

Carbon Stock Estimates for *Acacia mangium* Forests in Malaysia and Indonesia

Potential for Implementation of Afforestation and Reforestation CDM Projects

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Keywords: carbon accounting, reforestation, fast-growing tree species, yield table, A/R-CDM

Abstract: The Conference of the Parties 9 in Milano, Italy (COP 9, 2003) approved modalities and procedures for afforestation and reforestation (A/R) project activities under the Clean Development Mechanism (CDM) of the Kyoto Protocol. According to the conclusions of COP 9, several approaches are available to monitor temporary carbon sequestration in A/R-CDM projects. Developing baselines for such monitoring is difficult because of a lack of basic growth and management data. In this paper, we present guidelines for preparing a project design document (PDD), in which growth and yield prediction in plantation forests plays an important role, and present a methodology for modeling and estimating carbon stocks using inventory data from *Acacia mangium* plantations in Malaysia and Indonesia.

1. Introduction

Indonesia and Malaysia have the opportunity to serve as host countries for Clean Development Mechanism (CDM) projects through afforestation and reforestation (A/R) efforts. The Conference of the Parties 9 in Milano, Italy (COP 9, 2003) sought to clarify modalities and procedures of A/R-CDM project implementation under the Kyoto Protocol. One of the most difficult requirements for the formulation of A/R-CDM projects is meeting the requirements of an “additionality scheme.” Project participants are asked to describe the project scenario in the form

of a project design document (PDD). The PDD must clearly define the “additionality scheme,” or how the project will augment carbon sequestration with respect to the identified baseline scenario.

In this paper, we present brief guidelines for designing a PDD and discuss our approach to developing suitable carbon stock estimates for *Acacia mangium* plantation forests in Malaysia and Indonesia. These countries have a history of using *Acacia mangium* plantations for land rehabilitation under short rotation-high yield management schemes. Plantation forestry plays an important role in climate change mitigation, especially under the CDM scenario. *Acacia mangium* shows promise as tropical plantation tree species that provides significant benefits to investors and indigenous populations involved in A/R-CDM projects.

2. Modalities and Procedures for A/R-CDM Projects

Project participants are asked to submit the completed version of a CDM-PDD, together with any attachments, to an accredited designated operational entity for validation (Figures 1 and 2, based on Nur, 2004). The designated operational entity then examines the adequacy of the information provided in the CDM-PDD, giving extra attention to how well it satisfies the modalities and procedures relevant to CDM project activities. Based on this examination, the designated operational entity makes a decision regarding validation of the project.

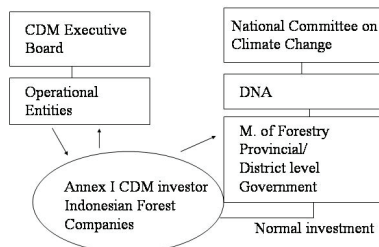


Figure 1. Certification and validation of CDM projects in Indonesia

- PDD by PP (Project participants)
- Certified by DNA (Designated National Authority) of investor and host countries

Organization structure of DNA

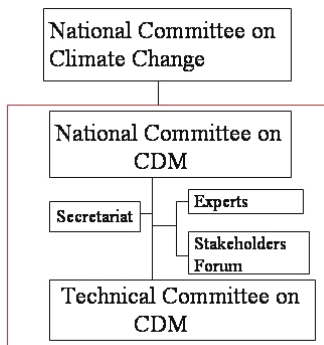


Figure 2. Certification flowchart

3. CDM Project Design Documents

A CDM-PDD presents information on the essential technical and organizational aspects of the project activity and is a key input into the validation, registration, and verification of the project, as required under the Kyoto Protocol. The CDM-PDD contains information on the project activity, the approved baseline methodology applied to the project activity, and the approved monitoring methodology applied to the project. It discusses and justifies the choice of baseline methodology and the applied monitoring concept, including monitoring data and calculation methods. The following is a general overview of PDD design in a CDM project (UNFCCC, 2004):

- 1) General description of project activity
- 2) Application of a baseline methodology
- 3) Duration of the project activity and crediting period
- 4) Application of a monitoring methodology and plan
- 5) Calculation of greenhouse gas (GHG) emissions by sources
- 6) Evaluation of environmental impacts
- 7) Stakeholders' comments
- 8) Appendices: 1) Contact information on participants in the project activity; 2) Information regarding public funding; and 3) Table of baseline data

4. Required Components of Forest Management Models

Properly describing a suitable forest management model is a key component of developing a PDD. The following are important components of a forest management model:

- 1) Category of project activity
- 2) Duration of the project activity
- 3) Monitoring methodology
- 4) Baseline methodology
- 5) Carbon pool
- 6) Financial analysis
- 7) Review of “additionality scheme”

