Ministry of Forestry of Indonesia
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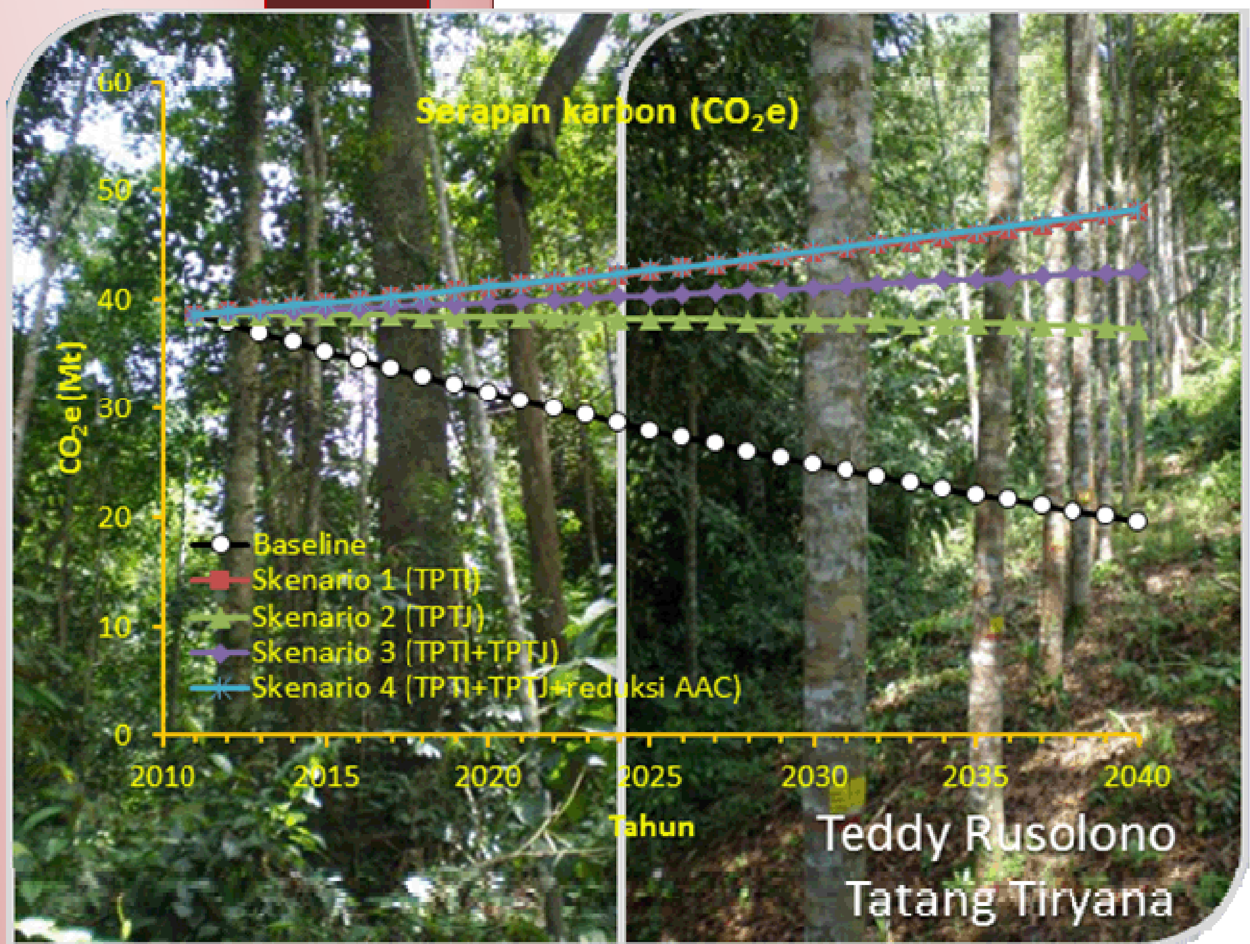
Enhancing Forest Carbon Stock to Reduce Emission from Deforestation and Degradation through Sustainable Forest Management (SFM) Initiatives in Indonesia

(*Peningkatan Stok Karbon untuk Pengurangan Emisi dari Deforestasi dan Degradasi Hutan melalui Inisiatif Pengelolaan Hutan Lestari di Indonesia) Initiatives in Indonesia*)



REVIEW OF EXISTING SUSTAINABLE FOREST MANAGEMENT (SFM)-BASED PROJECTS in INDONESIA

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Project Technical Report
Review of Existing Sustainable Forest Management (SFM)-Based Projects in Indonesia

Teddy Rusolono
Tatang Tiryana

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Enhancing Forest Carbon Stock
to Reduce Emission from Deforestation and Degradation
through Sustainable Forest Management (SFM) Initiatives
in Indonesia

Host Government: Indonesia

Executing Agency:
Directorate of Production Forest Use and Business
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Executive Summary

Since the 13th climate change conference (COP 13) in 2007, sustainable forest management (SFM) has been considered as an option for reducing emissions through REDD+ mechanism. Such international agreement provides a great opportunity for Indonesia to highly involve in the REDD+ mechanism, because Indonesia has abundant forest resources. The REDD+ mechanism through SFM, however, needs to be further investigated because until now there is no real implementation yet. This study was aimed to review the progress of SFM practices and REDD+'s demonstration activity projects in Indonesia, to analyze several SFM scenarios for reducing emissions, and to formulate relevant strategies for reducing emission through SFM.

Forest management in Indonesia has initially focused on the utilization of natural production forests to achieve sustained timber yield. Such forest management practice, which was started on around 1970 through forest concessionary licenses, tended to exploit the natural forest resources that resulted in high deforestation and forest degradation. In the period 1990–2009, the number of forest concessions decreased up to 45%, indicating an unsustain management of the natural production forests. Among 308 concessions, which were still exist until June 2011, only five concessions granted SFM certificates by FSC (Forest Stewardship Council) or LEI (LembagaEkolabel Indonesia, the Indonesian Ecolabeling Institute).

Considering the decline of natural forest resources, since 1989 Indonesian government has been developing industrial plantation forests (especially in outside of Java) to fulfill increased demands for timber and to improve productivity of critical lands. Until 2008, total area of plantation forests reached 4.3 million hectares. However, until June 2011 there were only three plantation forest management units certified by LEI.

Community forest management shows a promising progress, which is indicated by the increase of community forest areas in Indonesia, although most of the community forests (approximately 50%) concentrate in Java. Until June 2011, five community forest management units have been certified by FSC and twelve

other FMUs were certified by LEI. Until now, forest management practices at natural production forests, plantation forests, and community forests do not integrate yet the potential benefits of carbon sequestration into their management objectives.

The implementation of REDD+ mechanism in Indonesia is still limited to demonstration activities at national, provincial, district, or project level. Currently, there are at least 30 demonstration activity projects in Indonesia that are financially supported by various parties, e.g. Korea, Australia, Germany, United Kingdoms, The United Nations, ITTO (International Tropical Timber Organization), TNC (The Nature Conservancy), and WWF (World Wildlife Fund). The REDD+'s demonstration activity projects were implemented for a duration of 2–5 years.

Commonly, the REDD+'s demonstration activity projects conduct five main activities: 1) determining an appropriate baseline, 2) calculating the emission reduction of a project against the business as usual (BAU) scenario, 3) formulating procedures for monitoring, reporting, and verification (MRV) of emission reduction activities, 4) accounting tradable carbon units, and 5) developing distribution system for the payment of carbon trading to involved parties. Those projects are expected to provide lessons learned on methods and technical implementation of REDD+ mechanism in Indonesia. Until now, however, there is no REDD+'s demonstration activity project implemented in a forest management unit level, which could provide lessons learned for forest managers on how to reduce emission through SFM practices.

To explore the potency of SFM as an option for reducing emission in the REDD+ mechanism, this study developed and analyzed several scenarios for managing natural production forests, plantation forests, and community forests. For natural production forests, a case study in Sari BumiKusuma (SBK, Central Kalimantan) concession showed that emission reduction benefits can be gained if forest management unit (FMU) applies a multisystem silviculture (i.e. combination of TPTI and TPTJ systems) coupled with AAC (Annual Allowable Cut) reduction. For 30 years, such scenario could reduce carbon emission up to 447.75 MtCO_2e for a total effective area of 119,607.45 ha or an average of 124.78 tCO_2e/ha/yr. The emission reduction benefit of such scenario was similar to that of applying TPTI system to the entire effective area, which reduced carbon emission up to 443.82

$MtCO_2e$ or an average of 123.69 tCO_2e/ha/yr. The FMU would gain lower emission reduction benefits if it implements either TPTJ system to the entire area (i.e. 83.75 tCO_2e/ha/yr) or a multisystem silviculture without AAC reduction (i.e. 103.48 tCO_2e/ha/yr).

In addition to avoiding deforestation, another effort for reducing emissions is avoiding forest degradation. The case study of teak plantations in KPH Kebonharjo (PerumPerhutani Unit I, Central Java) confirmed that the FMU would gain the highest benefit of emission reduction (i.e. 202,630 tCO_2e/yr for KPH Kebonharjo or equal to 11.38 tCO_2e/ha/yr) if forest managers can avoid forest degradation. Such scenario, however, seems difficult to implement because teak plantations in Java always experience various disturbances that result in forest degradation. Alternatively, if FMU can control the rate of degradation to less than 2% per year (as occurred in KPH Kebonharjo in the period 1977–1987), the FMU would still gain relatively high benefit of emission reduction (average of 152,450 tCO_2e/yr or equal to 8.56 tCO_2e/ha/yr). These findings confirmed that avoiding forest degradation is a must to gain more benefits of emission reduction through plantation forests management.

Community forest management can also be used as an option to reduce emission. The case study of community forests managed by KoperasiHutan Jaya Lestari (KHJL, South Konawe, Sulawesi) showed that KHJL could gain the benefit of emission reduction up to 1.03 $MtCO_2e$ for 30 years (average of 34,459 tCO_2e/yr) if forest managers increase harvestable diameter limit from 20 cm to 30 cm coupled with replanting of harvested trees. The emission reduction benefit can be increased to a total of 3.1 $MtCO_2e$ or average of 103,469 tCO_2e/yr if KHJL expands their FMU by recruiting new member, replanting, and regulating harvestable diameter limit.

This study concluded that SFM practice (especially in natural production forests, plantation forests, and community forests) can be used as a promising option for reducing emissions in the REDD+ mechanism. Several strategies for reducing emissions at FMU level are: 1) controlling harvest level, 2) reducing logging damages, 3) minimizing land clearing for infrastructures, 4) eliminating or avoiding forest degradation, 5) conducting rehabilitation or restoration of unproductive areas, 6) tending residual stands to improve regrowth, 7) allocating some portions of production areas to protected areas, 8) selecting appropriate silvicultural systems that increase carbon stocks, and 9) optimizing growing space for maximizing forest biomass. Forest managers, however, need to be aware that trade-offs between emission reduction and sustained timber yield objectives are unavoidable. Incentive systems for forest managers, therefore, need to be formulated to support the implementation of REDD+ mechanism through SFM practices.

Table of Contents

List of Table

List of Figures

List of Boxes

List of Appendixes

Acronym

AAC	Annual Allowable Cut
CFMU	Community Forest Management Unit
FMU	Forest Management Unit
FSC	Forest Stewardship Council
ITTO	International Tropical Timber Organization
KHJL	*Koperasi Hutan Jaya Lestari* (a co-operative that manages community forests in South Konawe)
KPH	*Kesatuan Pengelolaan Hutan*(forest management unit)
LEI	*Lembaga Ekolabel Indonesia* (the Indonesian Ecolabeling Institute)
MBNP	Meru Betiri National Park
MC	Mandatory certification
MRV	Monitoring, Reporting, and Verification
PSP	Permanent Sample Plot
REDD	Reducing Emission from Deforestation and Forest Degradation
REL	Reference Emission Level
RIL	Reduced Impact Logging
SFM	Sustainable Forest Management
SLIMF	Small and Low Intensity Management of Forest
TPTI	*Tebang Pilih Tanam Indonesia* (Indonesian Selective Cutting and Planting)
TPTJ	*Tebang Pilih Tanam Jalur* (Selective Cutting and Line Planting)
VC	Voluntary certification

I. Introduction

1.1 Background

Deforestation and forest degradation are sources of greenhouse gas emissions (in particular CO_2), which contribute about 12 – 20% of the total emission (van der Werf *et al.*, 2009). Indonesia, therefore, has a commitment to reduce the greenhouse gas emissions up to 26% by 2020. An effective way in reducing the emission is implementing an international mechanism called REDD (Reducing Emissions from Deforestation and forest Degradation). The REDD mechanism provides financial incentives for developing countries that able to reduce the rate of deforestation and degradation from their forests.

Initially, the REDD mechanism was limited to the efforts of avoiding deforestation and forest degradation. Such mechanism only provides limited opportunity for developing countries that are still highly depending on forest resources for generating their national incomes. Since the 13th climate change conference (COP 13), which was held at Bali in 2007, the term REDD has been expanded into REDD-plus (REDD+) by including forest conservation, sustainable forest management (SFM), and enhancing carbon stocks (e.g., restoration and reforestation) as promising options (in addition to the avoiding deforestation and forest degradation) to reduce emissions. The international agreement of including SFM as an important option in REDD+ mechanism provides a great opportunity for Indonesia to highly involve in the implementation of the REDD+ mechanism.

SFM has been practicing in Indonesia since 1990 for managing natural production forests, plantation forests, and community forests. Several forest management units (FMU) have also been certified by independent certification bodies, either using mandatory certification (MC) or voluntary certification (VC) scheme. For natural production forests, the result of MC conducted by Ministry of Forestry until August 2010 has ranked 20 FMUs as good and 48 FMUs as fair with total area of 6,517,489 hectar. Among such 68 FMUs, 5 FMUs obtained certificates from LembagaEkolabel Indonesia (LEI) and*Forest Stewardship Council* (FSC) through VC schemes. For plantation forests, 6 FMUs (with total area of 1.1 million hectares) have been certified by MC scheme and 3 FMUs (with total area of 0.544

million hectares) by VC scheme of LEI. For community forests, 5 FMUs (with total area of 217,760.27 hectares) have been certified by FSC and 12 FMUs (with total area of 25,170.50 hectares) by LEI.

Implementation of SFM practices in various FMUs can promote the SFM as an option for reducing emission from deforestation and forest degradation. Imai *et al.* (2009) confirmed that SFM has not only enriched biodiversity but also enhanced carbon stocks in degraded production forests. If the efforts of reducing emission could be integrated into SFM practices, then the REDD+ mechanism could be a promising option for forest managers without the need of leaving their core forestry business.

The option of reducing emission through SFM needs a further study. Until now there is no FMU in Indonesia has a real experience in practicing the REDD+ mechanism. In addition, data and information concerning the practices of SFM that are potential to reduce emission are limited and distributed in various parties. Scientific studies that formulate SFM scenarios for implementing REDD+ mechanism are also still lacking. These issues call a need for a deep study to collect and analyze the data and information of SFM practices to formulate relevant strategies for reducing emission though SFM in various forest types in Indonesia.

1.2 Objectives

This study was conducted to collect and analyze data and information about REDD+ and SFM activities to formulate strategies for reducing emission through SFM in various forest types in Indonesia, especially in natural production forests, plantation forests, and community forests. Specifically, this study was aimed to:

1) Review the development of SFM practices in natural production forests, plantation forests, and community forests in Indonesia.
2) Review the development of REDD+'s demonstration activity projects in Indonesia.
3) Analyze the potency of timber, carbon sequestrations, and benefits of emission reduction from SFM practices in natural production forests, plantation forests, and community forests.
4) Formulate SFM strategies for reducing emission at natural production forests, plantation forests, and community forests.

II. Methods

2.1 Study Framework

This study used two approaches, i.e., literature study and field survey (Figure 1). The literature study was conducted to collected data and information on SFM practices and demonstration activity projects of REDD+ from various sources, such as FMU reports, project reports, and research publications. Such literature study provided a general information about SFM practices in each FMU type (natural production forests, plantation forests, and community forests), recent development of REDD+ activities, and research results related to the quantification of carbon sequestration through SFM practices and REDD+ activities. The field survey was conducted at several FMU to collect relevant data to formulate and analyze some scenarios for reducing emission through SFM practices. Such data analyses provided information on the potency of timber, carbon sequestration, and benefits of emission reduction for each SFM scenario, which were used to formulate strategies for reducing emission through SFM at natural production forests, plantation forests, and community forests.

2.2 Data Collection

This study used both primary and secondary data related to SFM activities (in natural production forests, plantation forests, and community forests) and REDD+ activities in Indonesia. The primary data were collected from several FMUs having unique characteristics as described in Table 1. The secondary data were collected by searching relevant literatures from various sources: scientific journals, university theses, project reports, and FMU reports. These data were obtained from internet searching and field surveys.

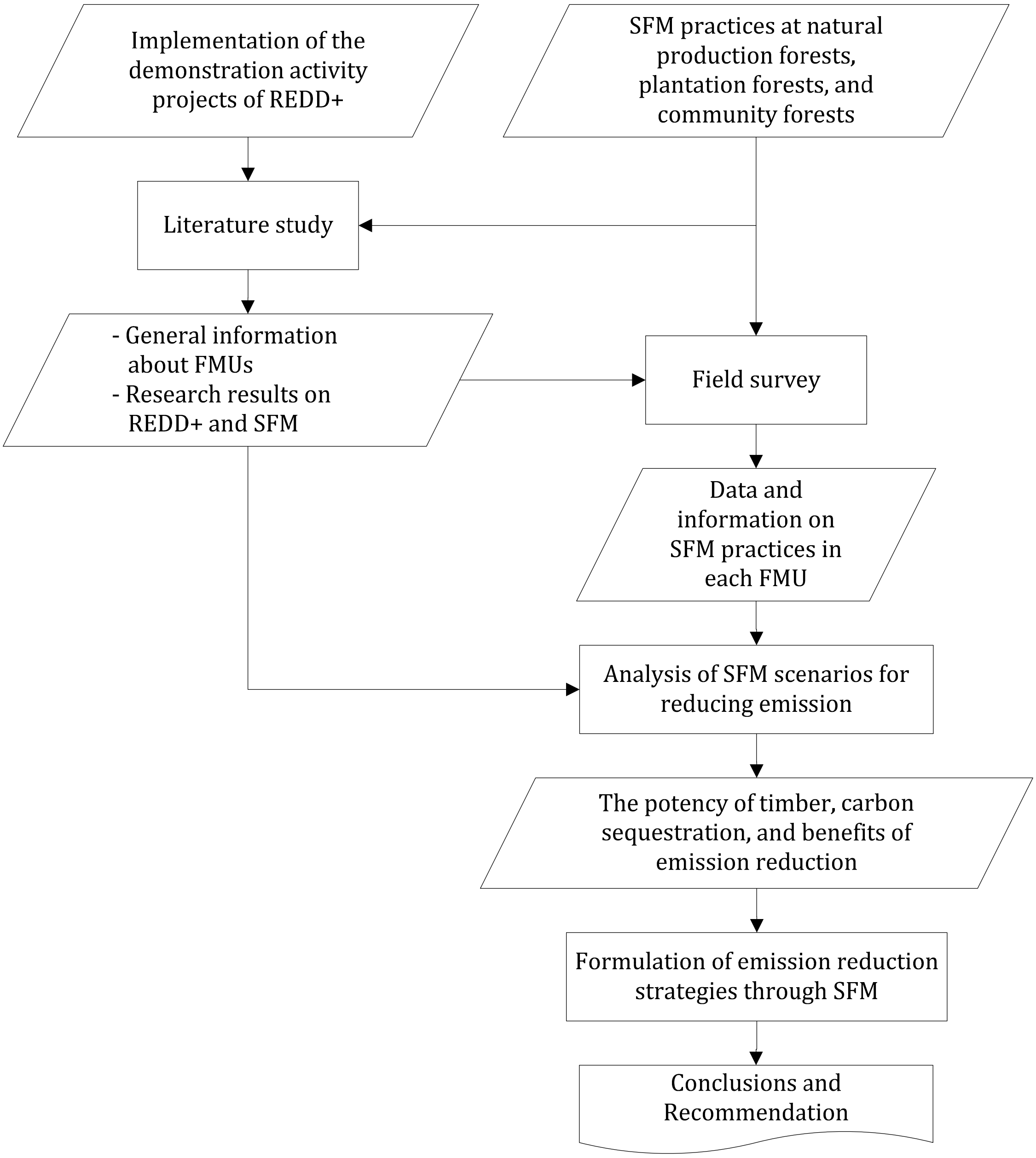


Figure 1. Framework of formulating and analyzing scenarios of emission reduction through sustainable forest management

2.3 Data Analysis

The data and information obtained from the literature study and field survey were then analyzed to calculate the potency of timber and carbon sequestration of each FMU and to formulate scenarios for reducing emission through SFM.

Table 1. Selected forest management units for this study

FMU type	FMU name	Location	Reason for selecting the FMU
Natural production forest	PT Sari BumiKusuma (SBK)	East Kalimantan	This FMU implement multisystem silviculture (TPTI and TPTJ), which have been certified by FSC and LEI
Plantation forests	KPH Kebonharjo (PerumPerhutani)	Central Java	This FMU is one of the best FMUs within PerumPerhutani, which manages a long rotation teak plantation (60 years). The forest management problem of this FMU (i.e. forest degradation) represent similar problem at other FMUs in Java
Community forest	KoperasiHutan Jaya Lestari (KHJL)	South Konawe, South East Sulawesi	KHJL manages teak plantations with a long rotation that were planted on community lands. This FMU is holding an FSC certificate.

a). Analysis on the potency of timber and carbon sequestration

Sustained timber yield is still an objective of forest management in Indonesia. This study calculated the potency of timber yieldbased on forest inventory data conducted by FMU. The change of timber yield from time to time was simulated by considering the regrowth and loss of forest stands due to harvestings or disturbances.

The forest stand data were then analyzed to calculate the stock and sequestration of forest carbon at FMUs using the gain-loss method as recommended by IPCC (2006). Forest management activities that increase carbon stock are planting, rehabilitation of degraded lands, regrowth of logged-over areas, and increasing of protected areas. Meanwhile, forest management activities that result in the loss of carbon stock are harvesting, logging damage, construction of infrastructures (e.g., basecamp and road network), and uncontrolled activities (e.g. shifting cultivation and gardening). This study estimated the gain and loss of carbon stock affected by such forest management activities; hence the change of carbon stock can also be estimated from time to time. Several assumption and approaches, which were supported by literature study, were used in calculating the carbon stock especially when FMUs did not have complete data.

b). Formulation of emission reduction scenarios through SFM

The estimate and change of carbon stock were then used to formulate scenarios for reducing emission at each FMU. This study developed two types of scenarios: baseline and SFM scenarios.

b.1) Baseline scenario

The baseline or business as usual (BAU) scenario analyzed the potency of stock and sequestration of forest carbon when SFM was not implemented in an FMU. This scenario assumed that activities resulted in unsustain forest resources, e.g., deforestation, forest degradation, and lack of regeneration, would occur in the future. The baseline scenario provided a basis for comparing SFM scenarios.

b.2) SFM scenario

The SFM scenario analyzed the potency of stock and sequestration of forest carbon when an FMU implemented SFM practices. This scenario further analyzed some options of best forest management practices, such as avoiding deforestation and forest degradation, implementation of multisystem silviculture, reduction of annual allowable cut (AAC), increasing of harvestable diameter limit, and other activities that potentially increase the carbon stock. The SFM scenarios were specifically developed for each FMU to represent forest management practices in natural production forests, plantation forests, and community forests.

