Standard Methods for Estimating Greenhouse Gas Emissions from Forests and Peatlands in Indonesia

(Version 2)

Chapter 3:

Standard Method – Forest Growth and Turnover

MINISTRY OF ENVIRONMENT AND FORESTRY
RESEARCH, DEVELOPMENT AND INNOVATION AGENCY

INDONESIAN NATIONAL CARBON ACCOUNTING SYSTEM (INCAS)

Chapter 3: Standard Method – Forest Growth and Turnover

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The other chapters and full publication are also available on the INCAS website www.incas-indonesia.org

3 STANDARD METHOD – FOREST GROWTH AND TURNOVER

3.1 PURPOSE

This standard method describes the process used by INCAS for defining the forest growth and turnover that will be used as inputs for quantifying GHG emissions and removals from activities occurring on forest lands including: deforestation, forest degradation, sustainable management of forests and enhancement of forest carbon stocks in Indonesia. This includes data collation, data analysis, quality control and quality assurance.

INCAS adopted an event-driven modelling approach (see Chapter 7, *Standard Method – Data Integration and Reporting*) to account for changes in forest carbon stocks, which includes processes that continuously occur (e.g. growth or production, turnover, breakdown) and events that periodically occur (e.g. harvesting, fire) which usually have an instantaneous impact on carbon flows and thus impact on biomass and carbon stocks at any point in time. Total biomass and carbon stocks at any point in time represents the result of a series of events applied to the initial biomass and carbon stocks at the initial condition before experiencing the disturbance or management events, influenced by growth (production), turnover and breakdown processes after the disturbances or management events. Impact of the disturbance or management events on forest condition from which GHG emissions and removals are derived need to be quantified to accurately estimate GHG emissions and removals.

The objective of this standard method is to describe the methodologies used for defining rate of growth, turnover of aboveground and belowground biomass and decomposition rate of debris, for each component of each biomass class.

Outputs from this standard method will be used as inputs in quantifying emissions and removals for the processes of production, turnover and breakdown for each biomass class (documented in Chapter 7, *Standard Method – Data Integration and Reporting*).

3.2 DATA COLLATION

Data used for defining forest growth were collated from various sources. This included information collated from time-series measurement data from permanent measurement plots (PMP) established in logged-over forests and other forest inventory data, such as permanent sample plots established specifically for long-term research to monitor forest growth/increment and stand dynamics as well as data and information available in published literature, including research reports.

PMP, known as *Petak Ukur Permanen* (PUP), is part of a national program initiated by the former Ministry of Forestry in 1995 through the Forestry Ministerial Decree No. 237/ Kpts-II/1995. The objective of this decree is to request all logging concession companies in Indonesia to establish PMPs for monitoring growth and yield in their managed forest areas after logging. The Forestry Research and Development Agency (FORDA) published the guideline for plot establishment and measurement through the Directorate General Decree No. 38/KPTS/VIII-HM.3/93. The PMPs were classified into two major forest types, i.e. dryland forest and swamp forest. The plots were established in a logged-over area 1 to 3 years after logging and periodically measured/monitored. Each forest management unit (FMU) needs to establish at least 6 plots for dryland forest and 16 plots for swamp forest. Each PMP consists of an observation plot of 100 m x 100 m in size in which the DBH of all trees ≥ 10cm are measured and their species are identified. The measurement results are used to obtain information on forest growth and productivity of aboveground biomass (DBH ≥ 10cm).

Another measurement data series used is the STREK (silvicultural techniques for the regeneration of logged-over forests in East Kalimantan) plots. These plots are considered to be one of, if not the only, relatively good PSPs of dipterocarp forests in the world (Priyadi et al., 2005). The plots were established within logged-over forest in East Kalimantan by FORDA in collaboration with CIRAD-forêt and PT Inhutani I in 1989/1990. These plots were established to represent three different logging or silvicultural techniques, i.e. reduced impact logging with diameter limit 50 cm (RIL 50); RIL 60 and conventional logging. PSPs were also established in primary forest as a control. Total plot permanent area was about 48 ha and was measured periodically every 2 years up to the late 2010s. Measurements were carried out for all species with a diameter limit of 10 cm. More detailed description of these plots can be found in Bertault and Kadir (1998) and Siran (2005).

