Plan Vivo Approved Approach

Estimating Reference Emissions Levels

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AA2 - Estimating Reference Emission Levels

For projects to control locally driven deforestation, this approved approach will derive estimates for the 2 key pieces of information needed to estimate the reference emission levels:

a. The baseline deforestation rate
b. The initial carbon stock

A. Estimating the Baseline Deforestation Rate

The baseline annual deforestation rate for the project intervention area is the deforestation rate that would apply without the project. It is expressed as a % of the measured forest area covered by the intervention.

Description

This approach involves measuring the historical deforestation rate for a reference area (a wider region that includes the project intervention area) and projecting this into the future under the baseline scenario.

This will provide an estimate of what would be expected to happen to the forest in the project intervention area without the project. To ensure that this estimate reflects the project baseline scenario as accurately as possible it is necessary to use good quality data and any other evidence (as far as this is available) to cross-check and validate the estimated deforestation rate. This includes seeking the views and advice of local experts. It is particularly important to ensure that the most appropriate reference area and historical time period are selected. There are a number of separate steps involved and a number of options available:

A1 Select the best methodology based on available data sources
A2 Select the most appropriate reference area
A3 Select the historical time period
A4 Estimate the baseline deforestation rate
A5 Cross-cross check and validate estimates with local experts

A1 Select the best methodology based on available data sources

Different methodologies to estimate the baseline deforestation rate are available depending on the availability of information and the capacities within the project to analyse the data. Table AA2.1 outlines these. They are arranged in order of preference – most projects using this methodology will use approach (a).

TABLE AA2.1		
Approach	**Type of data**	**Advantages/disadvantages**
a. Using the Global Forest Watch tool	• 30 m resolution maps and deforestation data are available on http://www.globalforestwatch.org/ using data from an analysis led by Matt Hansen and supported by Google. Details of the analysis and raw data are available at http://earthenginepartners.appspot.com/science-2013-global-forest • Other layers are available on the GFW site, but only the 30 m resolution data	• This is a versatile and simple to use tool that is freely available • It requires minimal IT capacity to use the tool • You can define your own reference area • The accuracy of the estimate can be improved by classifying the forest into canopy cover classes, and calculating changes in area of each class. Performing this

	provided by Hansen *et al.* is suitable for use in this methodology (coarser resolution MODIS-based products will miss small-scale deforestation). Other suitable products may be added to the GFW system at a later date: check with the Plan Vivo Foundation before using an alternative dataset • Any reference area can be selected using this tool and the forest cover change data within it can be analysed without the need for GIS software or data download • Maps can be produced for the reference area showing forest loss/gain over a specified time period	analysis will require downloading the raw data from http://earthenginepartners.appspot.com/science-2013-global-forest/download.html, as this analysis is not possible on the GFW website.
b. Analysis of remote sensing data	• Landsat or SPOT satellite imagery, or other imagery giving at least 30m resolution, can be downloaded or purchased • At least 2 datasets need to be obtained for the last 10 years including a recent set within the past 3 years • Analysis of forest cover change between the two years for the reference area will enable the annual deforestation rate to be calculated • The method can be improved by classifying the forest sub-classes (e.g. dense, medium and sparse crown cover) and using the remote sensing analysis to calculate change in the area of each of these classes	• There will be costs associated with obtaining the data and carrying out the analysis • Requires IT capacity to obtain the data and carry out the analysis • Forest definition can be defined by the user, rather than relying on an existing analysis that could potentially poorly represent local conditions
c. Secondary data analysis	• Publically available data on deforestation rates or forest cover • Use forest cover data for at least 2 different years over the past 10 years (including one set of recent data from within the past 3 years) to ensure accuracy • Comparison of the 2 data sets enables the annual deforestation rate to be estimated for the reference area (the area for which data are available)	• Data collection and analysis is simple and cheap • Sufficient data from at least 2 different years may not be readily available • Data will only be available for a fixed reference area (usually an administrative region or province) i.e. you cannot define your own reference area. This may limit its validity for the project. • It is unlikely that conditions in the area for which secondary data are available closely match those in the project area. Therefore any data should be applied and interpreted conservatively

Projects using approach (c) will be subject to a particularly intensive review during validation to ensure the likely accuracy and relevance of the data sources. Therefore, this approach is not normally recommended.