Consider the following overview of a forest management model. The *category* might include large-scale industrial plantation, rehabilitation of critical land, agroforestry, or some combination of these management schemes. The *duration* will be based on a twenty year renewable (maximum sixty years) or thirty year fixed scheme. The crediting period should also be classified as temporary Certified Emission Reductions (t-CER) and long-term Certified Emissions Reductions (l-CER). In terms of *monitoring methodology*, the following details must be described: 1) the name and reference of the approved monitoring methodology applied to the project activity, 2) a justification for the chosen methodology and an explanation of why it is applicable to the project activity, and 3) a description of the quality control (QC) and quality assurance (QA) procedures proposed for data monitoring. A description of *additionality* is the most important component of a PDD. The project participant should explain the land use change, *baseline methodology* for the *carbon pool* estimation, and provide a *financial analysis* of the project’s impact (as compared to “no-project” scenario).

The A/R-CDM model (or forest management model) should be constructed according to the steps outlined above. It should consist of two main parts - a standard plantation management plan and a CDM-related section with financial, growth, and carbon pool analyses. In this context, the construction of a suitable

yield table is quite important. However, due to a lack of long-term observed plantation data, it can be difficult to construct a precise table for the deviation of local yield. In this paper, we temporally construct a yield table that is derived from various plots in *Acacia mangium* plantations and propose a procedure for estimating carbon stocks.

5. Data Collection

Acacia mangium is a fast growing tree species that is well suited to reforestation efforts in degraded landscapes. In Malaysia, it has been widely planted since the beginning of the Compensatory Forest Plantation Program (CFPP) in 1981. Its initial survival rate is relatively high, but disease (frequently heart rot) sometimes appears in later years. Figure 3 (below), shows the location of field sites where data was collected for the yield table we have constructed (Matsumura and Ismail, 1996; Matsumura, 2004). Sites were distributed throughout the Malaysian Peninsula.



Figure 3. Data collection sites on the Malaysian Peninsula

6. Methods

According to the conclusions of COP 9, project participants must account for all changes in the following five carbon pools:

- 1) Above-ground biomass (leaf, branch, and trunk)
- 2) Below-ground biomass (root)
- 3) Dead wood

- 4) Litter
- 5) Soil organic carbon

Mean carbon stock (MC) is usually estimated by the biomass expansion factors method (IPCC 2003) that includes above- and below-ground biomass carbon pools:

$$[1] \quad MC = V \cdot D \cdot BEF \cdot (1 + R) \cdot CF$$

where the variables are defined as follows:

- MC: mean carbon stock (tC/ha)
 V: merchantable volume (m³/ha)
 D: wood density (t *dm*/m³), where *dm* means “dry matter”
 BEF: biomass expansion factor
 CF: carbon fraction (tC/t *dm*)
 R: root-shoot ratio (t *dm*)

Merchantable volume in *Acacia mangium* stands was estimated from a yield table and the other parameters are given as follows: D=0.5, BEF=1.3, CF=0.5, and R=0.18 (ICRAF, 2004; CFFMP, 2005).

Merchantable volume is generally estimated by the allometric relationship between diameter and height. The following basic equations were used to calculate mean values in *Acacia mangium* stands (Matsumura and Ismail, 1996; Matsumura, 2004):

- 1) Mean diameter at breast height (D)

$$[2] \quad D(t) = 41.10(1 - 0.8950 e^{-0.0783 \cdot t})$$

- 2) Mean height (H)

$$[3] \quad H(t) = 26.04(1 - 1.0747 e^{-0.2477 \cdot t})$$

- 3) Merchantable height HB

$$[4] \quad HB = 0.3539 \cdot H + 4.9397$$

- 4) Merchantable volume V (based on Wan Razali et al. 1989)

$$[5] \quad V = a \cdot D^b \cdot HB^c$$

where, $a = f(\text{trees per ha})$, $b = 1.5474$, and $c = 0.8093$

A flow chart of the growth model used to construct the yield table is shown in Figure 4. The yield table we derived for each study site was compared with the yield tables from other study sites in West Java and in Sabah (Inose, 1991).