The SFM scenarios were then compared to the baseline scenario to analyze the benefit of emission reduction of each FMU. This study hypothesized that the SFM scenarios would able to reduce emission compared to the baseline scenario (Figure 2). Based on such scenarios analysis, this study formulated and recommended effective SFM strategies for reducing emission at natural production forests, plantation forests, and community forests. In detail, methods used for calculating carbon stock, carbon sequestration, and formulating scenarios for reducing emission in each FMU are further discussed in Chapter 5.

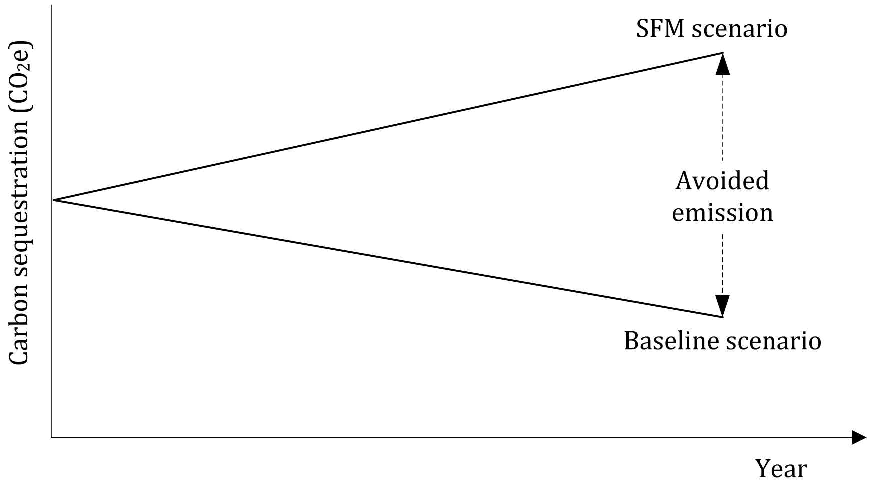


Figure 2. Illustration of emission reduction scenarios through sustainable forest management practices

III. Progress of Sustainable Forest Management in Indonesia

Forestry sector has important roles in the national development of Indonesia. Initially, forest management has been focused on natural production forests. In line with the decreasing of natural production forest resources, industrial plantation forests have also been developed to fulfill increased demand for timber. In addition to the natural production forests and plantation forests, recently there is also an increasing trend for developing small-scale community forests in many regions of Indonesia. This chapter discussed the development of SFM practices at natural production forests, plantation forests, and community forests in Indonesia, especially those have been certified by using voluntary or mandatory certification scheme.

3.1 Natural Production Forest Management

Natural production forest management in Indonesia has been conducting since 1970, although it tended to exploit natural forest resources to fulfill national economic development. The natural production forests were managed under forest concession systems established in many regions. Such forest concession systems were legally supported by the 1967 Forestry Law and the government policy on foreign capital investment that provided greater opportunities for foreigners to involve in managing natural production forests.

In 1990, the number of forest concession in Indonesia reached 557 units with total concession area of 58.9 million hectares. The number and area of concession continuously increased until 1993 (i.e. 575 units with total area of 61.7 million hectares), then drastically decreased up to 304 units (with total area of 25.8 million hectares) in 2009 (Figure 3). These figures show that during 19 years the number of concession has decreased up to 45%, which indicate that the past management of natural production forests has led to unsustain condition. The decrease of forest concessions was due to many concession holders have violated forestry rules, which resulted in the withdraw of concession rights, and due to the decrease of forest resources that less profitable for a long term forestry business (FWI/GFW, 2002).

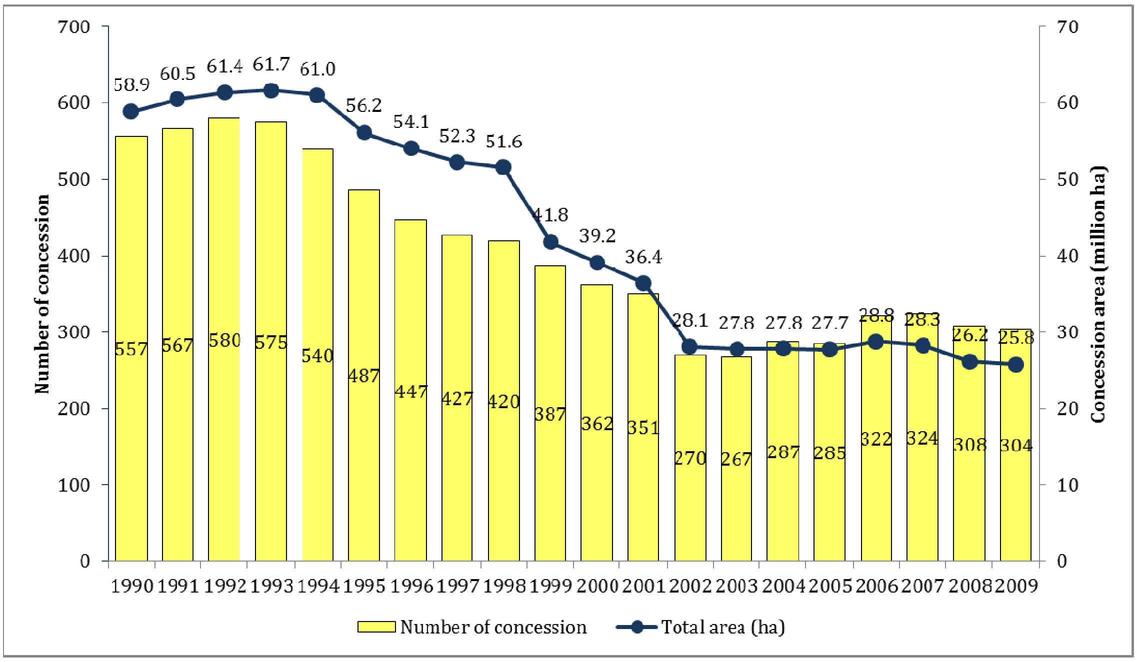


Figure 3. The number and area of natural production forest concessions in Indonesia in the periode 1990–2009 (Departemen Kehutanan, 2002, 2010)

The concession system for managing natural production forests, which was intended to maintain forest lands as permanent production forests, has been a major cause for deforestation and forest degradation (FWI/GFW, 2002). The high rates of deforestation and forest degradation in the tropics (including Indonesia) have brought international concerns on the sustainability of tropical forests. Entering 1990, a new paradigm of sustainable forest management (SFM) was promoted to replace the sustained yield principle. While the sustained yield principle only concerned with achieving the sustainability of timber production, SFM concerns on achieving all aspects of sustainability: economic (timber and non-timber productions), social, and environment. In SFM, forest managers should able to manage various forest products and services to fulfill increasing demands of society and environment(Berck, 2001; Kant & Lee, 2004).

To promote SFM (especially in tropical countries), international organizations developed forest certification systems. In Indonesia, forest certification system has been developing by LembagaEkolabel Indonesia (LEI, The

Indonesian Ecolabelling Institute) since 1994. In 1999, LEI formally issued a standard (criteria and indicators) for certification of natural production forests. Such system was then applied to assess several concessions, but only PT. Diamond Raya Timber, which manages natural production forests in Riau, that was awarded a LEI's certificate on April 2001 (FWI/GFW, 2002).

The progress of forest certification in Indonesia is not as fast as that of developed countries (Europe and United State of America). Among the 308 active concessions (Figure 3), until June 2011 there were only 5 concessions (with total area of 834,452 ha) awarded FSC's or LEI's certificate (Figure 4, Table 2): 1 concession in Riau (PT. Diamond Raya Timber) and 4 concessions in Kalimantan (PT. Erna Djuliawati, PT. Sari BumiKusuma, PT. Sarmiento Parakantja Timber, and PT. IntracawoodMfg). Among the five concessions, 2 concessions (PT. Diamond Raya Timber and PT. Sari BumiKusuma) received LEI's and FSC's certificates, 1 concession (PT. Erna Djuliawati) received FSC's certificate and 2 concessions (PT. Sarmiento Parakantja Timber and PT. IntracawoodMfg) received LEI's certificate (Table 2). These data confirmed that only 1.6% of the total active concessions have been certified by using voluntary certification schemes.

In addition to voluntary certification scheme, forest concessions are also certified by government through mandatory certification scheme. Until April 2010, the number of forest concessions that was certified using mandatory certification scheme reached 20 units (Table 2). Unlike the *voluntary certification* scheme, which is oriented to extend market access, the *mandatory certification* scheme is a government instrument to assess and evaluate performance of forest concessions in conducting sustainable forest management. For certified forest concessions, the government provides incentives in terms of self-approval of annual management plan with annual allowable cut determined by the real capability of management units.

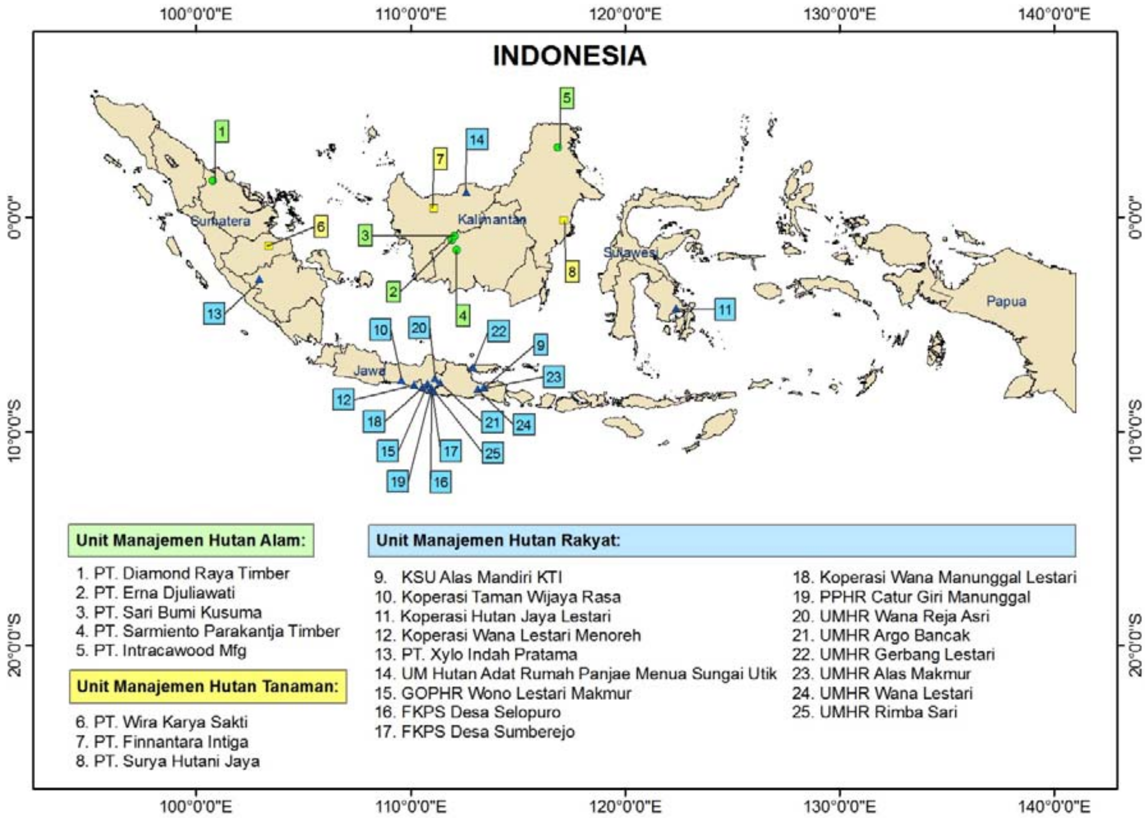


Figure 4. Distribution of forest management units that manage natural production forests, plantation forests, and community forests, which have been certified using voluntary certification schemes in Indonesia (until June 2011)

3.2 Plantation Forest Management

The deforestation and forest degradation that resulted in the decrease of natural production forest resources have motivated the government to issue an industrial plantation forests program in 1989, especially in outside of Java. This program was intended to rehabilitate unproductive natural production forests and to increase timber production to supply wood demands for forestry industries that increase from year to year. The target of such program was 4.6 million hectares of plantation forests in outside of Java in addition to the existing of 1.8 plantation forests in Java. Until 2008, the total are of plantation forests was 4,274,907.67 hectares (Figure 5). The area of established plantation forests fluctuated from year to year, ranging from 67,472 ha (in 2001) to 390,542 ha (in 1996) with an average of 213,745 ha/yr.

Tabel2. Forest management units (FMU) at natural production forests that were certified using voluntary certification (FSC and LEI) and mandatory certification schemes

No.	FMU name	Location	Area (ha)	Certification scheme	Certificate date
A.	**Voluntary certification**				
1.	PT. Diamond Raya Timber	RokanHilir, Riau	90,956	FSC, LEI	7 July 2006
2.	PT. Sari BumiKusuma	Seruyan, Central Kalimantan	147,600	FSC, LEI	26 September 2007
3.	PT. Erna Djuliawati	Seruyan, Central Kalimantan	184,206	FSC	6 September 2010
4.	PT. Sarmiento Parakantja Timber	KotawaringinTimur, East Kalimantan	216,580	LEI	2008
5.	PT. Intracawood Mfg.	Bulungan, East Kalimantan	195,110	LEI	2006
B.	**Mandatory certification**				
1.	PT. Suka Jaya Makmur	West Kalimantan	171,300	MC	18 February 2009
2.	PT. BinaOviviupariSemesta	West Kalimantan	10,100	MC	18 February 2009
3.	PT. Dwima Jaya Utama	Central Kalimantan	123,700	MC	13 February 2008
4.	PT. HutanMulia	Central Kalimantan	51,000	MC	13 February 2008
5.	PT. DasaIntiga	Central Kalimantan	129,100	MC	30 December 2008
6.	PT. Karda Traders	Central Kalimantan	98,400	MC	18 February 2009
7.	PT. AmprahMitra Jaya	Central Kalimantan	77,700	MC	5 August 2009
8.	PT. GrahaSentosaPermai	Central Kalimantan	44.970	MC	15 October 2009
9.	PT. KemakmuranBerkah Timber	East Kalimantan	72,000	MC	13 February 2008
10.	PT. Ratah Timber	East Kalimantan	97,690	MC	13 February 2008
11.	PT. RodamasTimber Kalimantan Coy. Ltd.	East Kalimantan	99,520	MC	13 February 2008
12.	PT. Balikpapan Forest Indutries	East Kalimantan	174,600	MC	30 December 2008
13.	PT. RizqiKacidaReana	East Kalimantan	29,350	MC	18 February 2009
14.	PT. ITCI KartikaUtama	East Kalimantan	262,500	MC	5 August 2009
15.	PT. WanaAdiprimaMandiri	East Kalimantan	33,090	MC	23 June 2009
16.	PT. WanaKencanaSejati	North Maluku	47,410	MC	13 February 2008
17.	PT. TelagaBaktiPersada	North Maluku	85,000	MC	30 December 2008
18.	PT. Nusa Padma Corp.	North Maluku	55,770	MC	18 February 2009
19.	PT. KaltimHutama	West Papua	155,000	MC	13 February 2008
20.	PT. Multi WahanaWijaya	West Papua	139,000	MC	30 December 2008

Source: FSC's website (www.fsc.org), LEI's website (http://www.lei.or.id/files/Certified%20UM_Feb11.pdf), and Report of Directorate General of Forestry Production Development (April 2010)

Note: MC = mandatory certification;this table only displays certified forest concessions ranked as good

Similar to natural production forests, SFM has also been implementing in managing plantation forests. Until June 2001, however, there were only three certified FMUs, i.e., WiraKaryaSakti, PT. FinnantaraIntiga, and PT. Surya Hutani Jaya (Table 3). These FMUs obtained SFM certificates from LEI. Until now, there is no plantation forest management unit in Indonesia obtain FSC certificate. One of the reasons is many plantation forests in Indonesia (that were established since 1990) developed from conversions of natural forests, so that it does not comply with the 10th principle of FSC standard about plantation forest.

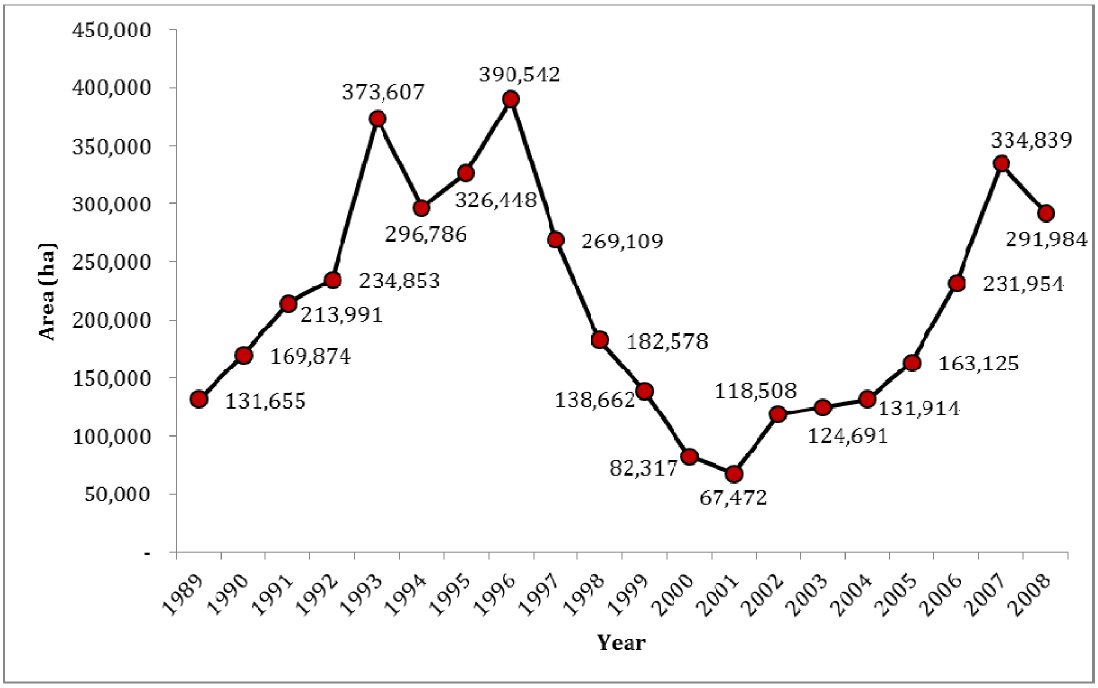


Figure5. Development of industrial plantation forests in Indonesia in the period 1989–2008 (Departemen Kehutanan, 2002, 2009)

Table3. Certified industrial plantation forest management units by LEI scheme

No.	FMU name	Location	Area (ha)
1.	PT. WiraKaryaSakti	TanjungJabung, Jambi	260,829
2.	PT. FinnantaraIntiga	Sanggau, West Kalimantan	126,806
3.	PT. Surya Hutani Jaya	Kutai, East Kalimantan	157,070

Source: LEI's website (http://www.lei.or.id/files/Certified%20UM_Feb11.pdf)

3.3 Community Forest Management

3.3.1 General Condition of Community Forests in Indonesia

Community forest, which is also called private forest, is a forest established on private lands (Hardjanto, 2003). Commonly, a community forest is formed by a group of trees that grow up at home yards, mixed gardens, and woodlots with relatively small areas (<1 ha). Community forests have been established since a long time ago, either by individuals or governmental projects such as reforestation programs (IPB, 1983 cited inHardjanto, 2003). Hindra (2006) stated that currently there are five types of community forests according to their development funds: self-funded community forest, subsidized community forest, community forest from a business credit scheme (called KUHR, Kredit Usaha Hutan Rakyat), community forest from a special allocated fund of reforestation fund (called DAK DR, Dana AlokasiKhususdari Dana Reboisasi), and community forest from the national program for forest and land rehabilitation (called GNRHL, GerakanNasionalRehabilitasiHutandanLahan).

Compared to the natural production forests and plantation forests, data and information related to community forests (e.g. areas, spatial distributions, tree species, and timber volumes) in Indonesia are very limited. An inventory conducted by Department of Forestry in 2004 predicted that total area of community forests in Indonesia reached 1,570,315.63 ha, in which most of them (approximately 62%) is self-funded community forests established by local communities in each province (Table 4). Approximately 50% of the total community forests in Indonesia are located in Java, especially in West Java, Central Java, and East Java (Table 4). A study conducted by BPKH XI and MFP (2009) confirmed that according to the interpretation of Landsat TM of 2006–2008 total area of community forests in Java currently reached 2.6 million hectares that distributed over six land cover types: dry-land forest, plantation forest, crop estate, dry-land agriculture, dry-land agriculture mixed with bush, and bush. Such study estimated the total potency of timber in Java reached 57.6–103.5 million m^3. Such high potency of community forests in Java could be resulted from the tradition of communities to plant various trees species in their lands (e.g. yards, gardens, and woodlots), despite relatively small land ownership in Java (i.e. 0.5–1.0

ha/household). In addition, increasing timber demand is another factor that promotes the development of community forests in Java.