Information available in the proceedings, journals, student theses, research reports based on studies conducted in Indonesia or other neighboring countries with similar ecosystem conditions (e.g. Putz and Chan, 1986; Nguyen The et al., 1998; Inoue et al., 1999; Simbolon, 2003; Hashimoto et al., 2004; Hiratsuka, 2006; Limbong, 2009; Meunpong et al., 2010; Krisnawati et al., 2011; Saharjo, 2011; Susilowati, 2011; Yuniawati et al., 2011; Dharmawan, 2012; Purba et al., 2012) were used. In addition, stand yield tables for the main plantation species in Indonesia (Suharlan et al., 1975) were also included. These information sources were used as references for the increment quantification approach in the modelling of GHG emissions and removals under INCAS to set the rate of growth, turnover of aboveground and belowground biomass and decomposition rate of debris, for each component of each biomass class.

3.3 ANALYSIS

Methodologies used in determining forest growth in this standard method consist of developing and analyzing growth and increment curves from the data and information collated from various sources as described in Section 3.2.

All data from inventory and research plots as well as information available from the literature were reviewed through a quality control process to ensure only valid data were used. For each data set, the location of the sampling site, forest conditions and the parameters that affect the results were recorded. Some of the data and information obtained from the literature (e.g. Putz and Chan, 1986; Nguyen The et al., 1998; Inoue et al., 1999; Simbolon, 2003; Hashimoto et al., 2004; Hiratsuka, 2006; Limbong, 2009; Meunpong et al., 2010; Krisnawati et al., 2011; Saharjo, 2011; Susilowati, 2011; Yuniawati et al., 2011; Dharmawan, 2012; Purba et al., 2012) were further analyzed and transformed to prepare forest growth and turnover rate data in the format required for INCAS.

Time-series data obtained from permanent sample plots established in logged-over forests in both PUPs and STREK plots were analyzed to quantify aboveground mass increment over time after logging. Calculations of aboveground biomass were carried out using the approach described in the monograph and guidelines on *Allometric models for estimating tree biomass at various forest ecosystem types in Indonesia* (Krisnawati et al., 2012; FORDA, 2013). Information available from stand yield tables (Suharlan et al., 1975) covering 10 main species of timber plantations (i.e. Jati, Rasamala, Damar, Pinus, Sonokeling, Mahoni, Akasia, Sengon, Balsa and Jabon) were re-analysed to produce average growth curves of various site index classes for each plantation species.

In analysing the growth, three phases of growth that occur in a stand are considered: (1) juvenile (young) phase with a fast growth rate, (2) full vigor phase with a constant growth rate and (3) senescent phase of declining growth rates. These three phases of growth will generally form a sigmoid curve (Figure 3-1).

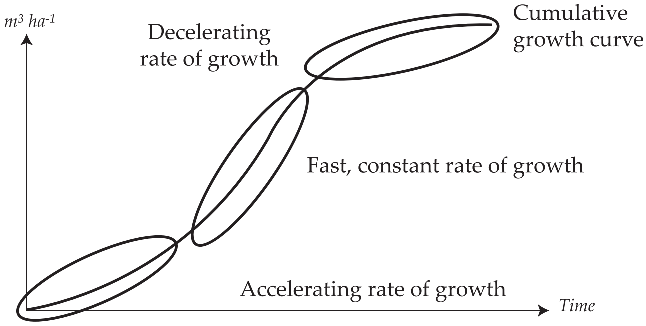


Figure 3-1. Phases of growth rates

Several other regression models that form the sigmoid curve or growth curve (Weibull, root, modified exponential, logistic, logistics power, Gompertz, two-exponential association, three-exponential association), were tested to generate the corresponding growth curve and the selection was based on a combination of statistical and logical criteria. These analyses are documented in the INCAS growth database.

Two types of increment curves were considered (Figure 3-2):

- CAI (Current Annual Increment), defined as the increment over a period of 1 year at any stage in forest's life.
- MAI (Mean Annual Increment), defined as the mean increment of the forest until a specific age.

However, for the purpose of modelling under INCAS framework, CAI data is needed when calculating annual biomass or carbon stocks (this can be generated from either biomass or volume).