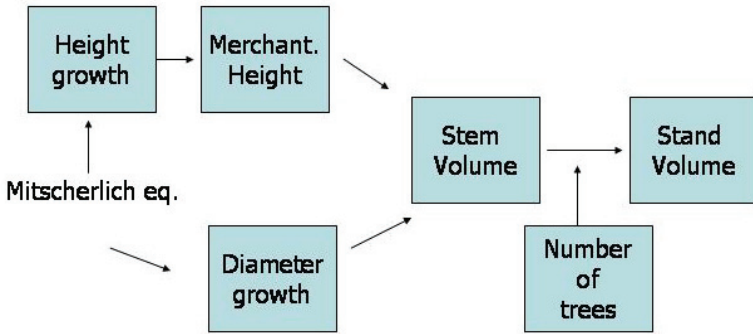


Figure 4. Flowchart of volume estimation procedure

Table 1. Regional comparison of study sites at age 10

	Sabah			P.Malaysia	Sumatra	West Java
	I	II	III	Chikus	Benakat	Maribaya
H10	25.71	22.18	18.66	23.7	21.4	25.1
Ratio	108	94	79	100	90	106
D10	29.14	23.18	18.34	24.2	23.9	27.8
Ratio	120	96	76	100	99	115
N10	429	530	641	524	673	225
Ratio	82	101	122	100	128	43
Volume 1C	0.646	0.372	0.206	0.408	0.542	0.654
Ratio	158	91	50	100	133	160
Vol10	277	197	132	214	365	147
Ratio	129	92	62	100	171	69
Carbon	106.2	75.5	50.6	82.1	140	56.4
Ratio	129	92	62	100	171	69

7. Results and Discussion

The comparison among study sites at age 10 is shown in Table 1. The values calculated for the local yield table in Sabah are given in three different site classes. For ease of comparison, the relative values are given in percentiles for the Chikus site in Peninsular Malaysia. Height growth and DBH shows the highest performance at the Sabah I and West Java sites. The Sabah I and Sumatra sites demonstrated highest volume growth and carbon stock performance, though it

depended on the total number of trees per ha. Figure 5 (below) shows estimated carbon stocks in the West Java and Malaysia study sites.

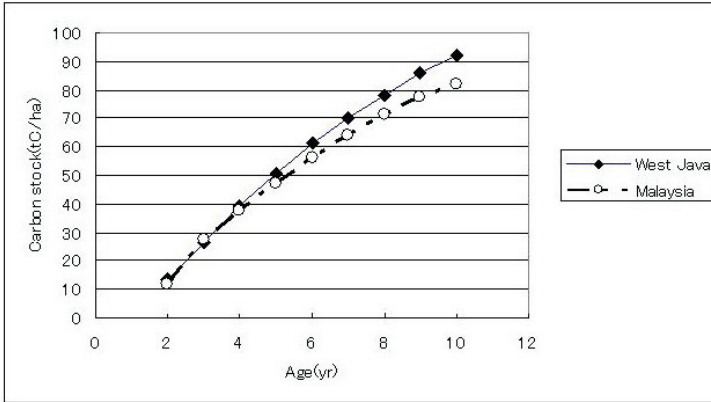


Figure 5. Carbon stock estimates of *Acacia mangium* stands

8. Conclusion

A suitable forest management model for A/R-CDM, in terms of carbon stock estimates, should be selected by considering similar case studies. For a small-scale project, we make the following suggestions:

- 1) Simplify modalities and procedures
- 2) Reduce the requirements for small scale CDM-PDD
- 3) Simplify baseline methodologies to reduce costs
- 4) Simplify monitoring plans
- 5) Allow the same operational entity to undertake validation, verification, and certification

To ensure a smooth implementation of A/R-CDM projects, it is also important to analyze the growth and carbon stock difference at local project sites from the investors' and communities' points of view, respectively. The design of A/R-CDM projects and PDD layout should become increasingly easier as general yield tables are developed for promising tree species in the coming years.

Acknowledgements

The authors wish to thank our Japan International Cooperation Agency (JICA) project collaborators in Malaysia and Indonesia for their invaluable cooperation. We also thank the collaborators of the consulting papers of the JICA projects and acknowledge two anonymous reviewers for their thoughtful and useful comments. This study was supported in part by Japan Society for the Promotion of Science grant number 17405034.

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マレーシアとインドネシアにおけるアカシア・マンギウム林の炭素蓄積量
の推定—A/R-CDMプロジェクトの適用可能性について—

松村 直人・仲摩 栄一郎・タワナ・スカンジ・リナルディ・イマニュエル

要約：京都議定書で規定された新規植林 / 再植林によるクリーン開発メカニズム吸収源プロジェクトの手続きと様式が2003年のCOP9において承認された。COP9の決定に従って、同プロジェクトにおける炭素蓄積量の暫定的な推定方法がいくつか提案された。しかし、ベースラインシナリオを作成する際に重要となる森林成長と森林経営に関する十分なデータがないため、手続きの開始が困難となっている。本論文では、マレーシアとインドネシアにおけるアカシア・マンギウム植林地の成長データに基づき、成長モデルの作成と炭素蓄積量の推定方法について検討した。プロジェクト設計文書において規定された方法論では、植林地における成長と収穫予測モデルが重要な役割を担っている。

キーワード：炭素収支, 再植林, 早生樹, 収穫表, A/R-CDM