Table 4. Distribution of community forest areas in Indonesia

No.	Province	Area of community forest (ha) *)						
		HR Swadaya	HR Subsidi	HR KUHR	HR DAK DR	HR GNRHL	Total	Percentage (%)
1	Aceh	16,563.40	6,763.20	2,226.00	2,295.32	3,000.00	30,847.92	1.96
2	Bali	6,610.24	3,582.50	0.00	155.00	2,730.00	13,077.74	0.83
3	Bangka Belitung	0.00	0.00	0.00	0.00	645.00	645.00	0.04
4	Banten	8,861.00	0.00	1,150.66	0.00	9,600.00	19,611.66	1.25
5	Bengkulu	3,349.00	62.50	0.00	340.00	1,000.00	4,751.50	0.30
6	DI Yogyakarta	26,760.70	14,154.00	0.00	411.70	13,690.00	55,016.40	3.50
7	DKI Jakarta	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Gorontalo	14,071.00	0.00	150.00	0.00	4,238.00	18,459.00	1.18
9	Irian Jaya Barat	2,960.00	0.00	0.00	0.00	550.00	3,510.00	0.22
10	Jambi	5,591.00	1,110.00	0.00	488.00	2,475.00	9,664.00	0.62
11	Jawa Barat	86,900.74	15,012.00	12,521.40	1,538.00	50,552.00	166,524.14	10.60
12	Jawa Tengah	174,125.59	44,351.19	4,796.43	5,313.20	97,143.00	325,729.41	20.74
13	Jawa Timur	84,738.07	18,980.75	7,005.83	1,660.00	100,987.00	213,371.65	13.59
14	Kalimantan Barat	4,419.00	85.00	0.00	300.00	6,780.00	11,584.00	0.74
15	Kalimantan Selatan	94,271.50	705.00	0.00	3,080.00	10,380.00	108,436.50	6.91
16	Kalimantan Tengah	10,054.00	0.00	0.00	495.00	5,000.00	15,549.00	0.99
17	Kalimantan Timur	8,424.00	0.00	650.00	0.00	2,700.00	11,774.00	0.75
18	Lampung	222.50	100.00	0.00	0.00	13,700.00	14,022.50	0.89
19	Maluku Utara	0.00	0.00	0.00	0.00	4,650.00	4,650.00	0.30
20	Maluku Utara	0.00	0.00	1,000.00	0.00	2,900.00	3,900.00	0.25
21	Nusa Tenggara Barat	8,610.58	1,405.00	1,000.58	0.00	5,350.00	16,366.16	1.04
22	Nusa Tenggara Timur	147,300.00	8,595.00	0.00	0.00	5,850.00	161,745.00	10.30
23	Papua	9,180.00	0.00	0.00	219.70	1,255.00	10,654.70	0.68
24	Riau	10,337.00	0.00	600.06	719.00	7,375.00	19,031.06	1.21
25	Sulawesi Selatan	134,962.25	6,856.39	3,520.00	308.00	18,937.00	164,583.64	10.48
26	Sulawesi Tengah	8,049.55	100.00	0.00	300.00	3,550.00	11,999.55	0.76
27	Sulawesi Utara	4,481.00	33.00	350.00	25.00	3,500.00	8,389.00	0.53
28	Sulawesi Tenggara	705.00	450.00	0.00	725.00	3,100.00	4,980.00	0.32
29	Sumater Barat	38,993.80	0.00	0.00	80.00	14,682.00	53,755.80	3.42
30	Sumatera Selatan	12,489.25	7,670.00	6,137.95	85.00	5,100.00	31,482.20	2.00
31	Sumatera Utara	45,692.10	1,075.00	677.00	280.00	8,480.00	56,204.10	3.58
	Total	968,722.27	131,090.53	41,785.91	18,817.92	409,899.00	1,570,315.63	100.00

*) *HR Swadaya is a self-funded community forest, HR Subsidi is a subsidized community forest, HR KUHR is a community forest established from a business credit scheme, HR DAK DR is a community forest established from a special allocated fund of reforestation fund, and HR GNRHL is a community forest established from the national program for forest and land rehabilitation.*

Source: *Ditjen RLPS (2004), which was cited by Hindra (2006) and corrected by the authors (because the original source contained some errors in calculating total area of community forests)*

Trees species in a community forest tend to vary. Commonly, local communities prefer to plant valuable and fast growing trees species that provide high economic benefits. A survey conducted by BadanPusatStatistik (BPS) in 2003 showed that communities mostly planted teak (35%), mahogany (20%), *Paraserianthesfalcataria* (27%), and acacia (14%) in their community forests both in Java and outer islands (Figure 6).

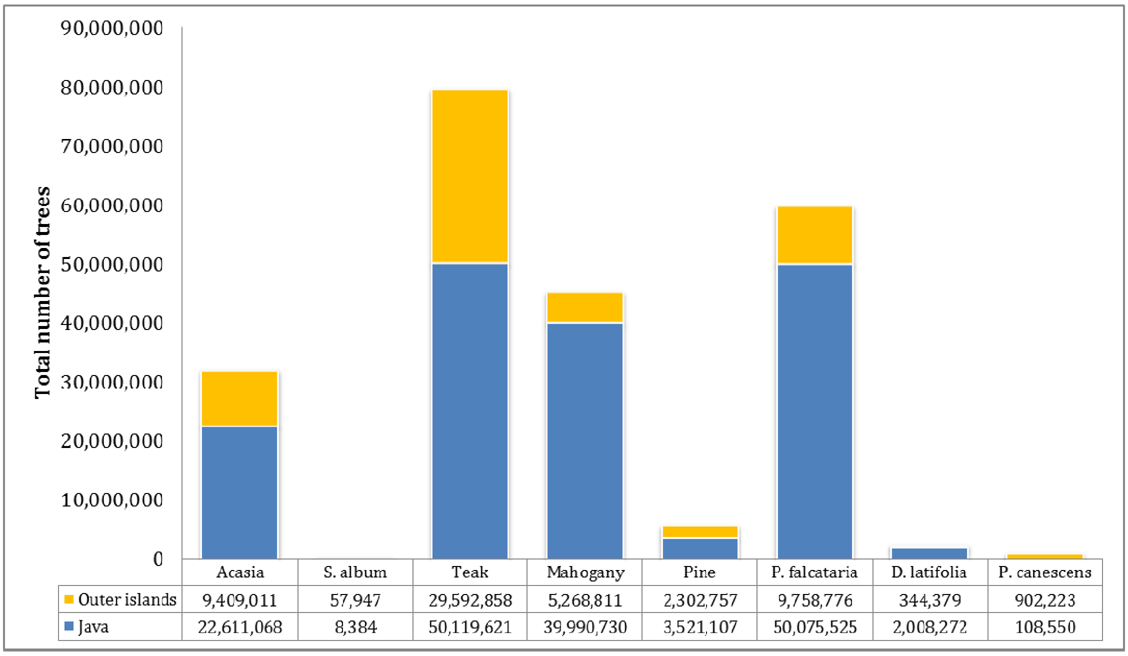


Figure 6. Species and total number of trees planted in community forests in Indonesia (DepartemenKehutanan, 2004)

3.3.2 Certification of Community Forests

Community forest development in Indonesia shows a promising progress, which is indicated by the extent of community forest areas (Table 4). In some regions, local communities are able to professionally manage their community forests by establishing forest co-operatives or forums for community forest managers (see also Box 1).

Until now, 17 community forest management units (CFMUs) have obtained SFM certificates (Figure 4, Table 5). Five CFMUs with total area of 217,760.27 ha obtained FSC certificates, while twelve other CFMUs with total area of 25,170.5 ha obtained LEI certificates. Among the 17 CFMUs, only three CFMUs are located in outer islands, while 14 other CFMUs are located in Java. These figures suggest that the community forest management in Java develops more rapidly than the outer islands.

Table 5. Certified community forest management units in Indonesia by FSC and LEI schemes until June 2011

No.	FMU name	Location	Area (ha)	Tree species	Certification scheme	Certification date
1.	KSU Alas Mandiri KTI (KAM KTI)	Probolinggo, East Jawa	331.6	*Paraserianthesfalcataria*, *Ochroma* sp., *Gmelinaarborea*, *Anthocephaluscadamba*, *Pterospermum* spp., *Hibiscus similes*, mahogany, *Meliaazadarach*, *Gliricidea* sp., *Tremaorientale*	FSC	22 Desember 2008 – 21 Desember 2013
2.	Koperasi Taman Wijaya Rasa (KOSTAJASA)	Kebumen, Jawa Central	119.5	Mahogany	FSC	2 June 2009 – 1 June 2014
3.	KoperasiHutan Jaya Lestari (KHJL)	South Konawe, South-East Sulawesi	152.35	Teak	FSC	21 October 2010 – 20 October 2015
4.	KoperasiWana Lestari Menoreh (KWLM)	KulonProgro, Central Java	129.82	Teak, mahogany, *Dalbergialatifolia*, *P. falcataria*	FSC	16 March 2011 – 15 March 2016
5.	PT. Xylo Indah Pratama	MusiRawas, South Sumatra	217,027	*Dyeracostulata*, *Alstoniascholaris*, *Heveabrasiliensis*	FSC	20 April 2007 – 19 April 2012
6.	UM HutanAdatRumahPanjaeMenua Sungai Utik	Kapuas Hulu, West Kalimantan	9,545.5	*Intsiabijuga*, *Dryobalanopsabnormis*, *Vatica* spp., *Hopea*spp, *Elateriospermumtapos*	LEI	May 2008
7.	GOPHR Wono Lestari Makmur	Sukoharjo, Central Java	1,179	Teak, mahogany, *Acacia* spp., *Samaneasaman*	LEI	5 March 2007 – 4 March 2012
8.	FKPS DesaSelopuro	Wonogiri, Central Java	262	Teak, mahogany	LEI	20 October 2004
9.	FKPS DesaSumberejo	Wonogiri, Central Java	547	Teak, mahogany	LEI	20 October 2004
10.	KoperasiWanaManunggal Lestari	GunungKidul, Yogyakarta	815	Teak, mahogany, *Dalbergialatifolia*	LEI	20 September 2006
11.	PPHR CaturGiriManunggal	Wonogiri, Central Java	2,434	Teak, mahogany, *Acacia* spp., *Samaneasaman*	LEI	27 January 2007
12.	UMHR WanaRejaAsri (WARAS)	Sragen, Central Java	1,404	Teak, mahogany, *Acacia* spp., *P. falcataria*	LEI	26 July 2009
13.	UMHR Argo Bancak	Magetan, East Java	600	Teak, mahogany, *Acacia* spp., *P. falcataria*	LEI	26 July 2009
14.	UMHR Gerbang Lestari	Bangkalan, East Java	2,889	Teak, mahogany, *Acacia* spp., *Sandoricum* spp.	LEI	21 July 2010
15.	UMHR Alas Makmur	Probolinggo, East Java	995	*P. falcataria*, mahogany, *Meliaazadarach*, *Gmelinaarborea*	LEI	23 July 2010
16.	UMHR Wana Lestari	Lumajang, East Java	3,427	*P. falcataria*, *Hibiscus similes*, mahogany, teak	LEI	5 March 2010
17.	UMHR Rimba Sari	Pacitan, East Java	1,073	Teak, mahogany, *Acacia* spp., *P. falcataria*	LEI	3 March 2010

Source: FSC's website (www.fsc.org) and LEI's website (http://www.lei.or.id/files/Certified%20UM_Feb11.pdf)

Box 1. Lessons leardned from community forest certification

Hinrichs*et al.*(2008)noted some lessons learned from community forest certification in Indonesia as follows:

1) Community forest certification is an effective instrument for improving knowledge and awareness of communities to the importance of sustainable forest management.

2) Motivation of communities to sustainably manage their community forests can be increased by convincing financial benefits of certification.

3) Preparation process of certification should consider market access of certified products.

4) Economic scale of community forests needs to be expanded to increase the production level of existing certified community forests.

5) Strong external supports and village leadership are required to fully adopt certification concept of community forest.

6) Concept of community forest certification needs to consider farmers mind-set who are used to conduct *tebangbutuh* (cutting trees only to meet immediate income) and to self-marketing timber.

7) Different approaches could be applied in establishing higher level of farmer associations.

8) A community forest certification project needs financial supports and a business plan for a long-term period.

9) Higher level farmer organizations need a start-fund for their operations.

10) Determining annual allowable cut and harvest planning are major challenges for sustainable management of community forests.

11) Preparation process of forest certification should pay sufficient attention to improve silvicultural techniques for community forests.

12) A chain of custody system should be developed to ensure the origin of traded timber from community forests.

13) Local government should play a vital role in community forest certification.

14) Time required for preparing a community forest certification can be reduced by promoting certification concept to communities and conducting study tours to existing certified community forests.

15) Experiences with community forest certification in natural forest areas are still lacking.

16) Certification can increase the capacity of community to manage forest resources and to increase community interests in tree planting activities.

17) Community forests play a vital role in reducing carbon emission through REDD+ mechanism.

IV. Progress of REDD+ Projects in Indonesia

Carbon trading through REDD+ mechanism is a new scheme that still need further studies for its implementation. Since 2008, therefore, Ministry of Forestry of Republic of Indonesia has been collaborating with other parties to develop demonstration activity (DA) projects for implementing REDD+ mechanism. Such DA projects, which are conducted at national scale (e.g. national parks), province level, district level, or project scale (e.g. forest management unit at natural or plantation forest), are intended to study the implementation of carbon trading mechanism at various scales and conditions of forest management (MoFor, 2008). Commonly, the DA projects for REDD+ conduct five main activities: 1) determining an appropriate baseline, 2) calculating the emission reduction of a project against the business as usual (BAU) scenario, 3) formulating procedures for monitoring, reporting, and verification (MRV) of emission reduction activities, 4) accounting tradeable carbon units, and 5) developing distribution system for the payment of carbon trading to involved parties (MoFor, 2008).

This chapter briefly discusses the progress of some demonstration activity projects for REDD+ in Indonesia. Most of the information related to the REDD+ projects in this chapter came from the project presentations at the workshops, i.e., "*Workshop on Review Status Pilot/Demonstration Activities REDD+ di Indonesia*" on Desember 21, 2010 and "*Workshop on the Implementation of Forest-based Initiatives for Climate Change Mitigation: Strengthening Information and Network Sharing Among Stakeholders*" on June 22–23, 2011, which were organized by the Ministry of Forestry of Indonesia.

4.1 Korea-Indonesia Joint Project for Adaptation and Mitigation of Climate Change in Forestry (KIPCCF)

KIPCCF is a collaboration project between Korean government (through Korean International Corporation Agency, KOICA) and Indonesian government (through Forest Research Development Agency, Ministry of Forestry). The main objective of KIPCCF is to implement REDD project. Specifically, this project is aimed to develop capacity building between Indonesia and Korea, to avoid deforestation and forest degradation, and to improve welfare of local communities. This project is conducted at a 10,000 ha protected forest in Batukliang Utara sub-district, Lombok Tengah district, Nusa Tenggara province for a period of 5 years with total budget of USD 5 million.

The main activities of KIPCCF project are: 1) developing socio-economic model (called In-Ko model), which includes the development of governance system, incentive system, capacity building, and local community involvement in REDD+ mechanism, and 2) developing methods and monitoring system for REDD+. Until January 2011, this project has conducted a study on using remote sensing technology to examine drivers of deforestation and forest degradation in Lombok. The result of such study was used to develop a socio-economic model and methods for implementing REDD+ mechanism, which was expected to finish on August 2011. In addition, starting on 2012 this project will also conduct monitoring activities for REDD+ mechanism by collaborating with involved parties (i.e. Forest Research Development Agency, Nusa Tenggara Barat provincial government, and Lombok Tengah district).

4.2 Kalimantan Forests and Climate Partnership (KFCP)

KFCP project is a bilateral cooperation between Indonesia and Australia governments, which is aimed to demonstrate reliable and effective ways for reducing emission from deforestation and forest degradation (including peat lands), in order to support global agreements on climate change after 2012 that enable Indonesia to participate in international carbon trading. This project covers a 120,000 ha protected forest in Kapuas district, Kalimantan Tengah province, for a period until June 2012 with financial support of Australian government in the amount of AUD 30 million.

The KFCP project uses a reference emission level (REL) at site and district levels. Until December 2010, this project conducted 14 activities: 1) developing a working group at district level, 2) conducting a socio-economic survey, 3) finishing technical and feasibility studies, 4) mobilizing teams for community involvement, 5) preparing methods for calculating emissions of peat lands, 6) mobilizing field teams to monitor hydrology and vegetation, 7) monitoring peat lands and hydrology (including water depth, peat surface position, canal water surface, and rainfall), 8) constructing and measuring 8 permanent sample plots of vegetations in natural forests and degraded areas, 9) formulating an incentive system through World Bank funds, 10) initiating consultation processes with two villages for improving community participation in REDD mechanism, 11) implementing a payment scheme based on reforestation activities, 12) assessing information system needs (including map of forest fire risk, villages profile, and profile of fire suppression teams), 13) preparing a canal division system, and 14) developing REL scenarios for district and project location levels. Some constraints facing with this project were 1) lack of coordination among involved government levels, 2) lack of guidelines on technical methods and key aspects of REDD mechanism (e.g. baseline and incentive payment system), 3) slow process in the approval of canal division by government, and 4) slow process in the analysis of environmental impact due to the delay of issuing Ministry of Forestry's decree.

4.3 UN-REDD Programme Indonesia

Indonesia UN-REDD programme is a collaborative program of the United Nations aimed at assisting Indonesia to prepare and implement its national strategies for REDD+. This project is conducted in Central Sulawesi province by Directorate General of Forestry Planning Agency (Ministry of Forestry) and Provincial Forestry Agency of Central Sulawesi, for the period of October 2009 to May 2011. The main targets of this project were to: 1) strengthen multi-stakeholders participation and consensus at national level, 2) demonstrate a pilot project for formulating REL, MRV, and payment systems based on the national design of REDD, and 3) to improve local capacities for implementing REDD at sub-national levels.

To achieve such targets, the UN-REDD programme conducted the following activities:

1) Developing a national strategy for REDD+, publishing a book on the process of developing the national strategy for REDD+, publishing a popular book on the national strategies for REDD+. This activity was conducted by BAPPENAS (Development Planning Agency of Indonesia).
2) Developing national level criteria for selecting locations of demonstration activity projects, which was conducted by Ministry of Forestry.

3) Conducting various activities related to international negotiations on climate change, which was conducted by DNPI (*DewanNasionalPerubahanIklim*, the national agency for climate change).
4) Participating on COP 16 activities in Cancun (e.g. Youth Delegation).
5) Initiating a policy formulation on FPIC (Free and Prior Informed Consent) for REDD+ at national level, which was conducted by DKN (*DewanKehutananNasional*, the national agency for forestry).
6) Publishing modules on multi-stakeholder process (including feedback mechanisms).
7) Collecting information on payment mechanism.
8) Conducting interpretation of the Lore Lindu National Park.
9) Approving Central Sulawesi as the UN-REDD location.
10) Distributing information on the UN-REDD Programme to public, both at Central Sulawesi and other Sulawesi's provinces.
11) Initiating working groups.
12) Initiating policy formulation on the FPIC of UN-REDD/REDD+ at provincial and district levels.

4.4 Tropical Forest Conservation for REDD+ in MeruBetiri National Park

In REDD+ mechanism, forest conservation is an important option for reducing emission. Considering there was no real REDD+ implementation related to forest conservation, the government of Indonesia has collaborated with ITTO (*International Tropical Timber Organization*) to establish a pilot project on tropical forest conservation for REDD+ in 58,000 ha MeruBetiri National Park (MBNP), East Java. The MBNP was selected as the project location because of its high biodiversity with various flora and fauna, ranging from beach to mountain ecosystems. In addition, the MBNP experienced unplanned deforestation and forest degradation due to human disturbances living in or around the forests. Therefore, the MBNP is suitable for conducting a demonstration activity project to study the contribution of conservation efforts and local community empowerment to reducing emission from deforestation and forest degradation and to enhance carbon stocks in tropical forests.

In the period 2010–2011, MBNP conducted 11 activities: 1) reviewing the existing REDD+ mechanism, 2) conducting multi-stakeholders consultation and cooperation on forest conservation, 3) promoting partnership programs on MBNP conservation, 4) promoting awareness raising programs and establishing a REDD+ institution, 5) conducting training programs for involving local community in MRV activities, 6) training on forest protection for local community, 7) reviewing methodology on carbon accounting based on IPCC guideline, VCS, etc., 8) formulating standard operating procedures for measuring and monitoring carbon stocks, 9) remote sensing analysis for detecting land cover changes and quantifying carbon stocks, 10) delineating boundary activities for facilitating the measurement and monitoring of carbon stocks, and 11) establishing baselines for analyzing land use and land cover change as well as carbon stocks change.

The results of MBNP study showed that in period 1997–2001 total emission reached 7.8 MtC/yr due to land cover changes (Table 6). However, in period 2001–2005 the MBNP has sinked carbon 236,000 tC/yr because of forest growth. The change from carbon emitter to carbon sinker of MBNP indicated that the historical emission method based on deforestation rate was not suitable for projecting emission levels in MBNP as a tropical conservation (FORDA, 2011).

Table 6. Estimation of emission and carbon sink in MeruBetiri National Park in the period 1997–2005 (FORDA, 2011)

No.	Type of land cover change	Carbon stock (ton C/yr)	
		1997–2001	2001–2005
1.	Forest land remain forest land	-484,961.52	754,776.04
2.	Land converted to forest land	2,038,985.38	679,368.65
3.	Crop land remain crop land	-597,205.17	-714,061.31
4.	Land converted to crop land	-3,398,413.27	-243,955.03
5.	Grass land remain grass land	0.00	0.00
6.	Land converted to grass land	-4,482,132.90	-181,370.15
7.	Wet land remain wet land	0.00	0.00
8.	Land converted to wet land	-85.40	-73.56
9.	Settlement remain settlement	0.00	0.00
10.	Land converted to settlement	-678,160.30	-28,379.70
11.	Land converted to other lands	-163,297.77	-30,240.79
	Total emission (-) or sink (+) of carbon	-7,765,270.95	236,064.15

4.5 Berau Forest Carbon Program

Berau Forest Carbon Program (BFCP) is a pilot project for REDD+ at Berau district level, East Kalimantan province, accounting for an area of 2.2 million ha. This project is funded by Multi-stakeholders Forum and facilitated by The Nature Conservancy (TNC) for a period of five years (2010–2014). The objective of BFCP project is to implement low carbon development strategies by improving the management of various land use systems to reduce carbon emission and to create a long term funding mechanism for supporting sustainable natural resources management.

One of the essential activities conducted by BFCP was determining a reference emission level (REL) for Berau district. The BFCP has abalyzed land cover changes to calculate emission from deforestation and forest degradation for the period 1990–2008. Based on the BFCP study (Table 7), during 18 years deforestation has contributed emission of 228 MtCO_2, while forest degradation has contributed emission of 130 MtCO_2. Most emission of deforestation was resulted by conversions from natural forests to plantation forests and agricultural lands. Emission of forest degradation was resulted from logging activities that converted undisturbed forests into logged-over forests. In total, the deforestation and forest degradation in the period 1990–2008 in Berau district have contributed to a total emission of 358 MtCO_2 with a rate of 19.9 MtCO_2/yr (GFA, 2010).

The BFCP calculated REL using three methods: historical emission, adjusted historical emission, and forward-looking. The historical emission method assumed that without appropriate efforts for reducing emission then deforestation and forest degradation in the future would be same as those of the past. Using this method GFA (2010) showed that annual emission in Berau in the period 1990–2000 was 15 MtCO_2, which then increased to 17 MtCO_2 in the period 2000–2005 and 26 MtCO_2 in the period 2005–2008. If such emission trend continued into the future, then annual emission from deforestation and forest degradation would reach 33 MtCO_2 in 2020 and 45 MtCO_2 in 2040. Cumulatively, total emission from deforestation and forest degradation between 2011 and 2040 would reach 1.1 billion tCO_2 or in average of 27 MtCO_2/yr (GFA, 2010). GFA (2010) further showed the REL calculations using the two other methods. The adjusted historical emission method, based on historical emission rate and population density, predicted that total emission from deforestation and forest degradation in Berau in the period 2011–2040 would reach 463 $MtCO_2$ or in average of 19.6 $MtCO_2$/yr (GFA, 2010). In addition, the REL calculation using the forward looking method, which modeled the drivers of deforestation and forest degradation, predicted that total emission between 2011 and 2040 would reach 635 $MtCO_2$ or in average of 21.2 $MtCO_2$/yr (GFA, 2010).