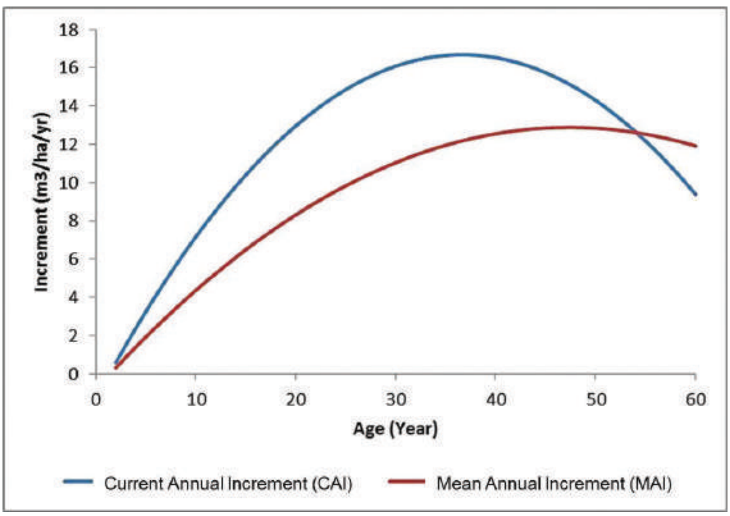


Figure 3-2. Example of increment curves generated from volume increment

3.4 QUALITY CONTROL AND QUALITY ASSURANCE

Quality control processes were implemented to check that the methods used for data collection and analysis of data used met minimum standards for appropriateness and completeness. This included checking the quality of measurement data from inventory or monitoring plots to see if there was any error in recording and measurement. Accuracy of the data was checked further by overlaying with relevant maps to check that forest types matched with species in the record. Some information such as stand density and basal area was used for checking the quality of the data. Procedures for data quality checking were done following the procedures as described in Krisnawati et al (2014) and also applied in Chapter 2 of this Annex.

3.5 OUTPUTS AND UNCERTAINTY ANALYSIS

In terms of growth rate, the annual change in biomass carbon stocks can be estimated using the gain–loss method, which combines the annual increase in carbon stocks due to biomass growth with losses due to turnover and management events. Gain of biomass used in INCAS is characterized as plantation growth or natural growth. Plantation growth is defined as the growth of plants that are deliberately planted. Natural growth is defined as growth that occurs as a result of natural process of succession after disturbances in natural forests, e.g. fire, logging.

Assumptions, data sources and results of the analysis that generated growth curves and increment tables for each species of timber plantation and each natural forest type are documented in the INCAS Growth Database (see the description of the database in Appendix 1). This includes:

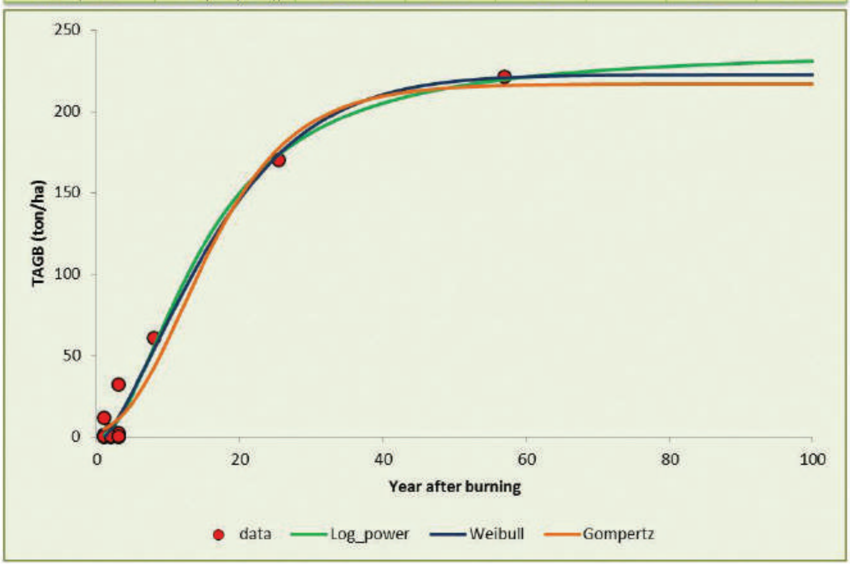
- Plantation growth
    - Agathis (*Agathis sp.*)
    - Akasia (*Acacia sp.*)
    - Balsa (*Ochroma bicholor*)
    - Jabon (*Anthocephalus cadamba*)
    - Jati (*Tectona grandis*)
    - Mahoni (*Swietenia sp.*)
    - Pinus (*Pinus sp.*)
    - Rasamala (*Altingia excelsa*)
    - Sengon (*Albizia falcataria*)
    - Sonokeling (*Dalbergia latifolia*)
    - Kemiri (*Aleurites moluccana*)
    - Environmental plantation (mix of species)