A2 Select the most appropriate reference area

This is a critical step for getting a good estimate of deforestation rates. Without an appropriate reference area your estimate of the baseline deforestation rate for the project intervention area will be poor. The following criteria should be used to select the most appropriate reference area:

- The reference area should be representative of the baseline conditions for the project intervention area in all possible ways
- The reference area should be geographically larger than the project intervention area and should include the project intervention area within it
- The size of the reference area can vary but it should normally extend approximately 20-30 km from the project intervention area in all directions (although this may not be possible if there are significant differences in the wider forest landscape surrounding the intervention area)
- The reference area should resemble the project intervention area i.e. with similar forest types, similar drivers of deforestation (locally-driven deforestation), similar proportions of forest in different conditions, similar ownership and management regimes, similar topography etc.
- The reference area should be defined to exclude forests that are significantly different from the project intervention area, e.g. national parks, as these will be subject to different deforestation rates and different drivers of deforestation
- The reference area should exclude any areas for which planned deforestation has already occurred e.g. conversion to oil palm monocultures on an industrial scale (normally greater than about 20 ha at one site).

If you are using method (c) in Table AA2.1, your selected reference area will depend on the areas for which secondary data are already available. These will normally be administrative areas such as districts, provinces or others. If the project intervention area falls close to the boundary of one of these, then you may need to consider combining data from adjacent districts/provinces to give a better estimate.

Using either of methods (a) or (b) in the Table AA2.1, you can select the reference area based on the criteria listed above. Try different reference areas (sizes, locations) and see what effect this has on changes in forest cover. Having tried several configurations, select (with justification) the one that gives the best indication of historical deforestation rates for the project area.

A3 Select the historical reference period

The historical reference period is the period over which you are calculating the baseline deforestation rate. It will have a significant effect on the accuracy of the baseline estimate for the project intervention area. Use the following criteria for selecting the historical reference period:

- The historical reference period should lie between 2 dates for which forest data are available. These mark the start and end of the historical reference period.
- The start and end dates should be separated by at least 3 years

- The start date should be more than 10 years before the start of the project quantification period
- The end date for the historical reference period should be as recent as possible

A4 Estimate the baseline deforestation rate

Using forest cover data for the reference area at the start and end of the historical reference period, calculate the change in forest area over this time (in ha). Divide this by the number of years between the start and end of the historical reference period to get the mean annual change in forest cover (in ha).

Mean annual change in forest cover ÷ forest cover at the start of the historical reference period = deforestation rate %

Example
Forest cover in the reference area in 2002 = 20,000 ha
Forest cover in the reference area in 2012 = 16,000 ha

Change in forest area (loss) = 20,000-16,000 = 4,000 ha
Mean annual change in forest area (loss) = 4,000/10 = 400 ha

% deforestation rate = 400/20,000 x 100 = 2%

A5 Cross check and validate estimates with local experts

Consult widely with local experts to determine whether your figure for the historical deforestation rate is realistic and acceptable based on their local knowledge and experience. Identify local experts who are familiar with the forest situation in the project area and ask them a series of questions to cross-check and validate your methodology and calculations. These can include:

- Are the drivers of deforestation in the project intervention area similar to those in the wider reference area?
- Are forest conditions in the project intervention area similar to those in the wider reference area?
- Does the reference area contain any forests that somehow are better protected or less well protected than the project intervention area?
- Have there been any significant events during the historical reference period that have had a sudden and significant impact on deforestation e.g. road construction, transmigration, declaration of protected areas etc.?
- Does the figure for the deforestation rate under the baseline scenario appear to be a good estimate based on their local knowledge and experience?

Based on the responses to these questions it may be advisable to reconsider the reference area and the historical reference period that you have been using. It is important to document these meetings and conversations, and responses from the experts (for example you could include as evidence attendance sheets from meetings, written statements following meetings, or email conversations).

Options and advice

Whatever data you use to calculate the historical deforestation rate, you must describe clearly its source in the accompanying text of the PDD. Give the full reference so that the source can be validated by Plan Vivo. The accompanying text should also include a justification for the selected reference area and historical reference period including a description of any alternatives that were considered before final selection was made.

Option using forest classification

The approach described above will give a sufficiently accurate estimate of the historical deforestation rate for the purposes of complying with the Plan Vivo Standard. However, for greater accuracy (especially for larger forest areas) it is recommended that you use a modification of this approach by classifying the forest into a number of different crown density classes at the start and end of the historical reference period e.g. dense, medium and open (sparse) forest. This involves the following steps:

- Use the satellite image analysis (or Global Forest Watch Data) to determine the area of forest in each crown density classes for the reference area at the start of the historical reference period
- Similarly find the area of forest in the same classes at the end of the historical reference period.
- Set this information out as shown in the example in Table AA2.2
- Use the satellite data to find how much forest in each crown density class has become degraded into a lower condition category. Set out this information in the form of the example shown in Table AA2.3