Table 7. Emissions from deforestation and forest degradation in Berau district in the period 1990–2008 (GFA, 2010)

Land cover type		Area (ha)	Emission		
1990	2008		Average (tCO_2e/ha)	Total tCO_2e	Rate tCO_2e/yr
Deforestation					
Forest	Plantation forest	98,355	731	71,897,505	3,994,306
Forest	Burnt forest	328	855	280,440	15,580
Forest	Agricultural land	104,781	779	81,624,399	4,534,689
Forest	Savanna	65,814	793	52,190,502	2,899,472
Forest	Settlement	18,396	811	14,919,156	828,842
Forest	Other land uses	8,940	840	7,509,600	417,200
	Sub-total	296,614	770	228,421,602	12,690,089
Degradation					
Undisturbed forest	Logged-over forest	362,942	346	125,577,932	6,976,552
Undisturbed mangrove forest	Logged-over mangrove forest	10,606	311	3,298,466	183,248
Undisturbed swamp forest	Logged-over swamp forest	3,708	311	1,153,188	64,066
	Sub-total	377,256	345	130,029,586	7,223,866
	Total	673,870	532	358,451,188	19,913,955

4.6 ForestProgramme – FC Module

Forest Programme-FC Module is a collaboration project between local governments, concession holders, and communities with Forestry Planning Agency of Ministry of Forestry, which is aimed to implement a pro-poor REDD mechanism in Kalimantan. This project was conducted in natural production forests in three regencies: Kapuas Hulu (West Kalimantan), Malinau and Berau (East Kalimantan) for a period of 7 years with total budget of EUR 20 millions provided by KfW (Germany).

The Forest Programme-FC Module conducted the following activities (starting on January 2011): 1) forest carbon inventory, 2) purchasing high resolution satellite imagery for detecting carbon stocks change, 3) determining REL and other basic data, 4) determining monitoring system at provincial and district levels, 5) capacity building for local partners at provincial and district levels, 6) workshop and information sharing, 7) integrated land use planning, 8) implementing various innovative and pro-poor pilot projects, 9) supporting sustainable livelihood for local communities, 10) developing and testing financial management and payment distribution systems (including revolving fund), 11) developing institutional capacity for finance and law of REDD, 12) supporting auditing and transparency systems, 13) supporting monitoring and verification systems, 14) formulating a mechanism for conflict resolution, and 15) signing agreement with banks.

4.7 Berbak Carbon Initiative Project

Berbak Carbon Initiative Project is a collaboration project between Zoological Society of London (ZSL) – Indonesia programme and Berbak National Park. This project is implemented in a 140,000 ha of Berbak National Park area, located in TanjungJabungTimur and Muaro Jambi regencies, Jambi province, starting from April 2009 until April 2012. The project is funded by Darwin Initiative (DFID, the United Kingdom) with a total budget of USD 520,000. The objectives of this project are: 1) to assist stakeholders in using the carbon trade mechanism for sustainable biodiversity conservations, 2) to develop a self-funding system in managing Berbak National Park, and 3) to contribute to economic development and conservation.

The project has conducted the following activities: 1) calculating the baseline of forest degradation and carbon stocks using remote sensing data (Landsat and SPOT5) and field verifications, 2) formulating MRV system, 3) initiating a foundation, 4) formulating incentive distribution system, 5) training on techniques of biodiversity data collection (using camera trapping), training on formulating strategic planning, and training on geographic information system. Some constraints of this project were: 1) the memorandum of understanding between ZSL and Ministry of Forestry is still in progress, hence the headquarter of

ZSL in London has not provided full supports yet, 2) lack of understanding about REDD at stakeholders level, 3) unclear policy about REDD, 4) misunderstanding among stakeholders about the project as source of instant income, and 5) overlapping of lands boundary.

4.8 Habitat Restoration of Indonesia's Orangutan

The project of sustainable forest for orangutan is implemented by Habitat Restoration of Indonesia's Orangutan (HRIO) in KutaiTimur and KutaiKartanegara regencies, East Kalimantan, with a total area of 86,450 ha. The HRIO's vision is to sustain the Borneo's orangutans and their habitat and to utilize forest products and environmental services in sustained manners based on local community participations. The HRIO's mission are: 1) to achieve ecosystem stability, 2) to implement conservation programs for orangutans and their habitat, 3) to utilize forest products and environmental services based on community participation, 4) to implement community empowerment programs, 5) to develop human resources that have competency, credibility, and professionalism in managing orangutans and restoring ecosystem with an effective and powerful governance, and 6) to promote participation and partnership among stakeholders.

To realize such vision and mission, the HRIO has conducted various activities on determining REL/RL, developing MRV system, developing institution, formulating incentive distribution system, capacity building, and local community involvement. Such activities, however, were not fully implemented in the field because the incentive distribution mechanism of REDD in the HROI area for local community was not clear yet. Some problems of this project were deforestation (at oil-palm plantations, mining areas, and other land uses), forest fires, and illegal logging, which occurred in the project area.

4.9 Harapan Rainforest

Harapan Rainforest (HR) is a restoration ecosystem concession (with total area of 98,555 ha) managed by PT. RestorasiEkosistem Indonesia (REKI), which is aimed to contribute in reducing carbon emission from Indonesia's forests by maintaining sustainability of biodiversity. Specific objective of this project is to manage the HR area as a concession model for ecosystem restoration and REDD purposes in Indonesia. This project has been conducting by PT REKI for 4 years (2010–2013) in MusiBayuasi (South Sumatra province) and Batanghari-Sarolangun (Jambi province), which is funded by KfW-BMU (Germany) with a total budget of EUR 7,050,000.

The project conducted the following activities: determining REL, developing MRV system, institution development, formulating incentive system, capacity building, and local community involvement. To determine REL, PT REKI conducted a historical analysis, performed land use projections, and identified drivers of deforestation and forest degradation. The rate of forest encroachment and illegal logging decreased significantly since PT REKI has been managing the concession area. The project is formulating an MRV system by conducting a comprehensive and periodical forest inventory (called InventarisasiHutanMenyeluruhBerkala, IHMB), monitoring a 20 ha of plantations, monitoring annual working blocks, and establishing permanent sample plots for monitoring stand growth. The institution development was focused on strengthening an internal system of forest management unit by formulating working plans of each department and recruiting field staffs (about 50 persons). The incentive distribution system of HR was developed by collaborating with local communities in three villages (about 1,000 households) as part of an agreement on managing forest resources. In terms of capacity building, PT REKI has conducted several training programs on flora and fauna restoration, forest monitoring, and management of natural production forest. The project has also promoted community involvement by establishing local community groups for nursery and planting programs (with a target of 500,000 seedlings/year), implementing collaborative forest monitoring, and conducting a study on multipurpose forest management system for managing non-timber forest products (e.g. resins of rubber, *jelutung* (*Dyeracostulata*), and *jernang* (dragon's blood) to support the objective of restoration ecosystem.

4.10 REDD+ Program REDD+ in Jayapura District

REDD+ Program in Jayapura district is one of the WWF Indonesia programs, starting from 2009 to 2013. The WWF Indonesia implemented REDD+ in UnurumGuay sub-district, Jayapura district, Papua province, which aimed at reducing emission from deforestation and forest degradation through community based sustainable forest management. The REDD+ activities were conducted in a 540,000 ha area, consisting of 125,501 ha protected forests, 48,938 ha production forests, 17,566 ha conservation forests, 271,415 ha limited production forests, and 188,500 ha area for other purposes.

One of the basic activities conducted by the WWF Indonesia was determining REL for Jayapura district level. Other REDD+ activities were: 1) signing a memorandum of understanding between WWF Indonesia and local government of Jayapura on May 2009, 2) disseminating REDD+ program to local government and communities who involved in the project, and 3) strengthening partnership with local communities. The constraint of this project was lack of participation of local communities in maintaining forest resources.

4.11 Sebangau Restoration Project

Sebangau National Park (SNP) is one of the national parks used as REDD+ site by WWF Indonesia. This project was conducted during three years in a 85,000 ha SNP' area, which was facilitated and funded by WWF Indonesia with a total budget of IDR 1 billion. The general objective of this project was to reduce greenhouse gases emission from peat lands in the SNP through hydrological restoration and collaborative management of SNP with local communities. The specific objective of this project were: 1) to develop credible methods and supporting documents for peat lands restoration as references for other larger areas with complex issues, 2) to formulate a baseline for calculating carbon stocks that is accepted or approved by a scheme at either national or international level, 3) to develop a project design document according to a certain standard for obtaining carbon credits though REDD+ mechanism that provide benefits for the SNP and local communities.

During three years, the WWF Indonesia conducted the following activities in the SNP area: 1) determining methods for peat lands restoration in large and complex areas, 2) calculating *ex-ante* project emissions for REDD+, 3) establishing 255 dams around the SNP area, 4) presenting the project to Ministry of Forestry, and 5) determining a standard model for measuring carbon emission at peat lands. This project experienced some constraints: no standard method for peat lands restoration, lack of study on determining parameters of ground water level in tropical peat lands, and difficulties in improving stakeholder involvement in managing the SNP.

4.12 Land Use Transformation of Kutai District

Land use transformation is not only occur at forestry sector but it also occurs at other sectors, e.g. estate crops, mining, and agricultures. Unbalanced land use transformation may release carbon emission. Such fact motivated the WWF Indonesia to launch a program for reducing carbon emission from forestry and other sectors in Kutai Barat district, East Kalimantan province, covering 3,857,914 ha areas that consist of 2,214,359 ha of forest cultivation areas (locally called KawasanBudidayaKehutanan, KBK), 892,125 ha of non-forest cultivation areas, 5,879 ha of conservation forests, and 745,551 ha of protected forests. This program was funded by WWF Indonesia with a total budget of IDR 4 billions for five years (2009–2013). The objective of this program is to reduce carbon emission form deforestation and forest degradation by strengthening local communities and transforming land uses of Kutai Barat district.

The WWF Indonesia conducted the following activities: 1) developing methods for carbon accounting using satellite images (by collaborating with Hatfield and Sumalindo Jaya Unit II), 2) signing an memorandum of understanding between WWF Indonesia and district government of Kutai Barat in 2009, 3) training and assisting local communities to conduct inventory at community forests, 4) surveying land owners of 80,000 ha community forests, and 5) training community organizations for developing micro-hydro facilities and promoting sustainable forest management. The main problem of this program was high deforestation due to forests conversion into palm-oil plantations and coal mining.

4.13 Merang REDD Pilot Project (MRPP)

Merang REDD Pilot Project (MPRR) is a project funded by the German Federal Ministry of Environment, Nature Conservation, and Nuclear Safety (BMU), which is implemented by GTZ Indonesia. This project was implemented through cooperation between Directorate General of Forestry Business Agency of Ministry of Forestry, Forclime-GTZ, Forestry District of South Sumatra, and Forestry District of MusiBanyuasin. The project covered 24,000 ha of peat land production forests at

MerangKepayang, BayungLencir sub-district, MusiBanyuasin district, South Sumatra province, for a period of four years (2008–2011). Total budget of the project was EUR 1,433,454 (for the first phase) and EUR 625,786 (for second phase).

General objective of the MRPP project was to contribute to sustainable forest management, biodiversity protection, and rehabilitation of degraded peat-swamp forests in South Sumatra province. Specific objective of the project were to:

1) Contribute to the protection and rehabilitation of peat-swamp forests through production forest management unit system (locally called KesatuanPengelolaanHutanProduksi, KPHP), and to prepare a compensation mechanism for reducing emission through REDD mechanism in South Sumatra.
2) Provide lesson learnt and experiences to stakeholders on MRPP implementation.
3) Establish networks among national and international donors to support avoiding deforestation and forest degradation of peat-swamp forests.

The MRPP project has calculated emission baselines of deforestation, forest degradation, and peat lands fire using satellite images (dated on 2008 and 1989). Emission average from deforestation and forest degradation was 417,000 tCO_2e/yr or 530,000 tCO_2e/yr when including forest fire.

To develop MRV system, the MRPP has developed allometric equations for estimating biomass of peat-swamp forests. In addition, the project has also conducted above-ground carbon inventory of peat-swamp forests using 45 sample plots. Carbon stocks of peat soil were estimated using an interpolation technique (i.e. kriging method) using 125 sample points with depth average of 3.8 m. The result of interpolation confirmed that the MRPP area stored carbon up to 56 MtC or approximately 230,000 tC/ha. The MRPP then produced a manual book titled Guidelines for Carbon Inventory in Peat-Swamp Forest Ecosystem (2009) and developed web-based software for analyzing and reporting the carbon inventory data.

In the context of institutional development, the MRPP initiated a climate change team of South Sumatra province and a forest management institution as a proponent for REDD mechanism. The project also initiated a corporate social responsibility (CSR) forum in MusiBanyuasin district, which aimed to harmonize the REDD activities with the capacity building of communities, and initiated a forum for Musi watershed management in South Sumatra province.

Activities for improving the capacity building of communities were seminars, workshops, comparative studies, and trainings for local government staff and related stakeholders (private companies, non-government organizations, and communities) on the REDD mechanism. To promote community involvement, the MRPP created KMPH (KelompokMasyarakatPeduliHutan, i.e. community groups for forest awareness), which was then supported by relevant trainings to improve the capacity building of such KMPH. To assist local communities, the project developed a financial credit scheme for KMPH (with a total budget of EUR 30,000) and it also promoted community business activities, such as poultry farm, cattle breeding, horticulture, and other agribusiness activities.

4.14 REDD+ of TessoNilo Forests

REDD+ of TessoNilo Forests (RTNF) project aimed at reducing deforestation and forest degradation, enhancing carbon stocks, and protecting the habitat of Sumatra's elephants and tigers. The project located in Pelalawan district, KuantanSingingi, Riau province, with a total area of 160,000 ha consisting of 83,000 ha of TesoNilo National Park areas and 77,000 ha of production forest concession areas (i.e. PT Hutani Sola Lestari and PT. Siak Raya Timber).

The RTNF project has been conducting by the WWF Indonesia for five years (2009–2013). During such period, the project has been several activities related to determining REL/RL, developing MRV system, formulating distribution incentive system, capacity building, and local community involvement. Specific activities of the project include: 1) calculating carbon stocks using Tier 2 approach that was finished on 2009, 2) conducting a REDD+ feasibility study that was finished on June 2010, 3) developing a project design document (PDD), 4) formulating an institution for REDD+ implementation, 5) formulating financial and benefit sharing schemes, 6) registering the project, 7) conducting validation (on 2011) and verification (on 2012) activities of the project. The constraint of this project was unclear regulations concerning financial and benefit sharing mechanisms.

4.15 Katingan Peat Restoration and Conservation Project

Katingan Peat Restoration and Conservation Project (KPRCP) is conducted by PT. RimbaMakmurUtama, which aimed at restoring and conserving peat forests in Katingan and KotawaringinTimur districts, Central Kalimantan, by involving various stakeholders. This project is conducting for five years (2011–2015) in a convertible production forest area (186,955 ha) and a production forest area (30,800 ha). The project was also proposed as a part of the feasibility study of ITTO and Marubeni Corporation, which is a bilateral cooperation on climate change between the government of Indonesia and Japan.

The project vision is to restore ecological function of tropical peat lands as carbon storages and sources of sustainable forest products through restoration activities and sustainable management of natural resources. The project missions are to: 1) restore peat lands and manage biodiversity, 2) reduce threats to peat lands ecosystem and avoid forest fire, illegal logging, and forest encroachment, 3) develop economic activities for local communities, 4) support researches on restoration ecosystem techniques, carbon stock accounting, and sustainable utilization of peat lands, and 5) improve environmental awareness of local communities through education and training programs.

To determine REL/RL, the KPRCP used medium and high resolutions satellite image data for analyzing the deforestation of peat lands in Central Kalimantan. The MRV system was developed by using relatively recent satellite image data (<5 years), which was verified by field surveys on 400 sample plots and 3 transects. Institutional development and formulation of incentive distribution system were developed by referring to the existing regulations. Capacity building of local communities and MRV system were developed by collaborating with non-governmental organizations and universities. Since 2009, the KPRCP project has been conducting public consultations with local communities dealing with participatory mapping, free prior and informed consent (FPIC) process, and planning for community-based economic development. The main constraint of this project was a delay in processing license for restoration activity due to delayed process of UKL/UPL (Environmental Management and Monitoring Plan) approval at Katingan district level.

V. Scenarios for Reducing Emission through Sustainable Forest Management

REDD+ mechanism includes sustainable forest management (SFM) as an option for reducing emission from deforestation and forest degradation. Such option is relevant with SFM objective, i.e. achieving sustainability of timber production, ecological function, and social function of a forest ecosystem. ITTO (1998) defined SFM as "the process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment". Such definition clarifies that the product of SFM is not only timber, but it also includes non-timber forest products and forest services, including carbon sequestration and carbon storage.

Lack of studies, however, has investigated the potency of SFM as an option for reducing emission from deforestation and forest degradation. The existing demonstration activity projects (see Chapter 4) have also not investigated such issue because the projects were not implemented at forest management unit level. This chapter presents the result of studies on several forest management units concerning SFM scenarios (for natural production forests, plantation forests, and community forests) for reducing emission from deforestation and forest degradation.

5.1 Senarios for Reducing Emission at Natural Production Forests

5.1.1 General Condition of the Study Site

To formulate strategies for reducing emission at natural production forests, this study used a case study at Sari BumiKusuma (SBK) concession, Seruyan, Central Kalimantan. The total area of this concession is 119,607.45 ha. Since 2011, the company has been implementing two silvicultural systems: TPTI (*TebangPilihTanam Indonesia*, Indonesian selective cutting system) on 59,098.56

ha of the area and TPTJ (TebangPilihTanamJalur, selective cutting and line planting) on 60,508.89 of the concession area.

All effective production areas are logged-over forest areas (Figure 7), resulting from the first rotation period (1978–1998). Forest inventory data (Figure 8) confirmed that forest stands were dominated by young trees (diameter of 10–19 cm) with stand density ranging from 21 trees/ha (diameter class of ≥50 cm) to 288 trees/ha (diameter class of 10–19 cm). Mean stand volume reached 197.62 m^3/ha (for trees with diameter of ≥10 cm), 122.55 m^3/ha (for trees with diameter of ≥40 cm, which is a harvest limit of the TPTJ system), and 94.52 m^3/ha (for trees with diameter of ≥50 cm, which is a harvest limit of TPTI system).

Figure 7. Logged-over forest of Sari BumiKusuma (SBK)

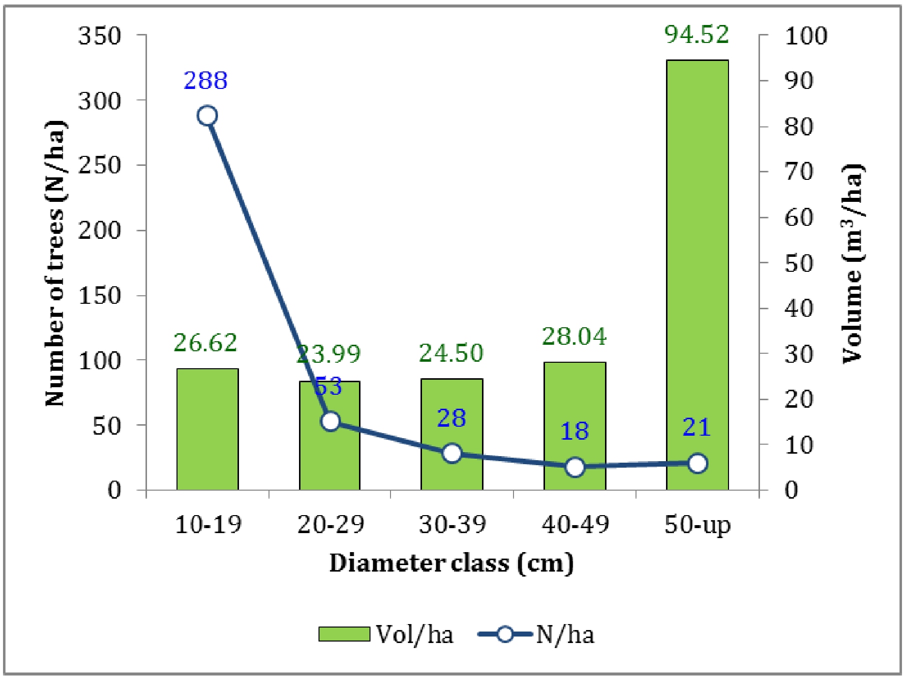


Figure 8. Number of trees and volume of the logged-over forests of Sari BumiKusuma (SBK)

The volume increment of logged-over forests of SBK was relatively high. Stand growth data of some permanent sample plots (PSP), which were observed since 1994 to 2010, confirmed that the volume increment ranging from 1.1 to 7.3 m^3/ha/yr that equivalent to 1.0 to 3.6%/yr of the total volume of standing forests, except for the PUP-6 whose a negative increment (Figure 9). In average, the mean volume increment of SBK is 3.6 m^3/ha/yr or 1.8%/yr of the total volume of standing forests. Such figures are relatively high compared to those of general logged-over forests in Central Kalimantan (see Box 2), i.e. 2.32 m^3/ha/yr(Imanuddin & Wahjono, 2005).

In addition to the TPTI system, since 1998 SBK has been implementing TPTJ system, which is also called an intensive silvicultural system (SILIN). In the TPTJ system, production forest areas are divided into two line types: clean-lines (3 m width) and inter-lines (17 m width). In the clean-lines, all trees are harvested and then regenerate with a spacing of 2.5 x 2.5 m (Figure 10). In the inter-lines, all trees with diameter ≥40 cm are harvested. In this study, the stand volume increment of inter-lines was assumed same as that of logged-over forests of the TPTI system (with harvestable diameter limit of ≥50 cm). The stand volume increment of clean-lines was assumed 4,07 m^3/ha/yr by considering that at the rotation age of 25 years the planted stands of clean-lines would reach volume of 101,7 m^3/ha (SBK, 2011).

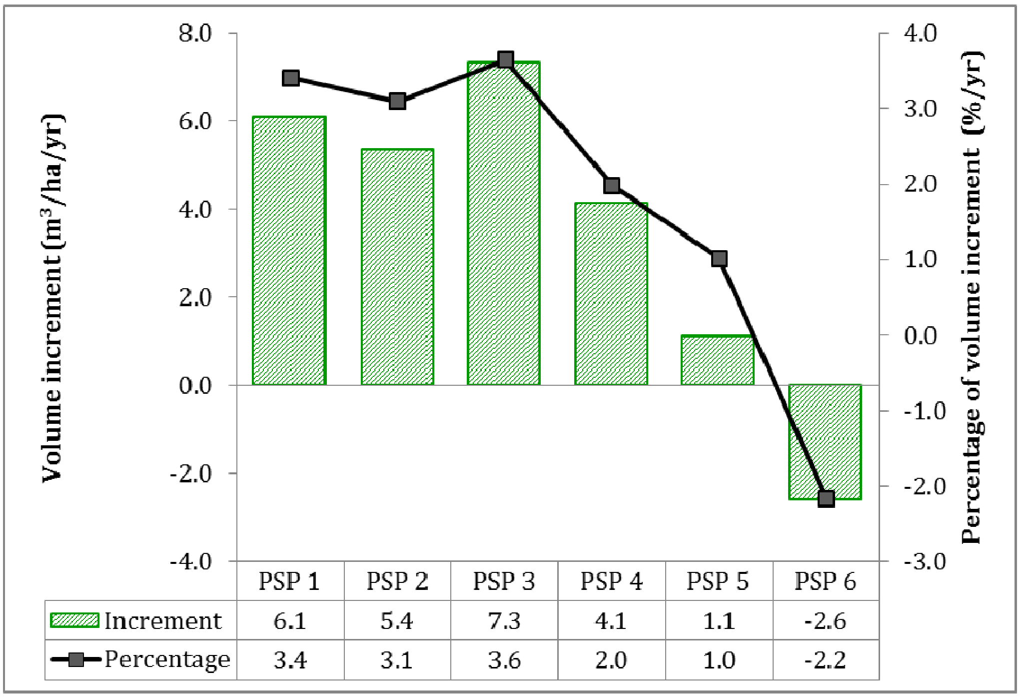


Figure 9. Increment of stand volume at the permanent sample plots of Sari BumiKusuma (SBK)

Figure 10. Meranti (*Shorea* spp.) trees of (a) 1 year and (b) 9 years after planting using TPTJ system at Sari BumiKusuma (SBK)

Box 2. Mean annual increment (MAI) of tree diameter and stand volume of natural production forests in Indonesia

Imanuddin&Wahjono (2005) reported that mean annual increment (MAI) of tree diameter at natural production forests was 0.70 cm/yr for commercial trees species, 0.64 cm/yr for non-commercial trees species, and 0.67 cm/yr for all trees species. Meanwhile, MAI of stand volume was 1.629 m^3/ha/yr for commercial trees species, 0.432 m^3/ha/yr for non-commercial trees species, and 1.849 m^3/ha/yr for all trees species.