- Natural growth
    - After burning
    - After logging

INCAS assumes there is no net growth in primary forests, for which the biomass stocks are assumed to be at equilibrium prior to human induced disturbances (i.e. growth is equivalent to turnover and decomposition). In natural forests that have been disturbed and then left without any disturbance for a long time, natural growth may compensate for biomass loss due to the previous disturbance; they may eventually attain the same biomass stock as the initial condition of forests, even though they may have different forest structure and species composition.

Quality control procedures were used to select the best available data for inclusion in the analysis. Statistical analysis was then conducted for a selection of models to derive growth curves for plantations and natural forests following disturbance. An example of the outputs from growth analysis for secondary swamp forest after burning is presented below (Figure 3-3).

Model	Form	Parameter				Standard error	R-sq
		a	b	c	d		
Logistik power	a/(1+((x/b)^c))	237.01	15.03	-1.9		9.35	0.98
Weibull	a-b*e^(-c*(x^d))	222.38	226.33	0.015	1.43	10.2	0.98
Gompertz	a*e^(-e^(b-cx))	216.84	1.45	0.12		11.3	0.98



Year	CAI (ton/ha/yr)
0	0.0
1	1.6
2	7.6
3	8.1
4	8.5
5	8.7
6	8.8
7	8.8
8	8.8
9	8.7
10	8.5
11	8.3
12	8.0
13	7.7
14	7.4
15	7.1
16	6.8
17	6.4
18	6.1
19	5.8
20	5.4
21	5.1
22	4.8
23	4.5
24	4.2
25	3.9
26	3.6
27	3.4
28	1.5
29	0.9
30	0.5
31	0.3
32	0.2
33	0.2
34	0.2
35	0.0

Figure 3-3. The example of outputs from growth analysis for secondary swamp forest after burning.

3.6 LIMITATIONS

Some limitations identified in this standard method are described below:

- Some plantation species and some conditions of natural forests have no permanent sample plots with long/periodical measurements for describing the long-term impact of management/events on growth.
- The same growth curves have been applied to all rotations in timber plantations and for each natural forest biomass class because the current approach does not differentiate between site conditions or finer scale management. Initial attempts to derive biomass classes based on site biophysical characteristics did not result in sufficiently robust relationships. This should be re-tried once more data is available.
- Turnover and debris decay rates were not available for Indonesia, hence default turnover and decay rates were adopted from tropical rain forest in Australia as an interim measure, because these forests are expected to have similar turnover and decay characteristics and detailed data is readily available.

3.7 IMPROVEMENT PLAN

Plans for improvement are outlined below:

- Data about plantation and natural forest growth could be improved by gaining access to additional existing data sets and through targeted research designed to fill knowledge gaps.
- Timber plantation growth curves could be improved by including more information about site biophysical characteristics and the impact of plantation management practices on growth, particularly site nutrition and water table management on peatlands.
- Secondary natural forest growth curves could be improved by including more information about site biophysical characteristics and the impact of management practices on subsequent growth.
- Research into turnover and decay rates in Indonesia should be undertaken to better understand the rate of turnover and decomposition under different natural forest and plantation conditions.

This publication describes in detail the standard methods of the Indonesian National Carbon Accounting System (INCAS) to quantify net greenhouse gas (GHG) emissions from forests and peatlands in Indonesia in a transparent, accurate, complete, consistent and comparable manner. The standard methods describe the approach and methods used for data collation, data analysis, quality control, quality assurance, modelling and reporting. The standard methods cover (i) Initial Conditions, (ii) Forest Growth and Turnover, (iii) Forest Management Events and Regimes, (iv) Forest Cover Change, (v) Spatial Allocation of Regimes, (vi) Peatland GHG Emissions, and (vii) Data Integration and Reporting. This second version of the standard methods includes improvements implemented in preparing the first comprehensive national GHG inventory for forests and peatlands, the results of which are reported in *National Inventory of Greenhouse Gas Emissions and Removals on Indonesia's Forests and Peatlands*. This publication has been prepared and published by the Indonesian Ministry of Environment and Forestry, under the Research, Development and Innovation Agency.

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