TABLE AA2.2

Forest category	Area in 2002 (ha)	Area in 2012 (ha)
Dense > 70% canopy cover	10,000	8,000
Medium 40-70% canopy cover	8,000	6,000
Sparse < 40% canopy cover	2,000	2,000
Open (non-forest)	0	4,000
Total	**20,000**	**20,000**

TABLE AA2.3

Land use change 2002-12	Area (ha)	% change (over 10 years)	Annual change %
Dense forest changed to medium forest	2,000	20%	2.0%
Medium forest changed to sparse forest	2,000	25%	2.5%
Medium forest changed to non-forest	2,000	25%	2.5%
Sparse forest changed to non-forest	2,000	0%	0%

Using the information in the PDD

These figures will be used to calculate the baseline emissions in Part G4 of the PDD

B. Estimating the Initial Carbon Stock

The initial carbon stock is that which exists in the project intervention area at the start of the quantification period. It is usually expressed in the form of tonnes of carbon (tC).

Description

The approach involves estimating carbon stocks by measuring them from available secondary data, through remote sensing or possibly by actually measuring tree inside the reference area.

Options and advice

Several options are available for estimating the initial carbon stock. They vary in their accuracy and effort/cost and also in the extent to which local people can be involved. This approved approach gives the option of selecting from either of 4 options (or combinations of these). Note that sample plot surveys are not necessarily required provided that alternative data sources for carbon stocks are available. Possible options include:

Option A: Using existing forest management plan data
Option B: Using other available national or sub-national data sources
Option C: Using remotely sensed data
Option D: Carrying out a biomass survey (inventory) using sample plots

Option A: Using existing forest management plan data

Accuracy - high; Effort/cost - low; Participation – low (high if communities have already been involved)

If a forest management plan for the project intervention area has already been prepared, then sample plot data or growing stock data may be available. If data from a forest management plan is recent it can be used to estimate the initial carbon stock.

A forest management plan usually contains volume (stem volume) data often presented in the form of growing stock (usually m^3/ha). It may be possible to obtain the actual sample plot data that was used to calculate this. This would normally be in the form of diameter (dbh) of trees recorded from a series of sample plots. Using this data, follow these steps:

- Convert stem volume (m^3/ha) to stem biomass (t/ha) using figures for wood density for the main forest type or tree species. Wood density figures can be obtained from http://datadryad.org/handle/10255/dryad.235 or http://www.worldagroforestry.org/sea/products/afdbases/wd/index.htm
- Estimate above ground biomass (t/ha) by applying standard conversion factors to stem biomass. These will vary from species to species. Alternatively overall forest-based conversion factors from growing stock to above ground biomass may be available.
- If sample plot diameter data are available, above ground biomass (t) per tree is estimated using allometric equations based on tree dbh. These have been developed for many tree species and can be found in published literature e.g. most recent generic tropical equations from Chave *et al*. 2014; http://onlinelibrary.wiley.com/doi/10.1111/gcb.12629/abstract and for individual tree species in online resources e.g. http://www.globallometree.org/
- Estimate the total above ground biomass for each sample plot from the total of the individual trees and convert this to t/ha based on the area of the plots.
- Calculate below ground biomass where BGB = 0.37*AGB
- Calculate total tree biomass (t/ha) as AGB+BGB
- Convert tree biomass (t/ha) to carbon (tC/ha) using a conversion factor of 0.47
- Convert carbon stock (tC/ha) to CO_2 ($tC0_2$/ha) using a conversion factor of 3.67

Options B: Using other available national or sub-national data sources

Accuracy - medium; Effort/cost - low; Participation - low

Published national and/or sub-national data sources may be available to give generalised forest carbon stock data for different forest types. If using such data the sources should be clearly indicated and should come from peer reviewed journals or be published by national forestry agencies. International sources of data (such as that published by IPCC) should not be used as they are too general for specific small forest areas and may give inaccurate results if used for this purpose.

Published figures may distinguish between different forest types and different crown density classes. Such data may be able to give an accurate-enough estimate of the initial carbon stock for the project intervention area for the purposes of estimating the reference emission levels. However, it is essential to clearly indicate the source of such data and demonstrate that it is applicable for the project intervention area. Information from such published sources should be applied conservatively. The source will be checked during project validation.

Option C: Using remotely sensed data
Accuracy – medium; Effort/cost – variable; Participation - low

Increasingly, remotely sensed data products that are maps of aboveground biomass have been produced. In particular two pan-tropical maps are available: one by Saatchi *et al* published in PNAS in 2011 (http://www.pnas.org/content/108/24/9899), and one by Baccini *et al.* published in Nature Climate Change in 2012 (http://www.nature.com/nclimate/journal/v2/n3/full/nclimate1354.html).