Province	MAI of diameter (cm/yr)			MAI of volume (m^3/ha/yr)		
	Commercial	Non-commercial	All species	Commercial	Non-commercial	All species
Central Kalimantan	0.05	0.40	0.49	2.207	0.198	2.324
East Kalimantan	0.58	0.50	0.55	2.503	0.629	2.956
West Kalimantan	0.52	0.46	0.50	1.878	0.215	2.094
South Kalimantan	0.90	0.91	0.90	1.922	0.318	2.240
Maluku	0.58	0.52	0.56	2.254	0.480	2.733
Jambi	0.69	0.62	0.67	2.170	0.326	2.404
Papua	0.77	0.64	0.77	2.262	0.486	2.748
Central Sulawesi	0.67	0.66	0.66	1.276	0.252	1.528
North Sulawesi	0.79	0.78	0.79	1.294	0.591	1.885
South Sulawesi	1.20	1.10	1.10	1.483	1.690	0.772
Aceh	0.60	0.52	0.57	0.088	0.009	0.097
Riau	0.45	0.36	0.39	1.358	0.130	1.488
South Sumatra	0.80	0.80	0.80	0.484	0.288	0.772
Average	**0.70**	**0.64**	**0.67**	**1.629**	**0.432**	**1.849**

Source: Imanuddin&Wahjono (2005)

5.1.2 Methods for Calculating Emission at Natural Production Forests

The emission of forest management activities at SBK was calculated using the gain-loss method. The loss of carbon stocks at certain period might be caused by deforestation and timber production activities: harvestings, logging damages, and infrastructures or forest openings. The gain of carbon stocks is resulted from stand regrowth and planting at the TPTJ's lines. Because of such loss and gain of carbon stocks, total carbon stocks at certain year (C_{t+1}) can be calculated by adding the previous total carbon stocks (C_t) with the difference of the gain and loss of carbon stocks within a certain period (Figure 11).

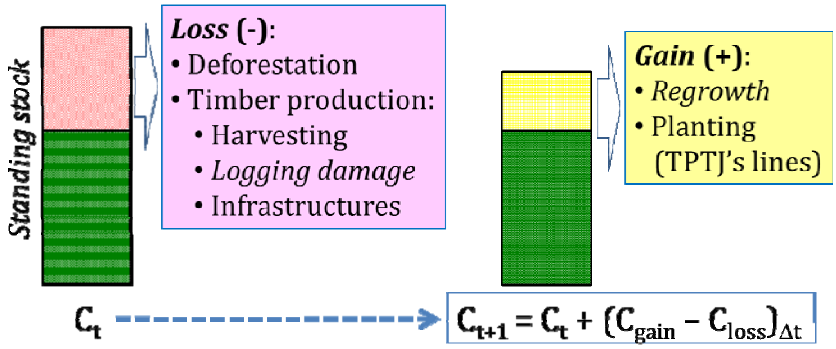


Figure 11. Illustration of the gain-loss method for calculating emission at natural production forests

The total carbon stocks of standing forests were calculated from stand volume (diameter of ≥10 cm) using volume-biomass conversion factor of 0.95, biomass-carbon conversion factor of 0.47, and C-CO_2 conversion factor of 3.67 (IPCC, 2006). The loss of carbon stocks was calculated by assuming that harvesting of 1 m^3 stands resulted in a logging damage of 0.25 m^3. This study also assumed that the proportion of stand damages due to infrastructures or forest opening was 0.05.

To analyze the benefit of emission reduction through natural production forest management, this study analyzed five scenarios as follows:

- Baseline scenario: deforestation continuously occurs in the forest management unit (FMU).
- Scenario 1: FMU manages the concession using TPTI system applied in the entire productive area.
- Scenario 2: FMU manages the concession using TPTJ system applied in the entire productive area.
- Scenario 3: FMU manages the concession using multisystem silvicultures, i.e. TPTI and TPTJ systems.
- Scenario 4: similar to scenario 3 but annual allowable cut (AAC) is reduced by 25% (FMU only harvests 75% of the normal AAC).

For each scenario, carbon stocks and their emission potency were calculated using several assumptions as shown in Table 8.

Table 8.Scenarios for reducing emission at natural production forests

Scenario	Assumption				
	Defores-tation[1)]	Silvicultural system	Harvest volume[2)]	Regrowth	Stand damage[3)]
Baseline	2.2%/yr	TPTI	Normal AAC	2.32 m^3/ha/yr	LD=0.25, PL=0.95, FO=0.05
Scenario 1	0	TPTI	Normal AAC	LOA= 3.6m^3/ha/yr = 1.8%/yr TPTJ's stands = 4.07 m^3/ha/th	LD=0.15 PL=0.95 FO=0.05
Scenario 2	0	TPTJ	Normal AAC		
Scenario 3	0	TPTI+TPTJ	Normal AAC		
Scenario 4	0	TPTI+TPTJ	75% of normal AAC		

1) Based on the deforestation rate of Central Kalimantan in the period 1985–1997
2) Normal AAC = total effective forest area/rotation (where the rotation of TPTI is 30 yrs and TPTJ is 25 yrs)
3) LD = logging damage (m^3/harvested m^3), PL = proportional logging, FO = forest opening/infrastructure

5.1.3 Timber Yield and Carbon Sequestration Service of Natural Production Forests

Simulation using the five scenarios (Table 8) confirmed that forest management activities at SBK concession may provide timber yield and carbon sequestration service that differ according to the management scenarios (Figure 12). If FMU does not manage the concession in sustainable manners, where deforestation continues into the future (i.e. similar to the baseline scenario), then timber yield would decrease from time to time, starting from 200,481 m^3/yr to 105,064 m^3/yr (see Appendix 1). Such situation is possible because deforestation would reduce both effective production areas and harvestable trees in the concession. The unsustain forest management (baseline scenario) would not only reduce timber yield, but it also reduced carbon stocks up to 51% during 30 years, i.e. from 38.73 to 19.64 $MtCO_2e$ (Figure 12b). The reduction of carbon stocks can be attributed to the decrease of standing stocks due to deforestation.

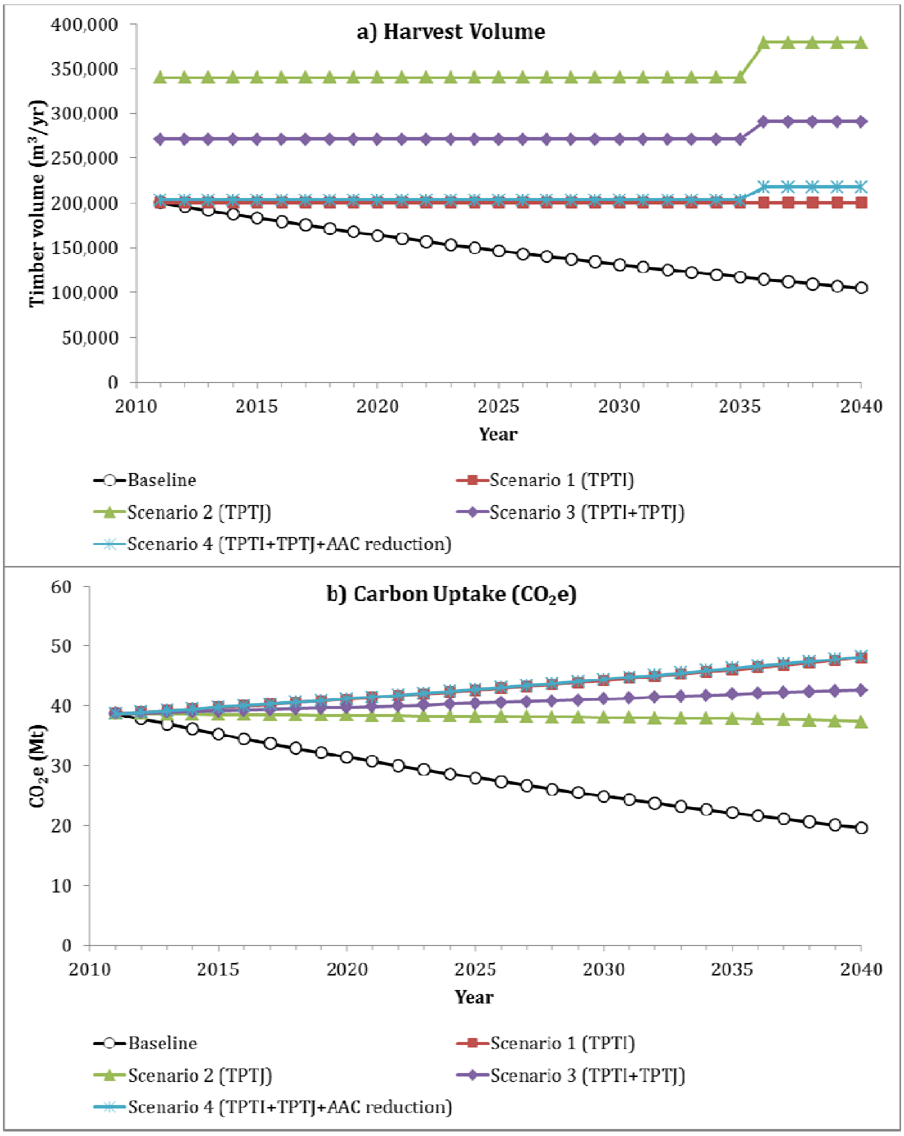


Figure 12. Estimated (a) harvest volume and (b) carbon uptake (CO_2e) from the five scenarios for managing natural production forests of Sari BumiKusuma (SBK) concession

When SFM is implemented in the concession, in which the FMU can avoid deforestation, timber yield and carbon stocks would highly depend on the applied silvicultural system (scenario 1, 2, and 3) and harvest regulation (scenario 4). The TPTI system applied in the entire productive area (scenario 1) produced the lowest timber yield (i.e. 200,481 m^3/yr) than the other scenarios. The scenario 1, however, has the highest increase in carbon stocks because the lowest harvest volume (only trees with diameter of ≥50 cm) does not greatly remove the stored biomass of standing forest. Conversely, if the TPTJ system is applied in the entire productive area (scenario 2), timber production would be maximum (340,442–

379,274 m^3/yr) because of higher harvest volume due to decrease in diameter harvest limit (≥40 cm) and additional timber yield from the stands of clean-lines. Even in 2036 timber production would drastically increase because of additional volume of the stands at clean-lines that have reached the rotation age. Although the TPTJ system (scenario 2) is profitable, such silvicultural system produced the lowest carbon stocks because the higher harvest volume would resulted in the higher removal of stand biomass.

Another alternative for managing the concession is applying a multisystem silviculture (scenario 3), where a part of concession area (59,098.56 ha) is managed using TPTI system and the other part (60,508.89 ha) is managed using TPTJ system, which is currently applied at SBK concession. Such multisystem silviculture provided higher timber yield (271,282–290,932 m^3/yr) than that of the pure TPTI system. Although the timber yield of scenario 3 is lower than that of the pure TPTJ system (scenario 2), such multisystem silviculture produced higher carbon uptake that tend to increase from time to time (38.73–42.65 $MtCO_2e$; Figure 12b, Appendix 1). This finding suggests that the multisystem silviculture (scenario 3) is a compromise management option for balancing the management objectives of timber production and carbon sequestration. To increase carbon sequestration up to 13% (i.e. 38.73–48.23 $MtCO_2e$), the FMU may apply the multisystem silviculture coupled with AAC reduction up to 25% (scenario 4). Such scenario, however, requires awareness of forest managers to sacrifice some economic objectives with ecological objectives for increasing carbon sequestration services.

The results of this study confirm that SFM practices can increase carbon sequestration at SBK concession. The amount of emission reduction benefits from the SFM practices can be calculated by comparing the rate of carbon uptake from the four SFM scenarios against the baseline scenario (Figure 13). The largest emission reduction benefits would be obtained if the FMU applies scenario 4 (i.e. applying the multisystem silviculture coupled with AAC reduction). For 30 years, the scenario could reduce carbon emissions by 447.75 $MtCO_2e$ for the effective area of 119,607.45 ha area in SBK concession (Figure 13a) or an average of 124.78 tCO_2e/ha/yr (Figure 13b). The emission reduction benefits of scenario 4 are not much different from the scenario 1, which produced 443.82 $MtCO_2e$ or an average of 123.69 tCO_2e/ha/yr, where the TPTI system is applied to the entire productive area. If the FMU only applies the TPTJ system to the entire productive area (scenario 2) or applying the multisystem silviculture without reducing AAC (scenario 3), the emission reduction benefits derived from scenario 2 (83.75 tCO_2e/ha/yr) and scenario 3 (103.48 tCO_2e/ha/yr) are lower than those of scenario 1 and 4. Such lower benefits are closely related to the fact that scenario 2 and 3 harvested more stand biomass (to obtain more timber yield) than scenario 1 and 4.

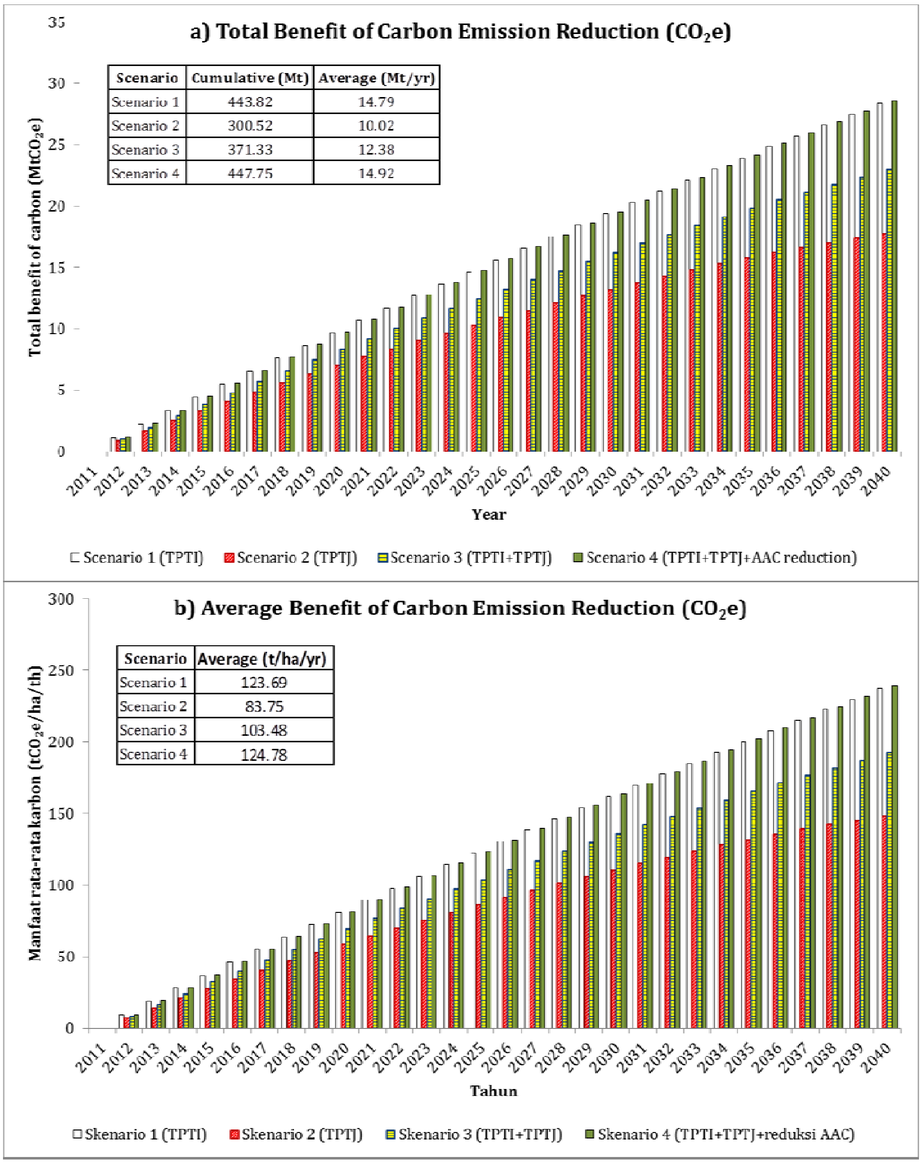


Figure 13. Estimated (a) total benefit and (b) average benefit of carbon (CO_2e) emission reduction from the five scenarios for managing natural production forests of Sari BumiKusuma (SBK) concession

5.2 Scenarios for Reducing Emission at Plantation Forests

In addition to natural production forests, plantation forests in Indonesia play an important role in reducing emissions. This study analyzed the potential of teak plantations in Kebonharjo FMU (PerumPerhutani Unit I of Central Java) for reducing emissions from forest degradation.

5.2.1 General Condition of the Study Site

Kebonharjo FMU is one of the 57 FMUs managed by PerumPerhutani (a state-owned forestry enterprise), which manages teak plantations. Most of the forest area (around 79%) of Kebonharjo FMU is located in Central Java, and some parts in East Java (PerumPerhutani, 2007; Tiryana, 2010). The total area of Kebonharjo FMU is 17,801.3 hectares, which is divided into three forest divisions for teak timber production (i.e. Balo, Merah, and Tuder) and one forest division (i.e. GunungLasem) for flora and fauna conservation purposes.

Teak plantation forest management at Kebonharjo FMU is conducted by applying a clear-cutting with artificial regeneration system, which is also applied in other FMUs of PerumPerhutani. Such silvicultural system is characterized by three main activities: planting, thinning, and harvesting. Planting is conducted by involving local communities through *tumpangsari* program. Local communities involved in the tumpangsari program are allowed to plant agricultural crops (e.g. corns, cassavas, rice, and beans) for two years if the communities also plant and maintain teak trees. Initial thinning is conducted when teak stands reach age 3, 6, and 9 years, which is only aimed to maintain the stands without generating valuable timber yield. Commercial thinning is conducted when teak stands reach age 12, 15, 20 years and then continue every five years until 10 years before clear-cutting. In 2007, Kebonharjo FMU has reduced rotation age from 80 to 60 years because of a decrease in forest resources and financial considerations of the company (PerumPerhutani, 2007).

The shifting of paradigm in managing forests, i.e. from sustained timber yield principle into sustainable forest management (SFM), has motivated Kebonharjo FMU to implement the SFM principles in managing teak plantations. Even during the period 1998–2000, the FMU has been certified by FSC. The FSC's certificate, however, was then revoked by FSC because PerumPerhutani(especially

Kebonharjo FMU) did not able to improve their management practices especially dealing with illegal logging and social conflict problems.

Recently, the implementation of SFM at Kebonharjo FMU poses a great challenge. Forest resources tend to decrease from time to time because of various disturbances (e.g. illegal logging, grazing, and forest fire). The age class structure of teak plantations is not balance, because most of the plantations (80.7%) are dominated by young stands (≤30 years old; Figure 14a). The unbalanced age class structure also occurs at other FMUs that manage teak plantations in Java (Gambar 14b). This is an alarming condition for the sustainability of forest resources, because the productive area of mature stands is decreasing. As a result, timber production at Kebonharjo FMU tended to decline within the last 30 years (1997–2007). In the period 1977–1997, the annual harvest volume of Kebonharjo FMU was 13,193–24,321 m^3/yr, but then drastically decline to 7,223–17,580 m^3/yr in the period 1998–2006 (Tiryana, 2010).

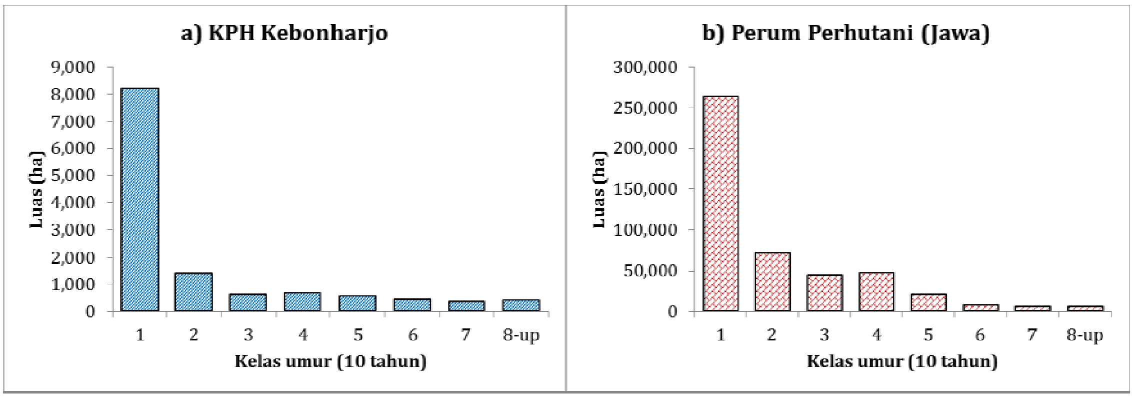


Figure 14. Age class structure of teak plantations in (a) Kebonharjo FMU and (b) the entire area of PerumPerhutani in Java

The decline of forest resources in Kebonharjo FMU is closely related to the rate of forest disturbance that occurred within the last 30 years (1977–2007). Tiryana et al. (2011) confirmed that the rate of stand destruction was low (<2% per year) in the period 1977–1987, but then increased to 3% per year in the period 1987–1997 and 14% per year in the period 1997–2007. These figures show that in the last 20 years, the rate of degradation of teak plantations in Kebonharjo FMU increased along with increasing forest disturbances, especially during the economic crisis period (1988–1999) that triggered rampant illegal loggings.

PerumPerhutani (2005) reported that the total theft of timber during the economic crisis period was 60 times larger than the previous period (1995–1997).

5.2.2 Methods for Calculating Emission at Plantation Forests

To calculate the benefit of emission reduction by avoiding forest degradation of teak plantations, this study used the results of carbon stocks calculation at Kebonharjo FMU that was conducted by Tiryana (2010). In his study, Tiryana (2010) calculated the gain and loss of carbon stocks in teak plantation using modeling techniques (i.e. simulation and optimization; Figure 15). The simulation was performed using a transition matrix approach to project age class structure from one period to another. In addition to the stand destruction factors (due to various disturbances), the change of stand structure from one period to another was also influenced by an optimum harvest level, which was determined by using linear programming method. The potency of carbon stocks of teak plantations would decrease because of thinning and harvesting (either clear-cutting or salvage-cutting at degraded stands), and would increase because of planting and growth of stands from time to time. In detail, data and procedures used in the calculation of timber yield and carbon stocks of teak plantations at Kebonharjo FMU can be seen in Tiryana (2010).

