forest and Natural Resources Conservation/Afforestation

<table>
<thead>
<tr>
<th>Data type</th>
<th>Description of Data</th>
<th>Data Acquisition Method</th>
</tr>
</thead>
</table>
| **Ratio of aboveground and belowground biomass \((R_i)\)** | Ratio of belowground biomass (dry matter roots) to aboveground biomass (dry matter stem, branches and leaves) \((-)\) | Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability.  
i Interview to competent authorities for data specifically used in this project  
ii Values announced in the target country  
iii Values based on data provided by IPCC or others  
(See Annex Table A-5) |
| **Biomass of cleared vegetation \((M_{c})\)** | Dry matter stems, branches, leaves and roots of vegetation grown originally on the project area \((t\text{-dm}/ha)\) | Not required: baseline absorption is assumed as 0 |
| **Original acreage \((A_j)\)** | Acreage of vegetation coverage originally grown on the project area \((ha)\) | Measured value |
| **Original aboveground biomass \((M_{a})\)** | Aboveground biomass of vegetation originally grown on the project area \((t\text{-C}/ha)\) | Preferably, the country-specific data and information should be used for calculation of aboveground biomass. Follow the steps below to check data availability.  
i Interview to competent authorities for data specifically used in this project  
ii Values announced in the target country  
iii Values based on data provided by IPCC or others  
(See Annex Table A-4) |
| **Original ratio of underground biomass to aboveground biomass \((R)\)** | Ratio of underground biomass to aboveground biomass \((-)\) | Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability.  
i Interview to competent authorities for data specifically used in this project  
ii Values announced in the target country  
iii Values based on data provided by IPCC or others  
(See Annex Table A-5) |

**Baseline Absorption**

<table>
<thead>
<tr>
<th>Before Project</th>
<th>After Project</th>
</tr>
</thead>
</table>

**Project Absorption**

<table>
<thead>
<tr>
<th>Before Project</th>
<th>After Project</th>
</tr>
</thead>
</table>

**Data Type**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Description of Data</th>
<th>Data Acquisition Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass of cleared vegetation ((M_{c}))</strong></td>
<td>Dry matter stems, branches, leaves and roots of vegetation grown originally on the project area ((t\text{-dm}/ha))</td>
<td>Not required: baseline absorption is assumed as 0</td>
</tr>
<tr>
<td><strong>Original acreage ((A_j))</strong></td>
<td>Acreage of vegetation coverage originally grown on the project area ((ha))</td>
<td>Measured value</td>
</tr>
</tbody>
</table>
| **Original aboveground biomass \((M_{a})\)** | Aboveground biomass of vegetation originally grown on the project area \((t\text{-C}/ha)\) | Preferably, the country-specific data and information should be used for calculation of aboveground biomass. Follow the steps below to check data availability.  
i Interview to competent authorities for data specifically used in this project  
ii Values announced in the target country  
iii Values based on data provided by IPCC or others  
(See Annex Table A-4) |
| **Original ratio of underground biomass to aboveground biomass \((R)\)** | Ratio of underground biomass to aboveground biomass \((-)\) | Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability.  
i Interview to competent authorities for data specifically used in this project  
ii Values announced in the target country  
iii Values based on data provided by IPCC or others  
(See Annex Table A-5) |
| 5. Others | (1) Project boundary  
Afforestation lands in the project area are in the scope of GHG estimation. |
|---|---|
| | (2) Leakage  
If 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, leakage should be calculated in consideration of cultivated acreage and number of livestock migrated out of the project boundary. For example, in CDM methodology (AR-AMS001), 15% of anthropogenic GHG reduction is calculated as leakage for cases where 10-50% of cultivated lands are migrated out of the project boundary (50% or more cultivated land migration may not regard as feasible as a project). |
| | (3) Monitoring  
JICA ODA loan projects usually require post-project evaluation only once after project completion. Baseline absorption (BCρ ) monitoring is not required in afforestation projects. Other items (project absorption and project emission) need monitoring at the timing when the afforestation outcomes can be confirmed for the purpose of post-project estimation. Challenges inherent to afforestation projects include difficulties to know the timing to implement post-project evaluation as well as the wide extent of the project area. To cope with such challenges, satellite images may provide useful means. The use of QuickBird in resolution of 1.0 m enabled to identify individual trees planted in a past afforestation project.  
For the long-term monitoring for 10-30 years throughout the forest growth period, set up the permanent sampling plots and temporary sampling plots (for soil plots) to monitor states after afforestation (2-3 years) and for several times after 5, 10 and following years. A permanent sampling plot is the site to monitor carbon pool changes throughout the project period. Such plots should be maintained at the same level as the other plots within the project boundary and never be destroyed during the monitoring period. A soil plot is the site to measure soil organic carbons. |
| | (4) Reference methods and the differences  
1) AR-AM0001 : Reforestation of degraded land  
【Difference】  
・The target area should be stratified based on the site category map/ chart, latest land use/ cover map or satellite images, soil map, vegetation map, topographical map and additional studies. It is required to define baseline scenarios by stratum; however, this requirement is integrated and simplified under this estimation formula, classifying the area up to 5 to 7 strata for species and the characteristic of the certain afforestation project. |
| | 2) AR-AM0007 : Afforestation and Reforestation of Land Currently Under Agricultural or Pastoral Use  
【Difference】  
・Baseline carbon pool changes should be defined based on the land use scenarios, however, this is not applied in this estimation formula.  
・Baseline absorption is estimated for littered or dead trees based on carbon stocks, however, it is not considered in this estimation formula.  
・Leakage associated with migration of residents and agricultural activities (cultivation, animal husbandry) is considered in relation to the project implementation, however, leakage is deemed as zero in this estimation formula. |
| | 3) J-VER003 : Increase of CO2 absorption through afforestation activities  
【Difference】  
・The following conditions are required to meet, however, they are not considered in this estimation formula.  
a) The project area does not fall in the forest prescribed in Article 5 or Article 7-2 of Forest Act as of March 31, 2008, and does not satisfy the following forest definitions. |
1. Forest and Natural Resources Conservation/Afforestation

<table>
<thead>
<tr>
<th>Definition</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum forest area</td>
<td>0.3 ha</td>
</tr>
<tr>
<td>Minimum canopy coverage</td>
<td>30%</td>
</tr>
<tr>
<td>Minimum tree height</td>
<td>5 m</td>
</tr>
<tr>
<td>Minimum forest width</td>
<td>20 m</td>
</tr>
</tbody>
</table>

b) The project is implemented for afforestation.

c) The project area is well-planned to be included within the forest planning area. Alternatively, the project area has been designated as the forest planning area at the inception of this project.

d) Follow the monitoring guideline (for forestry management projects) under offset credit (J-VER) scheme in monitoring.

4) The Carbon Assessment Tool for Afforestation Reforestation (CAT-AR)

【Difference】

- Kyoto Protocol defines three approaches for carbon dioxide absorption by forests, namely “afforestation”, “reforestation”, and “forestry management”. CAT-AR is the tool developed for “afforestation” and “reforestation” compatible to AR-CDM, however, this estimation formula is not AR-CDM compatible.