These maps can be compared interactively at http://carbonmaps.ourecosystem.com/interface/, which will also display other regional maps, which may be higher resolution and can also be used if available. The Carbon Comparison website will enable a project to estimate the average carbon stocks for their Project Intervention Area before the project start date using these layers: in order to be conservative we recommend using the lower of either the Saatchi or Baccini maps. Raw data for Saatchi or Baccini maps are available at http://carbon.jpl.nasa.gov/data/dataMain.cfm and http://www.whrc.org/mapping/pantropical/carbon_dataset.html respectively.

At a higher level of accuracy, LiDAR data is becoming available that can be used to measure tree height (canopy height) and hence estimate biomass. Conducting a LiDAR survey for the purposes of a Plan Vivo Project is unlikely to be cost-effective. However data may already be available and can be used.

The participatory element of this option can be improved by involving communities in ground-truthing and selection of reference sites for spectral signal matching.

Option D: Carrying out a biomass survey (inventory) using sample plots
Accuracy – variable; Effort/cost – high; Participation - high

Many countries have standard protocols for carrying out biomass surveys (or forest inventories) – usually for the purposes calculating the growing stock in forest management plans. Whilst such methodologies are accurate and can be an effective way to involve local people in these activities they can be expensive in terms of time and level of effort and may be beyond the capacity of many projects. Large forest areas with difficult terrain are particularly difficult to survey. Frequently costs are reduced by scaling-down such sample plot surveys (usually through having a lower sampling percentage) but there is a risk that by doing this carbon stock estimates may prove to be inaccurate and misleading.

If you use a standard methodology for sample plot surveying, you will fully meet the requirements of this approved approach. But it is important to follow the standard methodology carefully (especially in terms of the level of sampling) and a reference to the published methodology should be given so that it can be checked during project validation.

Sample plots

The purpose of sample plots is:

- To provide a means of assessing initial carbon stocks in forest of different density categories i.e. dense, medium, open
- To ground-truth the remotely sensed data i.e. to quantify forest carbon stocks for forest in different categories as assessed by remote sensing
- To enable community members to be involved on assessing baseline forest condition and project monitoring
- To provide a visual picture of the forest at different stages in the project (through the use of photographs)
- To ensure that there is a systematic and robust way to assess forest carbon stocks that can convince policy-makers and purchasers of credits of the validity of the approach
- To ensure that all the aspects of the Plan Vivo standard relating to quantification and monitoring of ecosystem services are met

Laying and recording sample plots in the project intervention area

Follow these steps:

- Decide on a sampling percentage for the sample plot survey. This should be at least 0.1% (but also refer to standard protocols for forest inventories)
- If necessary divide the area to be sampled into strata. Crown cover categories can form the strata for sampling. For smaller forest areas (less than 100 ha) stratification is not necessary. If the forest consists of more than one separate patch then each patch should be separately sampled.
- Using maps – first determine the location and number of sample plots required in a stratified sampling pattern. Once the sampling system has been finalised, geo-locate the plots on the ground using GPS.
- Plots can be any convenient shape and size (bearing in mind any approved technical protocols). Square plots are recommended of minimum size 50 x 50m - preferably larger
- Use a tape measure and compass to ensure that each plot is properly located on the ground and is the correct size and shape. During assessment of the sample plots it is convenient to temporarily mark the plot boundary with rope or tape to ensure that it is clear. This should be removed after plot assessments are complete.
- Plots should be permanent i.e. it should be possible to relocate them after a number of years for monitoring. Mark plots discretely so that they are not differently treated from the rest of the forest. Small marks at plot corners are preferable to marking all trees in the plot. Hammering long metal stakes deep into the ground, with the tips painted, has been shown to be a good long-term corner marker.
- Ensure that you have recorded the GPS readings for the plot corners.
- In each plot record the dbh and species of each tree > 10cm dbh

- Record other relevant information from the plots including: evidence of illicit cutting/harvesting e.g. number of cut trees/stumps; evidence of other damage e.g. fire or grazing; evidence of any other deforestation activities
- Take photographs from a fixed point in each plot. This will assist future relocation of the plots and will also contribute to a visual, photo-monitoring system
- Ensure that community members are fully involved in recording the plot data
- Make sure that all the plot data is safely recorded and back-up copies are made
- Follow the same methodology as for Option A to calculate the baseline carbon stock

Using the information in the PDD

This information is used to calculate the carbon emissions under the baseline scenario (Part G4 of the PDD template.

The methodology used should also be described in Part G4 (Plan Vivo Standard requirement 5.18).