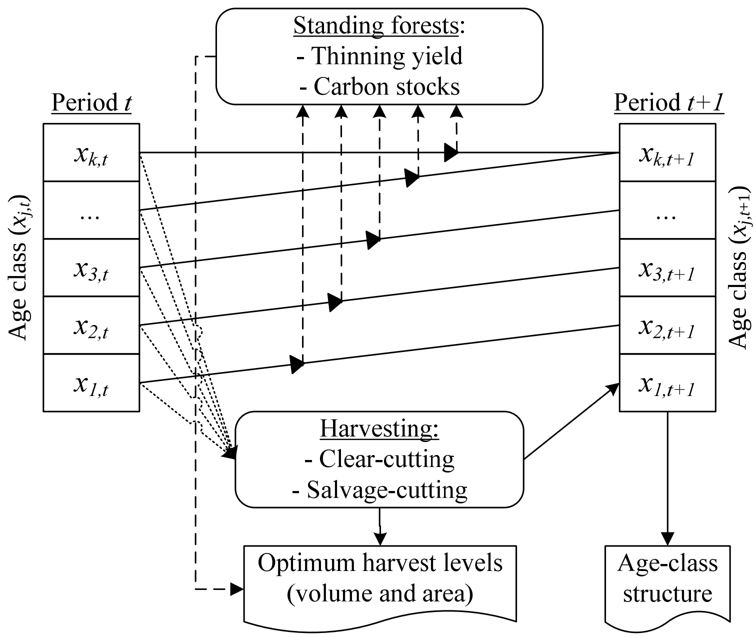


Figure 15. Conceptual model for calculating optimum timber yield and carbon stocks of teak plantations (adapted from Tiryana, 2010)

Following Tiryana (2010), this study further analyzed the benefit of emission reduction if FMU capable to avoid stand destruction that resulted in forest degradation. The analysis of emission reduction was conducted using the following scenarios:

1) Baseline scenario, which assumes that FMU would experience high forest degradation with the rate of 0.1–14% per year (depending on stands age), as happened at Kebonharjo FMU in the period 1997–2007. Such degradation rate was assumed to be equal to the rate of teak stands destruction in Kebonharjo FMU obtained from Tiryana (2010; 2011).
2) Scenario 1, which assumes that FMU would experience medium forest degradation with the rate of 0.6–3% per year, as happened at Kebonharjo FMU in the period 1987–1997.
3) Scenario 2, which assumes that FMU would experience low forest degradation with the rate of 0.9–2% per year, as happened at Kebonharjo FMU in the period 1977–1987.
4) Scenario 3, which assumes that FMU performs sustainable forest management so that no forest degradation. This scenario is used as a comparison to the ideal condition (i.e. without forest degradation), although such ideal condition would be difficult to achieve in the real practice.

These four scenarios assumed that FMU used a 60-year rotation (as currently used by Kebonharjo FMU) with the objective of maximizing total timber volume (from clear-cutting, thinning, and salvage-cutting) in the long term period (i.e. 140 years).

5.2.3 Timber Yield and Carbon Sequestration Service of Plantation Forests

Beside deforestation (see the case of SBK concession), forest degradation (indicated by a decrease in standing stocks) is a source of emission that need to be taken into account in the implementation of REDD+ mechanism. The results of simulation and optimization at teak plantations in Kebonharjo FMU (Figure 16a, Appendix 2) showed that timber production (from clear-cutting, thinning, and salvage-cutting) and carbon uptake were highly dependent on the rate of forest degradation due to various disturbances. In the baseline scenario, timber volume tended to decrease from 232,000 to 219,000 m^3/period (with an average of

44,000–46,000 m^3/yr) during the 28 period (140 years), which was caused by the high rate of forest degradation that continuously occurs from one period to another. The level of timber production can be increased if the FMU can reduce the rate of forest degradation. Harvest volume reached 217,000–285,000 m^3/period (average of 43,000–57,000 m^3/yr) at the medium degradation rate (scenario 1), 198,000–337,000 m^3/period (average of 40,000–67,000 m^3/yr) at the low degradation rate (scenario 2), and 198,000–361,000 m^3/period (average of 40,000–72,000 m^3/yr) if no degradation (scenario 3).

In contrast to the results of natural production forests and community forests, where carbon uptake is highly dependent on harvest level, the carbon uptake of teak plantations is not only affected by harvest volume but also affected by the rate of forest degradation (Figure 16b, Appendix 2). For example, the baseline scenario has smallest total harvest volume but also lowest carbon uptake (545,000–748,000 tCO_2e/period or 109,000–150,000 tCO_2e/yr) than the other scenarios. In contrast, the higher total harvest volume of scenario 3 can even increase carbon uptake from one period to another (780,000–2,022,000 tCO_2e/period or 156,000–404,000 tCO_2e/yr). This happened because the high rate of forest degradation (baseline scenario) resulted in the high loss of timber and stand biomass before harvesting. As a result, when the stands reached the rotation age the FMU only conducts clear-cutting to limited productive stands, because most of unproductive/degraded stands would have been clear-cut before reach the rotation age although they produce less timber than productive stands. If the FMU can reduce the degradation rates (scenario 1 and 2) or even avoid degradation (scenario 3), the timber yield and carbon uptake of productive stands at the rotation age would increase, because at the low rate of forest degradation the FMU would not much harvest the degraded stands.

Further analysis on the emission reduction benefits of forest degradation (Figure 17) confirmed that the FMU would have greater benefits (in terms of total or average) if capable to reduce the rate of forest degradation. The highest emission reduction benefit (average of 202,630 tCO_2e/yr at Kebonharjo FMU or equal to 11.38 tCO_2e/ha/yr) can be reached if the FMU can avoid forest degradation (scenario 3). The scenario 3, however, is difficult to apply because teak plantations always experience various disturbances that resulted in forest degradation (Tiryana *et al.*, 2011). A realistic management scenario is the scenario 2, where the FMU capable to control the rate of forest degradation does not exceed 2% per year, as happened at Kebonharjo FMU in the period 1977–1987. The scenario 2 is quite beneficial in terms of timber yield and also can provide higher emission reduction benefits (with average of 152,450 tCO_2e/yr or equal to 8.56 tCO_2e/ha/yr) than scenario 1. It can be concluded, therefore, the rate of forest degradation largely determines the amount of emission reduction benefits at an FMU.

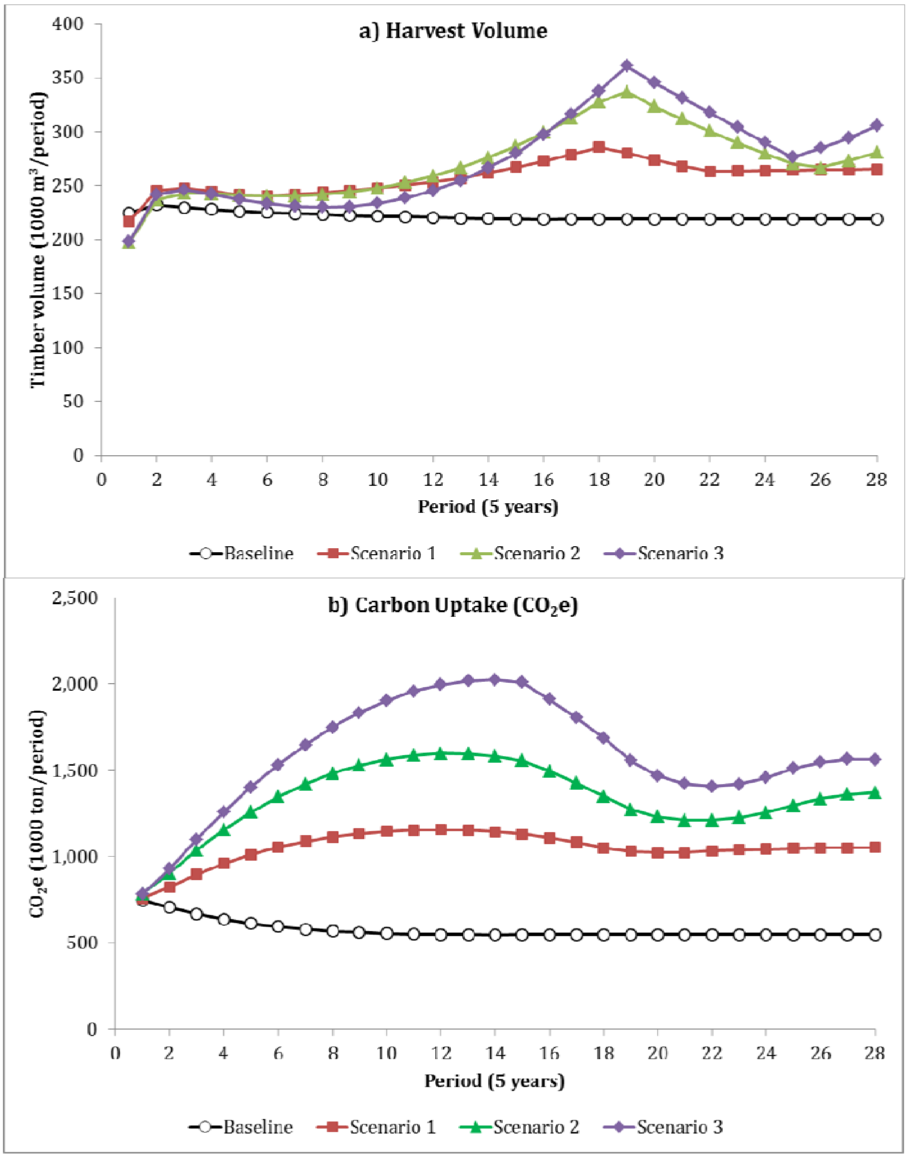


Figure 16. Estimated (a) harvest volume and (b) carbon uptake (CO_2e) from the four scenarios for managing teak plantations at Kebonharjo FMU, PerumPerhutani Unit I of Central Java

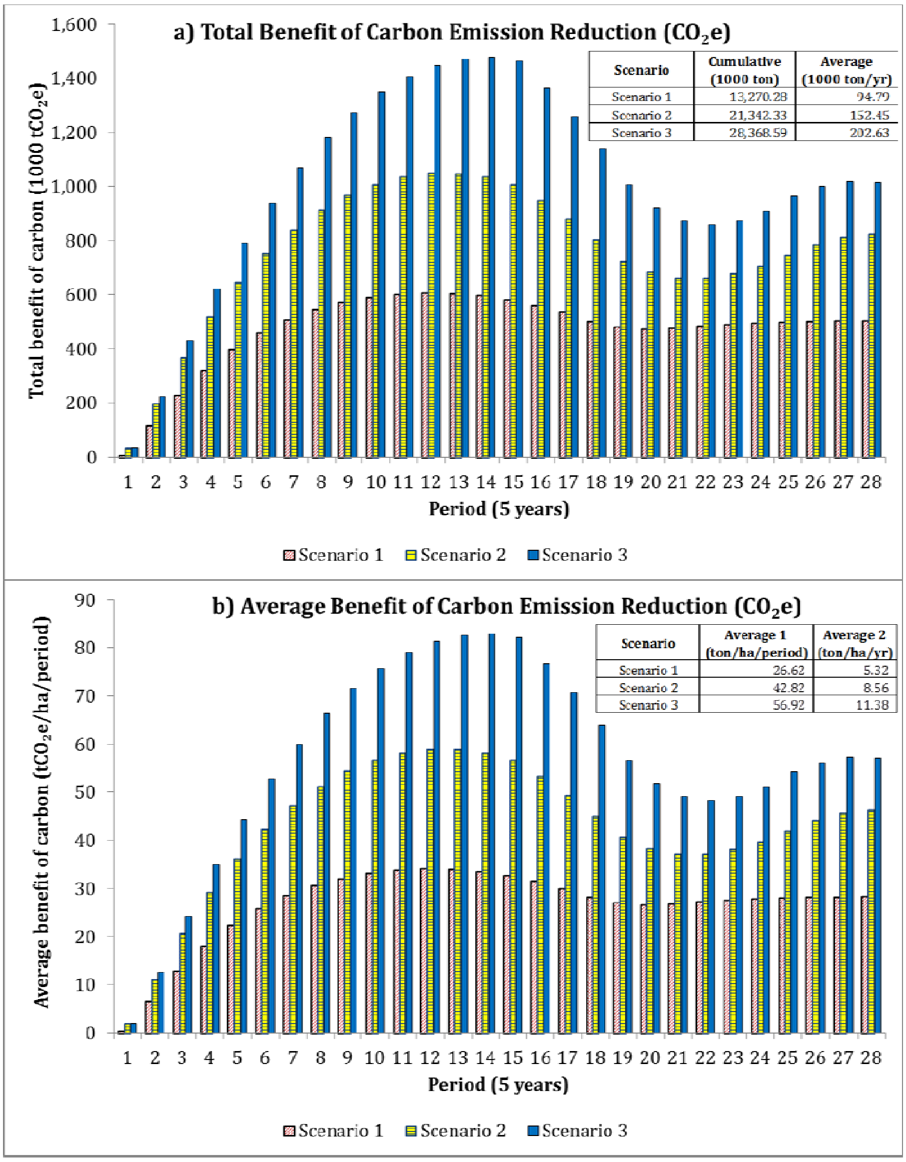


Figure 17. Estimated (a) total benefit and (b) average benefit of carbon (CO_2e) emission reduction from the four scenarios for managing teak plantations at Kebonharjo FMU, PerumPerhutani Unit I of Central Java

5.3 Scenarios for Reducing Emission at Community Forests

The existence of community forests, which are now emerging in many parts of Indonesia (see Chapter 3), has an important role in reducing emission. To assess the potential of community forests in reducing emission, this study investigated the practice of sustainable community forest management conducted by a forest co-operative called *KoperasiHutan Jaya Lestari* (KHJL) in South Konawe, Sulawesi.

5.3.1 General Condition of the Study Site

The community forests managed by KHJL is an ownership group of small-scale lands (<1 ha; consisting of woodlots, yards, and gardens) that are owned by individuals in South Konawe district. Initially, such community forests were established through a rehabilitation program for critical lands in the 1970's era. Before 2004, the community forests were not managed well, where their uses highly dependent on their owners without a proper planning. In fact, illegal logging was rampant and threatened the sustainability of forests. But the existence of assistance programs conducted by some NGOs (Non-Governmental Organization), such as TFT (*Tropical Forest Trust*), JAUH (*JaringanUntukHutan*, a network for forest), and MFP (*Multistakeholder Forestry Program*) have increased the awareness of local communities in South Konawe on the important of sustainable forest management In 2004, the communities agreed to establish a forest co-operative called *KoperasiHutan Jaya Lestari* (KHJL) as a management unit to manage sustainably the community forests.

Currently, KHJL manages 26 units of community forests distributed in six sub-districts of the South Konawe (KHJL, 2009), i.e. Laeya, Lainea, Kolono, Palangga, Buke, Baito, and Andoolo sub-districts. The number of lands managed by KHJL is 225 units with a total area of 771 ha. The member of KHJL is 769 people, which tends to increase from year to year (KHJL, 2009).

The main stand of KHJL is teak (*Tectonagrandis*). In contrast to teak plantations in Java that generally are even-aged forests, the teak plantations managed by KHJL are uneven-aged forests because the stands were planted by owners at different time. The result of forest inventory conducted by KHJL in 2008 confirmed that forests are dominated by small trees (diameter of 10–19 cm), accounting for 35,382 trees. While harvestable trees (diameter of ≥30 cm) reached 11,938 trees with a total volume reached 5,022.51 m^3 (Figure 18).

The community forests managed by KHJL provide an example on how communities capable to sustainably manage the forests. The KHJL's communities are able to practice a well forest management, starting from harvesting mature trees, replanting logged-over areas, and maintaining forest stands to reach harvestable stands (Figure 19). The eagerness and hard works of the KHJL's communities resulted in a well-managed community forest that has been certified by FSC for the period 2010–2015. The community forests that are managed professionally by KHJL provide economic benefits to its members from the selling of certified wood products.

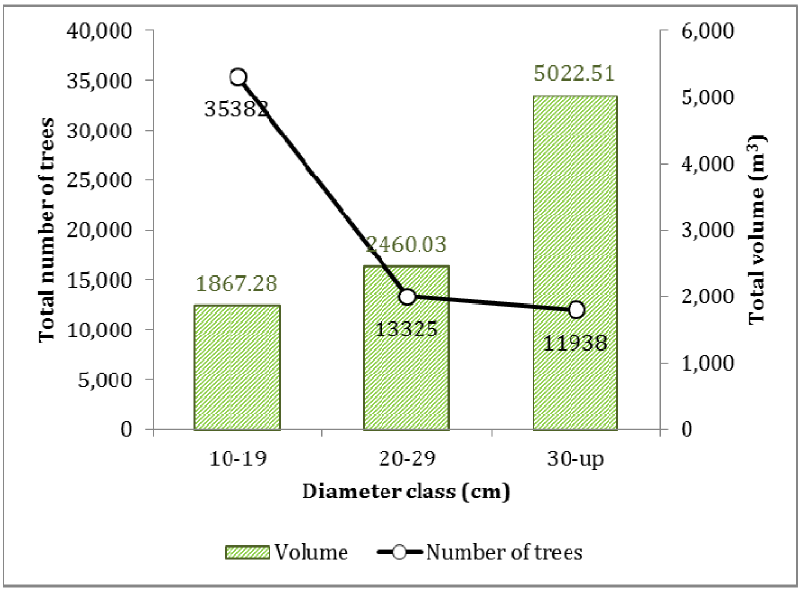


Figure 18. Total number of trees and volume of community forests managed by KoperasiHutan Jaya Lestari (KHJL) in South Konawe

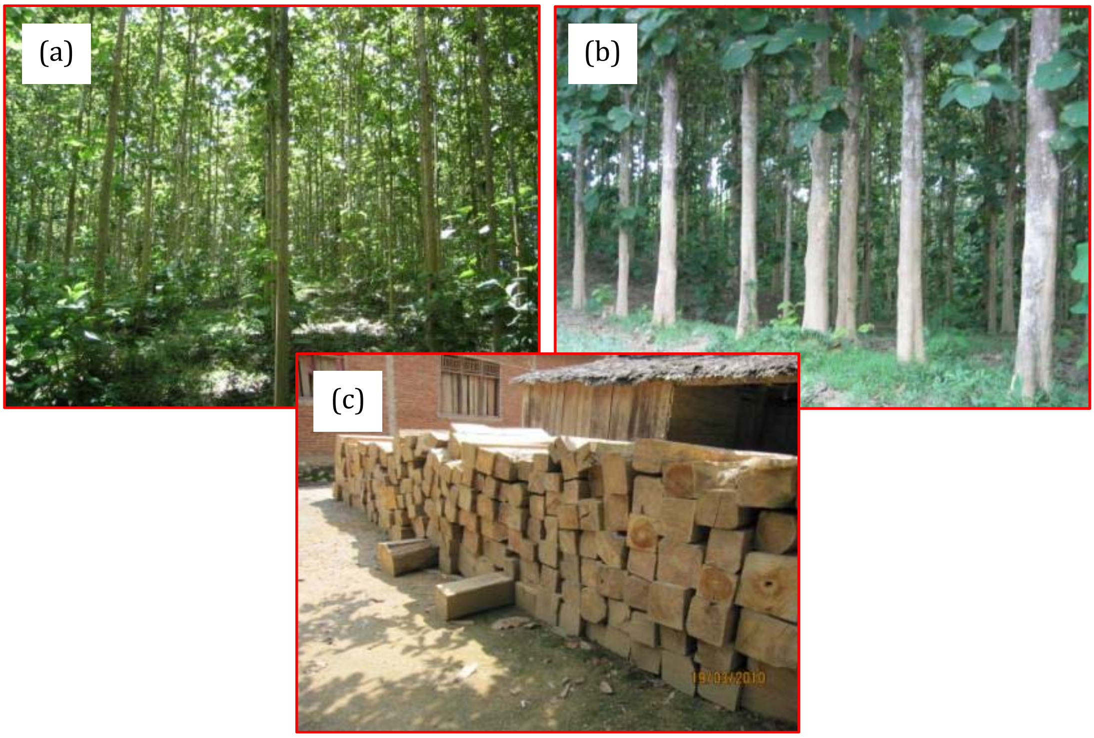


Figure 19. Young teak stands (a), mature stands (b), and teak timber (c) from community forests managed by KoperasiHutan Jaya Lestari (KHJL) in South Konawe

5.3.2 Methods for Calculating Emission at Community Forests

To calculate carbon uptake level of the KHJL's community forests, this study used the gain-loss method (Figure 20). The loss of carbon stocks at the community forests was only caused by trees harvesting using a selective cutting system conducted carefully by KHJL; hence, this study assumed that no logging damages occurred during the harvesting. The gain of carbon stocks at the community forests came from regrowth of trees in various diameter classes. Because of the lack of stand growth data measured from permanent sample plots in the KHJL's community forests, this study used the following assumptions:

- Diameter increment of teak trees is 1.5 cm, so that within 7 years the teak trees will move from one diameter class to another. It means that the proportion of upgrowth is 0.14 per year. Based on this assumption, annual allowable cut (AAC) is calculated using this formula (as currently used by KHJL): AAC = $Vt/7$, where Vt is the total volume of harvestable trees in a given year.
- The proportion of tree mortality at a diameter class is 0.05 per year.
- The proportion of trees staying at a diameter class is 0.81 per year.
- The proportion of ingrowth (entering the smallest diameter of 10 cm) each year is assumed fixed of 13.421 trees, which was calculated from a ratio of the number of trees per diameter class (q-ratio) based on the existing stand structures (see Figure 18).

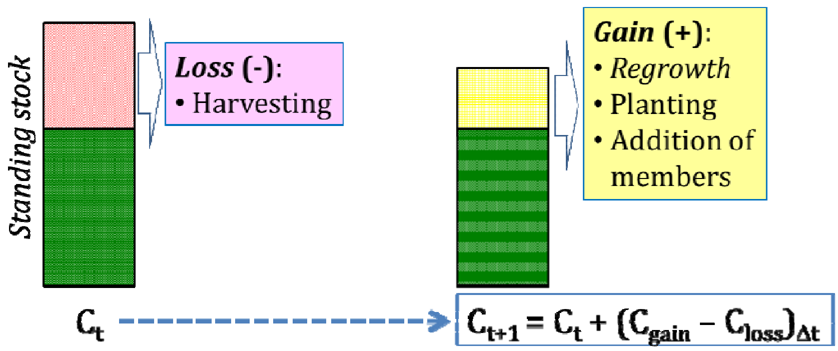


Figure 20. Ilustration of the gain-loss method for calculating carbon emission at community forests

Another source of carbon stocks gain is planting and addition of KHJL's members. Commonly, the KHJL's communities replant 10 times more than the harvested trees. This study, therefore, assumed that KHJL conducts 10% replanting each year. In addition, KHJL continuously develops the community forests by recruiting new members whose lands planted with trees (especially teak). In this study, the addition of new members was assumed 10% per year that resulted in an increase of the number of trees in each diameter class of: 50.8% for the diameter class of 10–19 cm, 22.5% for the diameter class of 20–29 cm, and 26.7% for the diameter class of ≥30 cm. These figures were calculated from the average of annual trees increment for each diameter class based on the land inventory of new members in the period 2005–2009.

To quantify the potential emission reduction through sustainable community forest management at the KHJL area, this study developed three scenarios as follows:

1) Baseline scenario, in which the communities tend to early harvest trees with minimum diameter of 20 cm without replanting. This scenario illustrates an unsustain forest management before establishing KHJL.
2) Scenario 1, in which the communities harvest trees with minimum diameter of 30 cm that are followed by replanting 10 times more than the number of harvested trees until reach stand density of 500 trees/ha. This scenario describes the existing forest management conducted by KHJL.
3) Scenario 2, in which the communities harvest trees with minimum diameter of 30 cm that are followed by replanting 10 times more than the number of harvested trees, the KHJL's members increase by 10% per year, and maximum of harvest volume is limited to 5,000 m^3/yr (following the FSC standard for Small and Low Intensity Management of Forest, SLIMF). This scenario describes a developed community forest management practice.

5.3.3 Timber Yield and Carbon Sequestration Service of Community Forests

The results of simulation confirm that the unsustainable community forest management (baseline scenario) would produce a maximum timber yield only for the first three years (around 852–1,024 m^3/yr), which then drastically decrease compared to scenario 1 and 2 (Figure 21a, Appendix 3). The unsustainable community forest management would not only produce unfavorable economic benefits, but also lead to the decrease of carbon uptakes from 15,284 to 91

tCO_2e/yr (Figure 21b), so that it would be a source of carbon emission. The decrease of timber yield and carbon uptake was caused by early harvesting of relatively small trees (diameter of ≥20 cm) without replanting in order to obtain early financial gains for the communities. As the result, the potential standing stocks are decreasing from time to time.

When the KHJL's communities implement sustainable forest management as at present (scenario 1), both timber yield and carbon uptake tend to increase every year. During 30 years, timber yield increased from 672 m^3 to 2,240 m^3 and carbon uptake increased from 15,284 tCO_2e to 72,997 tCO_2e (Figure 21, Appendix 3 3). The increase of timber yield and carbon uptake is possible because the communities postpone harvesting until the trees reach a diameter of ≥30 cm, so it does not much eliminate the stand biomass compared to the baseline scenario. The carbon uptake continuously increase along replanting the harvested trees until the stands reach density of 500 trees/ha. The SFM practice would not only provide economic benefits from timber production, but it also provides environmental benefits in terms of carbon sequestration services.

If KHJL expands the community forest management unit (scenario 2), timber production and carbon uptake would increase significantly, i.e. 672–5,232 m^3/yr and 15,284–246,627 tCO_2e/yr, respectively, compared to scenario 1. Such increases are associated with the increase of 10% members per year that contribute to the increase of stand volume and biomass from time to time, in addition to the saving of potential stands by postponing harvesting the trees until reach a minimum diameter of 30 cm. Because the FSC standard on SLIMF scheme only allow a maximum AAC of 5,000 m^3/yr, KHJL could only expand the management unit until 2029 because the annual harvest volume would have reached 5,232 m^3/yr.

Compared to the baseline scenario, the increase of carbon uptakes in scenario 1 and 2 indicates that both scenarios for managing the community forests can provide emission reduction benefits (Figure 22). For 30 years, the emission reduction of 1,03 $MtCO_2e$ (average of 34,459 tCO_2e/yr) could be gained if KHJL manages the community forests using scenario 1 (i.e. limiting harvestable trees diameter of ≥30 cm and replanting). Such emission reduction benefit can be increased up to 3,1 $MtCO_2e$ or average of 103,469 tCO_2e/yr if KHJL expands the

FMU as illustrated in scenario 2 (i.e. recruiting new members, replanting, and limiting harvestable trees diameter of ≥30 cm). These results confirm that sustainable community forest management can be used as an option for reducing carbon emission.

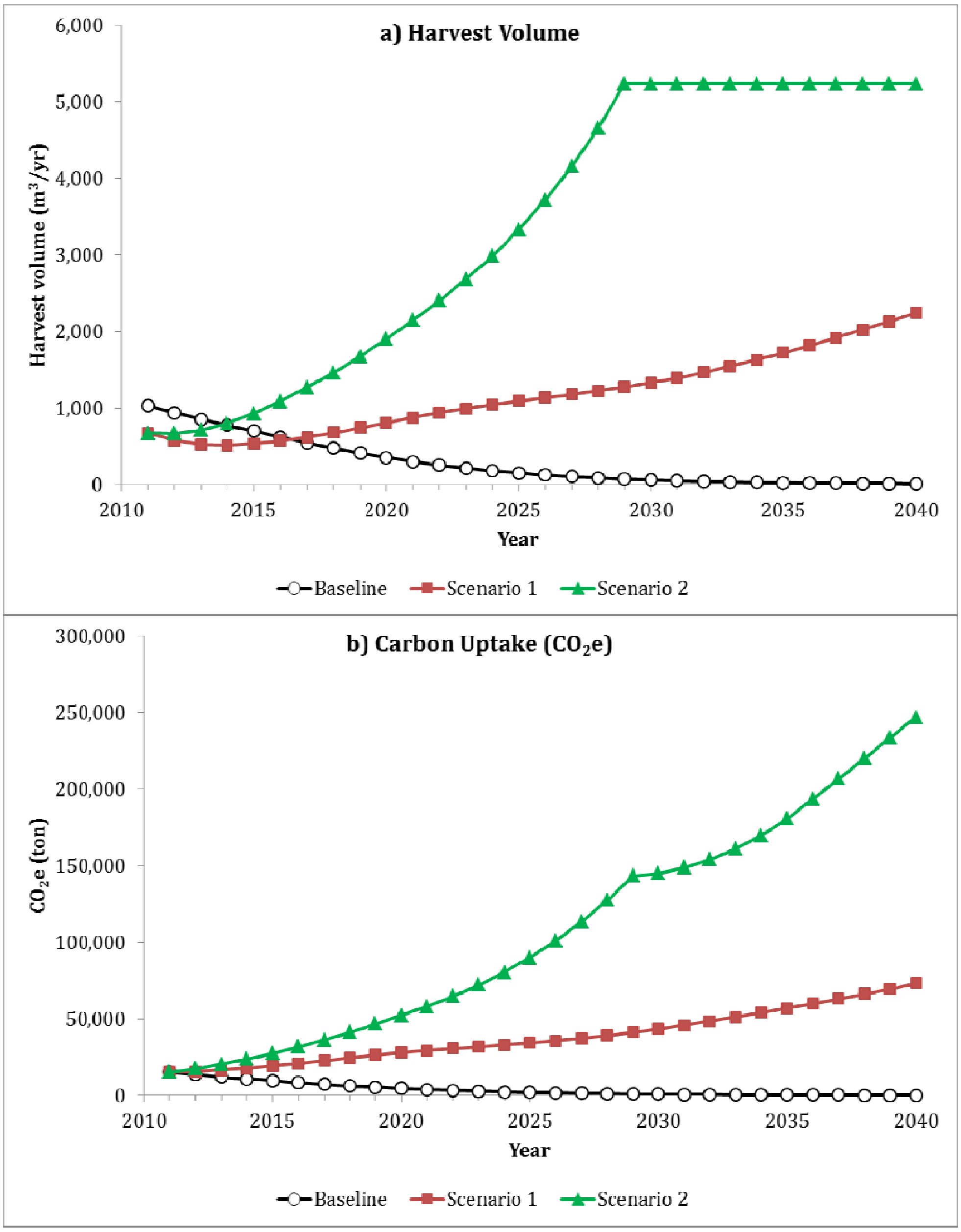


Figure 21. Estimated (a) harvest volume and (b) carbon uptake (CO_2e) from the three scenarios for managing community forests at KoperasiHutan Jaya Lestari (KHJL)

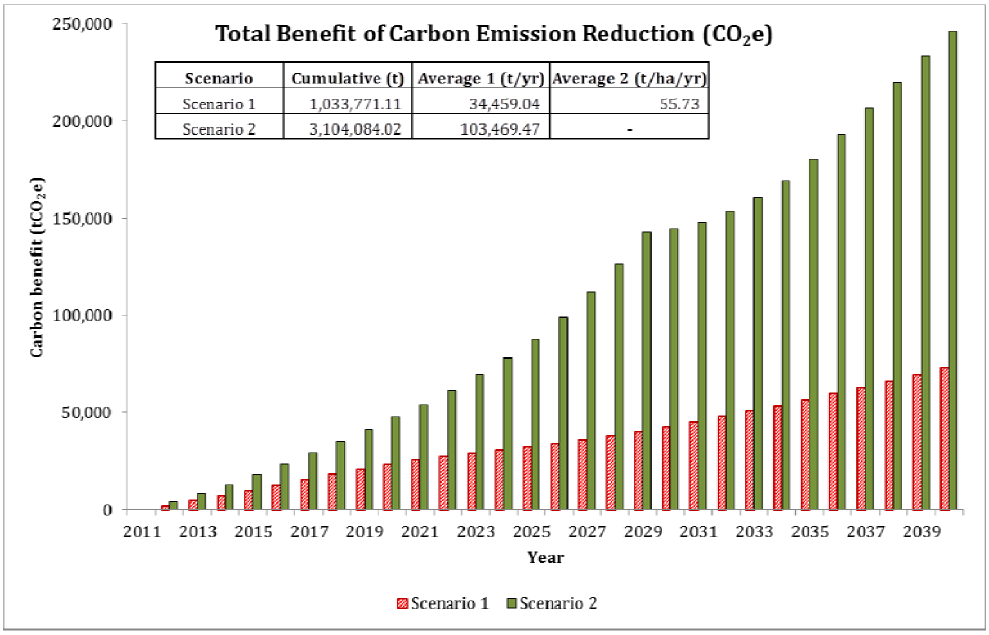


Figure 22. Estimated benefits of carbon (CO_2e) emission reduction from the two scenarios for managing community forests at KoperasiHutan Jaya Lestari (KHJL)

VI. Strategies of Sustainable Forest Management for Reducing Emission

The results of this study (Chapter 5) confirmed that sustainable forest management (SFM) practices provide not only timber yield, which is the main objective of current forest management practice in Indonesia, but also carbon sequestration benefits. The amount of timber yield and carbon sequestration benefits is dependent on the applied forest management scenarios. A forest management unit, therefore, needs to develop relevant SFM strategies to increase carbon uptakes and emission reduction. This chapter discusses several SFM strategies for managing natural production forests, plantation forests, and community forests for reducing carbon emissions.

6.1 Strategies for Managing Natural Production Forests

To increase carbon sequestration and carbon stocks in natural production forests, forest managers may conduct the following activities:

1) Controlling harvest level

The REDD+ mechanism is based on the IPCC (2006) standard that considers only five carbon pools: above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter. It means that in the REDD+ mechanism timber harvesting is considered as a source of emission that potentially reduces forest carbon stocks.

The results of this study at Sari BumiKusuma concession (see section 5.1) confirmed that that increasing harvest volume resulted in reduction of carbon uptakes and associated reduction emission benefits (Figure 12b and 13). To increase carbon uptakes and carbon stocks in natural production forests, forest managers must be able to control harvest volume levels. For example, reducing AAC up to 25% (scenario 4) can increase the benefit of emission reduction up to 21% (compared to the scenario 3).

2) Reducing logging damages

Harvesting activities generate damages to residual stands due to the fall of harvested trees. The loss of forest biomass and carbon stocks is therefore not only due to the harvested trees but also due to the logging damages of other trees (including understory vegetation) around the harvesting sites.

To reduce logging damages, forest managers may apply reduced impact logging (RIL) techniques that are more environmentally friendly than conventional harvesting techniques. Sist*et al*. (2003) reported that RIL techniques can reduce logging damages up to 40% compared to conventional techniques. The present study assumed that forest managers implement a RIL technique that capable to reduce logging damages up to 0.25 m^3 for each 1 m^3 of harvest volume (see section 5.1.2). Although this study did not compare the benefits of emission reduction of RIL with those of conventional harvesting techniques, Putz*et al*. (2008) reported that RIL techniques can reduce carbon emission up to 30% compared with conventional harvesting techniques.

3) Minimizing land clearing for infrastructures

Construction of infrastructures for forest management, such as basecamps, road networks, log-ponds, and other forest opening activities, is potentially reduce forest carbon stocks. A study conducted by Brown *et al*. (2010) at four forest concessions in East Kalimantan confirmed that average carbon emissions resulted from the construction of skid trials, log-ponds, and road networks were 111±14 tC/km, 56±23 tC/log-pond, and 1,150 tC/km, respectively. To reduce carbon emissions from such forest opening activities, forest managers must be able to minimize land clearing for infrastructure constructions.

4) Avoiding forest degradation from encroachment and forest fire

Forest encroachment and fire are common problems in managing natural production forests in Indonesia, which resulted in the loss of forest carbon stocks. The encroachment conducted by communities living surrounding forest areas tends to convert forests into shifting cultivation fields or gardens that remove forest carbon stocks. Forest fire (especially in peat lands) is an emission source because it burns carbon stored in trees biomass and release them into the atmosphere in terms of carbon dioxide (CO_2). Information on estimated emissions from forest encroachment and fire at a management unit scale in Indonesia are still lacking. But at national level, Verchot*et al*. (2010) reported that avoiding peat lands fire could reduce emissions up to 23–45%.

5) Rehabilitation/restoration of unproductive areas

Rehabilitation/restoration of unproductive areas in a forest management unit is an option for forest managers to increase carbon sequestration and hence carbon stocks in forests. Trees planting will increase forest biomass. During initial growth phases, young stands sequester more carbon than older stands. Forest managers may choose fast growing tree species to accelerate carbon sequestration, especially in degraded areas that are allocated for timber production.

6) Tending residual stands to improve forest regrowth

Forest carbon stocks will decrease due to harvesting, but will increase along the regrowth of residual stands. In TPTJ system, regrowth occurs at planting-lines in addition to the regrowth of logged-over and unlogged areas. The growth of residual stands, therefore, needs to be optimized through appropriate silvicultural treatments and forest monitoring activities.

7) Allocating some production areas to protected areas

Common SFM standards require forest managers to allocate and manage some portions of concession areas as protected areas. For example, FSC standard requires forest areas dedicated as high conservation value forests (HCVF). In addition to the protection of flora and fauna, the HCVF areas are also potential for storing forest carbon. Increasing protected areas, such as from logged-over areas, can reduce emission from harvesting and increase carbon stocks along the stand growth of protected areas (VCS, 2008).

8) Selecting appropriate silvicultural system

Commonly used silvicultural system for managing natural production forest in Indonesia is TPTI system. But, some FMUs also apply TPTJ system or commonly called intensive silvicultural system (SILIN). The results of this study (see section

5.1) confirmed that carbon uptakes and reduction emission benefits are highly dependent on the applied silvicultural systems. The TPTI system (scenario 1) is the most appropriate if forest managers want to increase carbon uptakes and hence obtain greater emission reduction benefits. In contrast, TPTJ system (scenario 2) is less appropriate for FMUs that are oriented for reducing emissions. Alternatively, forest managers may apply a multisystem silviculture, i.e. combining TPTI and TPTJ system (scenario 3 and 4) as currently practiced in Sari BumiKusuma (SBK) concession, if they want to make a balance between timber production and emission reduction objectives through forest management activities.

6.2 Strategies for Managing Plantation Forests

This study analyzed teak plantations (in KPH Kebonharjo, PerumPerhutani) that always face forest degradation. To increase carbon uptakes and associated reduction emission benefits from plantation forests in Java (especially teak plantations), forest managers may conduct the following activities:

1) Eliminating forest degradation

This study (see section 5.2) showed that carbon uptakes and benefits of emission reduction from teak plantations will increase if FMU able to eliminate or even avoid forest degradation. Commonly, degradation of plantation forests in Java is caused by disturbances, such as illegal logging, forest encroachment, fuel-wood collection, and forest fire (Tiryana *et al.*, 2011). Such disturbance factors can reduce stands productivity, which is indicated by the decrease of basal-area density and volume of standing forests. High forest degradation does not only reduce stand volume but also reduce carbon uptakes and carbon stocks (see section 5.2.3). Therefore, regular forest monitoring is essential to minimize or even avoid forest degradation. In addition, forest managers (PerumPerhutani) should evaluate their regulation on salvage cutting for unproductive stands, in which currently based on the basal-area density of ≤ 0.59, in order to reduce carbon emission from forest harvesting.

2) Controlling harvest level

Similar to natural production forests, harvesting of plantation forests (using a clear-cutting system) is a source of carbon emission because some portions of forest biomass are removed by trees harvesting. In managing degraded plantation forests, controlling harvest levels is essential to ensure the sustainability of timber yield and carbon sequestration service. This study revealed that harvest volume decreased when the rate of forest degradation increased (Figure 16a, subsection 5.2.3). This finding suggests that FMU should not conduct harvesting with a constant volume level (as commonly practiced by PerumPerhutani), but it should be adjusted with forest degradation rates that might occur in the future.

In addition to controlling harvest level, another option for increasing carbon uptakes and carbon stocks in plantation forests is extending rotation age (VCS, 2008). Tiryana (2010) proved that extending rotation age from 50 years to 60 or 70 years can increase carbon stocks up to 8.3–22.3% at no forest destruction, 8.7–18.9% at low forest destruction, 6.8–15.3% at medium forest destruction, and 1.6–3.8% at high forest destruction. Such finding confirms that extending rotation age will increase carbon stocks benefits if FMU capable to reduce or even avoid forest degradation.

3) Accelerating rehabilitation of unproductive areas

Forest disturbances that always occur in plantation forests in Java contributed to the increase of unproductive areas. The risk of destruction in young stands (≤30 years) is higher than older stands (Tiryana *et al.*, 2011). Such condition treats the sustainability of forest resources, because the harvesting of older stands does not followed up by the growth of young stands. Thus, a forest management unit must rehabilitate unproductive stands to increase timber yield and carbon uptakes. Stand monitoring activities are also required to ensure the survival of young stands to reach a rotation age.

6.3 Strategies for Managing Community Forests

The results of this study (see section 5.3) confirmed that sustainable community forest management can provide both emission reduction benefits and timber yield. The following are several strategies for reducing emission though community forest management:

1) Controlling harvest level

Carbon uptakes and carbon stocks of community forests are also affected by timber harvesting. An FMU may control harvest level by increasing diameter limit of harvestable trees and by limiting AAC. For the case of KHJL areas (see section 5.3), increasing diameter limit from 20 cm (scenario 1) to 30 cm coupled with regeneration (scenario 3) can increase carbon uptakes and emission reduction benefits. This fact also true when AAC is limited to 5,000 m^3/yr (see FSC standard for SLIMF scheme). Thus, controlling harvest level enables an FMU to gain greater emission reduction benefits.

2) Optimizing growing space to maximize forest biomass

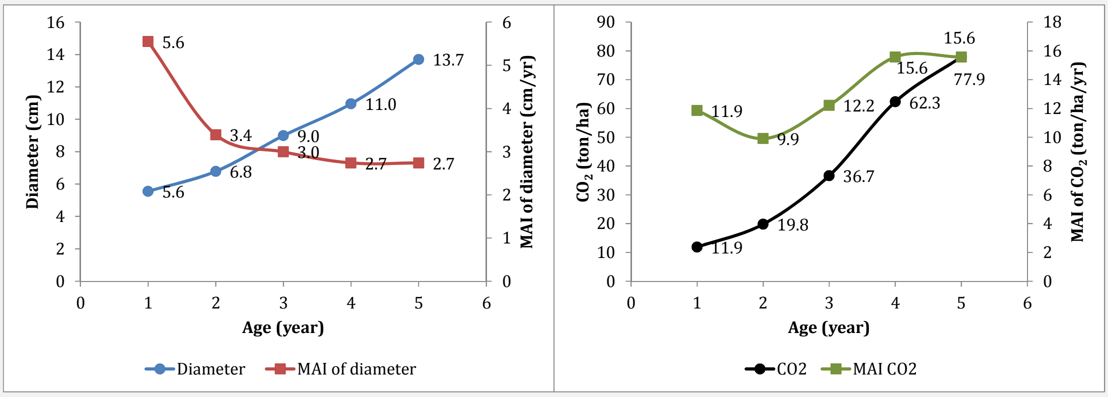
To obtain optimum timber yield and carbon stocks, forest managers need to conduct appropriate management activities for optimizing growing spaces that maximize forest biomass. For example, planting logged-over areas with a multispecies system would increase carbon uptake because each tree species has different rate of carbon uptake. In addition, a multi-rotation system (e.g. a combination of short and long rotations) can be applied to increase carbon uptake, because such system enables to balance the loss of carbon stocks due to the harvesting of long rotation trees species with the gain of carbon stocks from the planting of short rotation trees species.

3) Improving stand regrowth through silvicultural treatments

In the existing community forest management practices, commonly communities do not conduct any silvicultural treatments. In fact, appropriate silvicultural treatments are needed to optimize stand growth. To obtain superior trees with high biomass contents, an FMU needs to develop and plant superior trees species that suitable to local sites (see Box 3). In addition, pruning and thinning of stands are also required to optimally accelerate the growth of trees, which eventually increase carbon uptake and carbon stocks.

Box 3.Growth characteristic of a superior teak species

One of the superior trees species for community forest is a superior teak called *JatiUnggul Nusantara* (JUN teak). Currently, JUN teaks are planted in community forests, which are managed by a co-operative named Unit Usaha BagiHasilKoperasiPerumahanWanabakti Nusantara (UBH-KPWN), in several districts of Java: Madiun, Magetan, Ponorogo, Ngawi, KulonProgo, Purwakarta, and Bogor. Based on forest inventory data collected by UBH-KPWN at those districts, the JUN teaks of 1–5 years old have a mean diameter of 5.6–13.7 cm with a mean annual increment (MAI) of 2.7 cm/yr (*note: the growth data of 5 years old of the JUN teaks are estimates, because the JUN teak stands of 5 years old were not exist yet*. Such mean diameter of JUN teak stands is higher than mean diameter of teak stands at PerumPerhutani (a state-owned forestry enterprise) areas at site class 1–5 that reached 3.7–9.5 cm at 5 years old (see Wolf von Wulfing's yield table). The mean annual increment of diameter of JUN teak stands is also higher than that of teak stands at community forests managed by KoperasiHutan Jaya Lestari (KHJL), which reached only 1.5 cm/yr. In terms of carbon sequestration, the JUN teak stands of 1–5 years old could sink carbon (CO_2) up to 11.9–77.9 ton/ha with a mean annual increment of carbon of 15.6 ton/ha/yr.



The rapid growth of JUN teak stands could be attributed to the following superiority of JUN teak seedlings(UBH-KPWN, 2011):

- The JUN teak seedlings were derived from superior parent trees growing at suitable sites in Indonesia.
- The JUN teak seedlings were developed with a vegetative technique that maintains the superior properties of parent trees.
- The JUN teak seedlings have a compound-taproot system, which is not exist in other teak seedlings derived from seeds or tissue-cultures.

In addition to the seedling superiorities, the rapid growth of JUN teak stands is also triggered by intensive silviculture treatments, i.e. periodical fertilizations (at least twice a year until trees reach four years old) and intensive tendings (e.g. pest and disease prevention, watering, and fire prevention).

4) Expanding land area through afforestation

Most of the existing community forests (e.g. KHJL's community forests) was developed through forest rehabilitation or afforestation of critical lands. The transformation of critical lands to productive community forests is a real effort towards increasing carbon stocks and reducing carbon emissions. For regions having critical lands, community forest managers need to expand their FMU through the afforestation of critical lands (especially those owned by individuals). Such afforestation activities would not only increase timber yield, but also increase carbon uptake and its associated emission reduction benefits, as described by scenario 3 of section 5.3 (see also Box 4).

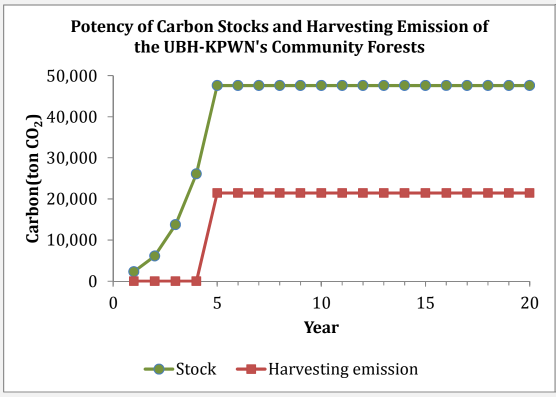
Box 4. Potency of carbon sequestration of community forests managed by UBH-KPWN

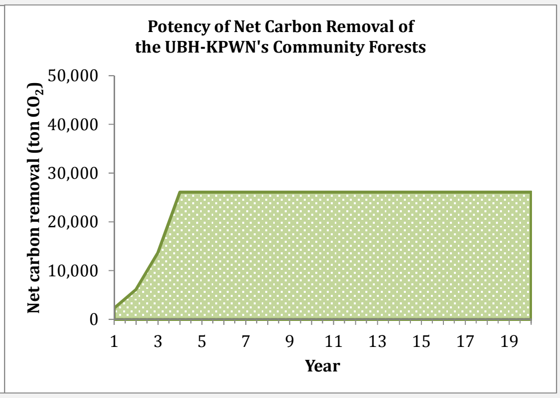
Since 2007, the UBH-KPWN has been developing community forests in Java through a partnership program involving five parties: investors, land owners, farmers, village governments, and UBH-KPWN as a facilitator. The main objective of such community forest program is to supply teak timber for wood processing industries and to sustainably increase economic, environmental, and social benefits for communities. Prioritized lands for developing the UBH-KPWN's community forests are private lands with clear evidences of land ownership and free of disputes, non-rice field lands, and other suitable lands for teak trees.

Commonly, teak trees are planted in woodlots, which were bare lands or un-productive lands, with a spacing of 5×2 m^2 or 1,000 trees/ha. The UBH-KPWN expects that teak trees (originated from the JUN teak seedlings) could be harvested at 5 years old with stem diameter at least 20 cm (an acceptable stem size for wood processing industries). Such target, however, seems unrealistic because the existing teak stands of UBH-KPWN's community forests only reached a mean diameter of 13.5 cm at 5 years old (see Box 3). For the last five years (2007–2011), UBH-KPWN has planted about 815,000 teak trees or roughly equal to 815 ha, which are distributed in six districts in Java: Madiun, Magetan, Ponorogo, Ngawi, KulonProgo, Purwakarta, and Bogor. The UBH-KPWN will continue to develop community forests in other regions with a target of 200,000 trees per year (equal to 200 ha/yr).

Based on the growth data of JUN teak stands (see Box 3) and community forest management schemes developed by UBH-KPWN, this study predicted that for each planting of 200,000 trees/ha, which are then followed by harvesting of 200,000 trees/yr of 5-years old stands (using a clear cutting system), would generate carbon stocks of 2,321–47,564 tCO_2/yr during 20 years period. The potency of carbon stocks is higher than potential emissions due to harvesting that reached 21,451 tCO_2/yr. These figures suggest that the teak stands managed by UBH-KPWN could generate net carbon removals of 2,321–26,114 tCO_2/yr or in average of 11,61–130,57 tCO_2/ha/yr for the 20 year simulation period.

Box 4 (continued)





VII. Conclusionsand Recommendation

7.1 Conclusions

This study aimed to analyze sustainable forest management (SFM) practice as an option for reducing emission using REDD+ mechanism. This report describes the progress of SFM and demonstration activity projects of REDD+ in Indonesia, and presents relevant scenarios for reducing emission through SFM at natural production forests, plantation forests, and community forests.

Review on the progress of forest management practices confirms that SFM is relatively difficult to apply in managing natural production forests and plantation forests in Indonesia, which is indicated by a few numbers of certified FMUs. In contrast, community forest management shows a promising progress in which the number of certified community forest management units tends to increase from time to time. In the current forest management practices, the main objective of managing natural production forests, plantation forests, and community forests are still focused on sustainability of timber production. Meanwhile, reducing emissions though forest carbon sequestration does not included yet in the existing forest management practices. This fact is probably because of the unclear implementation of REDD+ mechanism for SFM scheme.

The implementation of REDD+ mechanism in Indonesia is still limited to demonstration activity projects, which were conducted at national, provincial, district, or project level. Until now, there is no REDD+'s demonstration activity project, which is conducted at forest management unit level, to assist forest managers in preparing and implementing the REDD+ mechanism through SFM practices.

Based on case studies at several FMUs at natural production forests, plantation forests, and community forests, this study concludes that SFM can be used as an option for reducing emissions in REDD+ mechanism. The benefits of emission reduction would dependent on applied forest management scenarios. For natural production forests, the benefit of emission reduction will increase when FMUs capable to avoid deforestation, apply appropriate silvicultural systems, and reduce harvest volume. For community forests, greater emission reduction benefits can be gained if FMUs control harvest level (either through increasing diameter limit of harvesting or AAC limitation) and expanding their FMUs (e.g. through recruiting new members). For plantation forests in Java, forest managers will obtain higher emission reduction benefits if they can eliminate or even avoid forest degradation. In general, the following strategies are relevant for reducing emissions at FMU level: 1) controlling harvest level, 2) reducing logging damages, 3) minimizing land clearing for infrastructures, 4) eliminating or avoiding forest degradation, 5) conducting rehabilitation or restoration of unproductive areas, 6) tending residual stands to improve regrowth, 7) allocating some portions of production areas to protected areas, 8) selecting appropriate silvicultural systems that increase carbon stocks, and 9) optimizing growing space for maximizing forest biomass.

7.2 Recommendation

This study shows that trade-offs in forest management objectives are unavoidable, in which the objective of reducing emissions are not in line with the objective of increasing timber yield. It is necessary, therefore, to formulate an appropriate incentive system to compensate the decline in economic benefits from timber production when greater emission reduction benefits are expected from SFM practices. In addition, some REDD+'s demonstration activity projects at FMU level are required to assist forest managers in preparing and implementing REDD+ mechanism through SFM scheme.

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Appendix

Appendix 1. Recapitulation of harvest volume, carbon stock, and carbon uptake (CO_2e) generated by some scenarios for managing natural production forests in Sari BumiKusuma (SBK) concession

a). Recapitulation of baseline scenario, scenario 1, and scenario 2

No.	Year	Baseline: Deforestation & TPTI			Scenario 1: TPTI at the entire area			Scenario 2: TPTJ at the entire area		
		Timber volume (m^3)	Carbon stock (Mton)	CO_2e (Mton)	Timber volume (m^3)	Carbon stock (Mton)	CO_2e (Mton)	Timber volume (m^3)	Carbon stock (Mton)	CO_2e (Mton)
1	2011	200,480.59	10.55	38.73	200,480.59	10.55	38.73	340,442.00	10.55	38.73
2	2012	196,063.09	10.31	37.85	200,480.59	10.62	38.98	340,442.00	10.55	38.70
3	2013	191,742.93	10.08	36.98	200,480.59	10.69	39.23	340,442.00	10.54	38.67
4	2014	187,517.96	9.85	36.14	200,480.59	10.76	39.49	340,442.00	10.53	38.65
5	2015	183,386.09	9.62	35.31	200,480.59	10.83	39.75	340,442.00	10.52	38.62
6	2016	179,345.26	9.40	34.50	200,480.59	10.90	40.01	340,442.00	10.51	38.58
7	2017	175,393.47	9.19	33.71	200,480.59	10.98	40.28	340,442.00	10.50	38.55
8	2018	171,528.75	8.98	32.94	200,480.59	11.05	40.56	340,442.00	10.50	38.52
9	2019	167,749.19	8.77	32.18	200,480.59	11.13	40.84	340,442.00	10.49	38.49
10	2020	164,052.92	8.57	31.44	200,480.59	11.20	41.12	340,442.00	10.48	38.46
11	2021	160,438.09	8.37	30.72	200,480.59	11.28	41.41	340,442.00	10.47	38.42
12	2022	156,902.91	8.18	30.01	200,480.59	11.36	41.71	340,442.00	10.46	38.39
13	2023	153,445.62	7.99	29.32	200,480.59	11.45	42.01	340,442.00	10.45	38.35
14	2024	150,064.52	7.80	28.64	200,480.59	11.53	42.31	340,442.00	10.44	38.32
15	2025	146,757.91	7.62	27.98	200,480.59	11.61	42.62	340,442.00	10.43	38.28
16	2026	143,524.17	7.45	27.34	200,480.59	11.70	42.94	340,442.00	10.42	38.25
17	2027	140,361.68	7.28	26.70	200,480.59	11.79	43.26	340,442.00	10.41	38.21
18	2028	137,268.88	7.11	26.08	200,480.59	11.88	43.59	340,442.00	10.40	38.17
19	2029	134,244.22	6.94	25.48	200,480.59	11.97	43.93	340,442.00	10.39	38.13
20	2030	131,286.21	6.78	24.89	200,480.59	12.06	44.27	340,442.00	10.38	38.09
21	2031	128,393.38	6.62	24.31	200,480.59	12.16	44.61	340,442.00	10.37	38.05
22	2032	125,564.29	6.47	23.74	200,480.59	12.25	44.97	340,442.00	10.36	38.01
23	2033	122,797.54	6.32	23.19	200,480.59	12.35	45.32	340,442.00	10.35	37.97
24	2034	120,091.75	6.17	22.65	200,480.59	12.45	45.69	340,442.00	10.33	37.93
25	2035	117,445.58	6.03	22.12	200,480.59	12.55	46.06	340,442.00	10.32	37.88
26	2036	114,857.72	5.89	21.60	200,480.59	12.65	46.44	379,274.31	10.31	37.84
27	2037	112,326.88	5.75	21.09	200,480.59	12.76	46.83	379,274.31	10.28	37.73
28	2038	109,851.81	5.61	20.60	200,480.59	12.87	47.22	379,274.31	10.25	37.62
29	2039	107,431.28	5.48	20.11	200,480.59	12.98	47.62	379,274.31	10.22	37.51
30	2040	105,064.08	5.35	19.64	200,480.59	13.09	48.03	379,274.31	10.19	37.39

Appendix 1 (continued)

b). Recapitulation of scenario 3 and 4

No.	Year	Scenario 3: TPTI+TPTJ			Scenario 4: TPTI+TPTJ+AAC reduction		
		Timber volume (m^3)	Carbon stock (Mton)	CO_2e (Mton)	Timber volume (m^3)	Carbon stock (Mton)	CO_2e (Mton)
1	2011	271,286.46	10.55	38.73	203,464.84	10.55	38.73
2	2012	271,286.46	10.58	38.84	203,464.84	10.62	38.99
3	2013	271,286.46	10.61	38.95	203,464.84	10.69	39.25
4	2014	271,286.46	10.64	39.06	203,464.84	10.77	39.51
5	2015	271,286.46	10.67	39.17	203,464.84	10.84	39.78
6	2016	271,286.46	10.71	39.29	203,464.84	10.91	40.05
7	2017	271,286.46	10.74	39.41	203,464.84	10.99	40.33
8	2018	271,286.46	10.77	39.53	203,464.84	11.07	40.62
9	2019	271,286.46	10.80	39.65	203,464.84	11.15	40.91
10	2020	271,286.46	10.84	39.77	203,464.84	11.23	41.20
11	2021	271,286.46	10.87	39.90	203,464.84	11.31	41.50
12	2022	271,286.46	10.91	40.03	203,464.84	11.39	41.80
13	2023	271,286.46	10.94	40.16	203,464.84	11.48	42.11
14	2024	271,286.46	10.98	40.29	203,464.84	11.56	42.43
15	2025	271,286.46	11.02	40.43	203,464.84	11.65	42.75
16	2026	271,286.46	11.05	40.57	203,464.84	11.74	43.08
17	2027	271,286.46	11.09	40.71	203,464.84	11.83	43.41
18	2028	271,286.46	11.13	40.85	203,464.84	11.92	43.75
19	2029	271,286.46	11.17	40.99	203,464.84	12.02	44.10
20	2030	271,286.46	11.21	41.14	203,464.84	12.11	44.45
21	2031	271,286.46	11.25	41.29	203,464.84	12.21	44.80
22	2032	271,286.46	11.29	41.45	203,464.84	12.31	45.17
23	2033	271,286.46	11.34	41.60	203,464.84	12.41	45.54
24	2034	271,286.46	11.38	41.76	203,464.84	12.51	45.92
25	2035	271,286.46	11.42	41.92	203,464.84	12.62	46.30
26	2036	290,931.56	11.47	42.09	218,198.67	12.72	46.69
27	2037	290,931.56	11.51	42.23	218,198.67	12.82	47.07
28	2038	290,931.56	11.54	42.36	218,198.67	12.93	47.45
29	2039	290,931.56	11.58	42.50	218,198.67	13.03	47.84
30	2040	290,931.56	11.62	42.65	218,198.67	13.14	48.23

Appendix 2. Recapitulation of harvest volume, carbon stock, and carbon uptake (CO_2e) generated by some scenarios for managing teak plantations in KPH Kebonharjo (PerumPerhutani Unit I, Central Java)

a). Recapitulation of baseline scenario and scenario 1

No.	Year	Baseline: High degradation			Scenario 1: Medium degradation		
		Timber volume (1000 m^3)	Carbon stock (1000 ton)	CO_2e (1000 ton)	Timber volume (1000 m^3)	Carbon stock (1000 ton)	CO_2e (1000 ton)
1	2007	224.91	203.68	747.506	217.13	205.87	755.543
2	2012	232.10	191.96	704.493	245.60	223.98	822.007
3	2017	229.70	181.67	666.729	247.44	244.15	896.031
4	2022	227.89	173.09	635.240	244.88	260.83	957.246
5	2027	226.38	166.55	611.239	241.53	275.16	1009.837
6	2032	225.15	161.45	592.522	240.60	286.93	1053.033
7	2037	224.11	157.58	578.319	241.98	296.15	1086.871
8	2042	223.24	154.57	567.272	243.60	303.15	1112.561
9	2047	222.43	152.34	559.088	245.36	308.22	1131.167
10	2052	221.72	150.76	553.289	247.65	311.71	1143.976
11	2057	221.10	149.66	549.252	250.34	313.75	1151.463
12	2062	220.50	149.01	546.867	253.35	314.45	1154.032
13	2067	219.93	148.72	545.802	257.00	313.77	1151.536
14	2072	219.48	148.59	545.325	261.75	311.51	1143.242
15	2077	219.07	148.67	545.619	267.05	307.56	1128.745
16	2082	218.93	148.72	545.802	272.73	301.77	1107.496
17	2087	219.00	148.75	545.913	278.74	294.71	1081.586
18	2092	219.03	148.78	546.023	285.49	285.98	1049.547
19	2097	219.05	148.81	546.133	280.18	280.55	1029.619
20	2102	219.06	148.81	546.133	273.90	278.36	1021.581
21	2107	219.07	148.82	546.169	268.33	278.71	1022.866
22	2112	219.08	148.81	546.133	263.20	281.01	1031.307
23	2117	219.08	148.81	546.133	263.75	282.80	1037.876
24	2122	219.08	148.80	546.096	263.97	284.13	1042.757
25	2127	219.08	148.80	546.096	264.46	285.13	1046.427
26	2132	219.08	148.80	546.096	264.89	285.70	1048.519
27	2137	219.08	148.79	546.059	264.98	286.12	1050.060
28	2142	219.08	148.79	546.059	265.51	286.31	1050.758

Appendix 2 (continued)

b). Recapitulation of scenario 2 and 3

No.	Year	Scenario 2: Low degradation			Scenario 3: No degradation		
		Timber volume (1000 m^3)	Carbon stock (1000 ton)	CO_2e (1000 ton)	Timber volume (1000 m^3)	Carbon stock (1000 ton)	CO_2e (1000 ton)
1	2007	197.53	213.11	782.114	198.21	212.60	780.242
2	2012	237.04	246.19	903.517	241.84	252.70	927.409
3	2017	243.02	282.51	1036.812	245.99	299.12	1097.770
4	2022	242.63	314.56	1154.435	242.26	342.26	1256.094
5	2027	241.03	342.53	1257.085	237.14	381.77	1401.096
6	2032	240.34	366.37	1344.578	233.39	417.07	1530.647
7	2037	240.56	386.58	1418.749	231.00	448.48	1645.922
8	2042	241.92	403.17	1479.634	230.20	475.94	1746.700
9	2047	244.08	416.17	1527.344	230.62	499.31	1832.468
10	2052	247.64	425.54	1561.732	233.56	518.11	1901.464
11	2057	252.82	431.78	1584.633	238.67	533.04	1956.257
12	2062	258.93	434.71	1595.386	245.55	543.25	1993.728
13	2067	266.86	434.28	1593.808	254.81	549.34	2016.078
14	2072	276.18	430.74	1580.816	266.62	551.02	2022.243
15	2077	286.81	423.32	1553.584	279.80	546.89	2007.086
16	2082	299.26	406.94	1493.470	297.34	520.48	1910.162
17	2087	312.74	388.24	1424.841	316.61	491.26	1802.924
18	2092	327.65	367.26	1347.844	337.82	459.00	1684.530
19	2097	337.25	346.31	1270.958	361.21	423.28	1553.438
20	2102	323.47	334.82	1228.789	345.37	399.85	1467.450
21	2107	311.91	329.30	1208.531	331.53	386.82	1419.629
22	2112	300.65	329.34	1208.678	317.82	382.93	1405.353
23	2117	289.98	333.73	1224.789	304.00	386.69	1419.152
24	2122	279.90	341.62	1253.745	289.98	396.87	1456.513
25	2127	270.43	352.32	1293.014	276.24	411.42	1509.911
26	2132	266.77	363.17	1332.834	284.85	421.27	1546.061
27	2137	273.29	370.12	1358.340	294.23	426.12	1563.860
28	2142	280.51	373.21	1369.681	305.58	425.56	1561.805

Appendix 3. Recapitulation of harvest volume, carbon stock, and carbon uptake (CO_2e) generated by some scenarios for managing community forests in KoperasiHutan Jaya Lestari (KHJL) areas

No.	Year	Baseline:			Scenario 1: Current FMU			Scenario 2: Developed FMU		
		Timber volume (m^3)	Carbon stock (ton)	CO_2e (ton)	Timber volume (m^3)	Carbon stock (ton)	CO_2e (ton)	Timber volume (m^3)	Carbon stock (ton)	CO_2e (ton)
1	2011	1,024.01	4,164.51	15,283.73	671.77	4,164.51	15,283.73	671.77	4,164.51	15,283.73
2	2012	933.94	3,696.86	13,567.46	572.09	4,237.20	15,550.54	663.10	4,718.68	17,317.56
3	2013	852.14	3,291.77	12,080.79	522.84	4,472.11	16,412.64	708.02	5,486.22	20,134.41
4	2014	772.89	2,922.44	10,725.34	512.59	4,816.39	17,676.15	799.03	6,421.92	23,568.45
5	2015	694.22	2,578.72	9,463.92	530.72	5,227.61	19,185.32	927.08	7,485.05	27,470.12
6	2016	616.89	2,258.63	8,289.17	568.54	5,673.06	20,820.13	1,084.29	8,640.93	31,712.21
7	2017	542.86	1,963.08	7,204.49	618.97	6,128.34	22,491.02	1,263.95	9,860.82	36,189.22
8	2018	472.80	1,693.32	6,214.49	677.29	6,674.81	24,496.54	1,459.38	11,220.24	41,178.28
9	2019	408.63	1,450.43	5,323.07	738.36	7,156.26	26,263.47	1,671.35	12,648.74	46,420.89
10	2020	349.91	1,234.26	4,529.75	803.76	7,583.70	27,832.16	1,898.69	14,164.35	51,983.15
11	2021	297.65	1,044.27	3,832.48	870.35	7,966.61	29,237.45	2,141.00	15,798.76	57,981.46
12	2022	252.25	878.93	3,225.68	933.39	8,317.41	30,524.89	2,399.85	17,594.96	64,573.50
13	2023	211.98	736.09	2,701.45	990.91	8,652.18	31,753.48	2,678.81	19,603.66	71,945.42
14	2024	177.43	613.96	2,253.23	1,042.52	8,988.25	32,986.86	2,985.34	21,879.36	80,297.26
15	2025	148.05	510.19	1,872.40	1,088.62	9,342.73	34,287.84	3,327.33	24,475.13	89,823.71
16	2026	122.88	422.50	1,550.56	1,132.36	9,729.94	35,708.90	3,714.24	27,444.01	100,719.51
17	2027	101.53	348.88	1,280.39	1,175.70	10,163.21	37,298.96	4,154.34	30,836.59	113,170.27
18	2028	84.02	287.40	1,054.77	1,221.01	10,651.88	39,092.40	4,657.87	34,701.10	127,353.03
19	2029	69.20	236.12	866.55	1,271.04	11,199.44	41,101.93	5,232.32	39,083.66	143,437.03
20	2030	56.88	193.56	710.37	1,326.99	11,804.45	43,322.33	5,232.32	39,493.81	144,942.28
21	2031	46.48	158.36	581.20	1,390.03	12,462.16	45,736.14	5,232.32	40,462.72	148,498.20
22	2032	38.19	129.42	474.97	1,461.35	13,165.29	48,316.62	5,232.32	41,914.73	153,827.06
23	2033	31.06	105.55	387.36	1,540.15	13,906.45	51,036.66	5,232.32	43,832.88	160,866.66
24	2034	25.08	86.02	315.68	1,626.04	14,679.09	53,872.25	5,232.32	46,236.92	169,689.48
25	2035	20.45	70.12	257.34	1,717.84	15,478.37	56,805.61	5,232.32	49,171.89	180,460.85
26	2036	16.79	57.10	209.55	1,815.16	16,302.39	59,829.76	5,232.32	52,698.75	193,404.41
27	2037	13.90	46.40	170.29	1,916.42	17,151.40	62,945.64	5,232.32	56,297.38	206,611.37
28	2038	11.00	37.58	137.92	2,020.83	18,028.50	66,164.58	5,232.32	59,943.21	219,991.59
29	2039	9.08	30.52	112.00	2,128.78	18,939.31	69,507.25	5,232.32	63,589.30	233,372.73
30	2040	7.34	24.72	90.74	2,239.89	19,890.19	72,996.99	5,232.32	67,200.91	246,627.35

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MINISTRY of FORESTRY

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to Reduce Emission from Deforestation and Degradation
through Sustainable Forest Management
(SFM) Initiatives in Indonesia

Manggala Wanabhakti Building IV
7th Floor Room A709
Jl. Gatot Soebroto, Senayan, Jakarta
Indonesia 10270
Tel : +62-21-5703246 ext. 5400
Fax: +62-21-37750400
E-mail : ittoredpd7@gmail.com
Website : http://www.red-pd79.org/