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South Sumatra Forest Fire Management Project (SSFFMP)

Draft Report

International Consultancy on

Carbon Stock Estimation in Peat Swamp Forest Area of Merang - Kepayang

by

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PREFACE

The South Sumatra Forest Fire Management Project (SSFFMP) is a technical co-operation project jointly funded, in terms of the financing memorandum IDN/RELEX/1999/0103, by the European Commission and by the Government of the Republic of Indonesia through the Ministry of Forestry (MoF).

This report has been completed in accordance with the project's Second annual Work Plan (AWP II) and

in fulfillment of Activity 3.1.1.3 "conduct a land cover, landuse and peat distribution mapping study in the priority areas, and train counterparts / target groups on-the-job"

and activity 4.1.2 "to provide technical assistance on management & organization to relevant agencies to support improvements to the fire detection and early warning system"

to achieve Result 3 "to create capacities and support initiatives to bring land and natural resources under sustainable management" and Result 4 "to support government and non-government organizations to establish systems to monitor the impact of improved fire management on the environment and people and the results of the work place in the public domain"

to realize the five-year project purpose, which is to "Aid and facilitate the establishment of a coordinated system of fire management at province, district, sub district and village level throughout South Sumatra province in which all involved stakeholders, including the private sector, work together to reduce the negative impact of fire on the natural and social environment."

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The report is acknowledged and approved for circulation by the Project Co-Directors when duly signed below.

Palembang, 05.09.2008

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Thank you all very much.

Terima kasih.

ABBREVIATION

BMU	Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BPKH	Balai Pemantapan Kawasan Hutan - Forest Mapping Agency
C	Carbon
CDM	Clean Development Mechanism
CO ₂	Carbon Dioxide
COP	Conference of Parties
DBH	Diameter Breast Height
Dinas Kehutanan	Ministry of Forestry
FDR	Fire Danger Rating
FIS	Fire Information System
FTA	Fire Threat Analysis
GHG	Green House Gas
GIS	Geographical Information System
GPS	Global Positioning System
Gt	giga tonne
ha	hectare
HPH	Hak Pengusahaan Hutan - logging concession
HPT	Hutan Produksi Terbatas - limited production forest
HTI	Hutan Tanaman Industri – palm oil concession
IPCC	Intergovernmental Panel on Climate Change
km	kilometre
LCCS	Land Cover Classification System
Lidar	Light Detection and Ranging - optical remote sensing to find range and/or other information of a distant target
m	meter
MAI	Mean Annual Increment of tree growth
MODIS	Moderate Resolution Imaging Spectroradiometer
Mt	mega tonne
REDD	Reducing emissions from deforestation and degradation in developing countries
RHM	Rimba Hutani Mas – Concessionaire belonging to Sinar Mas Group
RTRWN	Rencana Tata Ruang Wilayah National - National Spatial Planning

RTRWP	Agency Rencana Tata Ruang Wilayah Propinsi - Provincial Spatial Planning Agency
SRTM	Shuttle Radar Topography Mission
SSFFMP	South Sumatra Forest Fire Management Project
t	tonne
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Deforestation and forest degradation in Merang have been driven by destructive logging and forest clearance – both illegal and legal – for development of agricultural land and plantations.

CO₂ emissions caused by deforestation, forest degradation and peat decomposition were estimated for the years from 1997 to 2007. These estimates are based on medium resolution satellite data (Landsat) and field measurements. This approach may significantly over- or underestimate the actual emissions because, for many processes, sufficiently detailed data on carbon stocks and carbon emissions (stock decrease) were not available for the past (and present). However, considering all possible errors and uncertainties the results indicate the order of magnitude of the emissions scenario and provide valuable information for decision makers and stakeholders.

The carbon stock of the Merang Peat Dome Forest was calculated based on peat corings, conducted by the University of Palembang. The peat dome stores approximately 102 Mt C. The maximum peat depth is about 6 m and averages about 1.3 m.

The carbon stored above ground was calculated to be about 24 Mt C in 2007; however, the carbon release in the recent last ten years was 66 Mt CO₂ due to peat fires, with peaks in the years 1997 and 2006. Another big carbon emission factor in the last 20 years was peat oxidation caused by lowering of the water table (peat draining) and land use change. Oxidation was calculated to have emitted about 26 Mt CO₂, tending to increase as a result of ongoing conversion of peat forest to acacia and palm oil plantations.

The current ongoing land use change process, also known as the “business as usual scenario”, predicts an overall tripled yearly net emission of CO₂ (from 6 Mt to 18 Mt/year) due to the systematic conversion of the peat forest to plantation. Net emission could be reduced by 4 Mt CO₂ per year through a potential project implementation of the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) in cooperation with concessionaires.

Major Findings

- Significant decrease of closed peat swamp forest within the last 20 years (1989 – 2007)
- Peat fires of the year 1997 and 2006 emitted huge amounts of CO₂
- CO₂ emissions from peat decomposition increased due to drainage for plantations
- In 2007 the above ground biomass of the Merang Kepayang Area added up to about 24 Mt C
- Peat fires in the period 1997 to 2007 emitted about 66 Mt CO₂ (emissions from soil alone)
- Peat soil decomposition emitted about 26 Mt CO₂ from 1989 to 2007
- Deforestation of the Merang Peat Dome forest 64 Mt CO₂ from 1989 to 2007
- Within the last 20 years about 144 Mt CO₂ have been emitted due to peat fire, land cover degradation and peat oxidation
- Future potential CO₂ savings could be accomplished by avoided deforestation, fire prevention, and restoration of the peat dome hydrology
- Project implementation should include the neighbouring concessionaire Rimba Hutani Mas
- A saving of about 1,75 Mt/year CO₂ could be achieved (prediction until 2015) for the conservation area of Rimba Hutani Mas and the unallocated concession in the south of the peat dome
- Given a larger project area, including the conservation area of Rimba Hutani Mas, an annual saving of 4 Mt CO₂ could be achieved (prediction until 2015)

Recommendations

The current study, conducted for SSFFMP in 2008, highlights the driving factors of the emissions of the greenhouse gas relevant CO₂, the current carbon stock, and future estimation of CO₂ emissions of the Merang Kepayang Forest, based on different scenarios.

The SSFMP project itself focuses on an extension with the objective of establishing a REDD Pilot prior to 2012, as suggested during the World Climate Conference in Bali 2007. For such a REDD Pilot, it is necessary to estimate the CO₂ savings that might be achieved by sustainable land use in comparison with a "business as usual scenario". To do so, it is necessary to determine reliable figures on the current carbon stock and changes in area. The study uses the current carbon status to develop future carbon dioxide emissions based on the previous land conversion factors. The above- and below ground biomass carbon stock, however, requires a much more detailed assessment in order to satisfy the REDD requirements (IPCC conform). For that, the following suggestions are given:

The below ground biomass was calculated using data collected during several peat coring surveys. Due to severe restrictions in accessibility, the corings were not distributed equally on the Merang peat dome as it would be required for precise 3D modeling. No corings are available for the south, where the project area is allocated. As a consequence, the average peat depth is only 1.3 meters, which is a severe underestimate. It is therefore recommended, to conduct further peat corings in the planned project area as already described by Ballhorn in a previous report for SSFFMP (Ballhorn, 2007).

A new method to determine peat depth was developed recently by the Technical University of Munich, which uses electrical resistance measurements in the peat soil to determine peat depth. This method has been tested successfully by RSS in boreal peat domes. This method is much more accurate than peat coring (measurements every 8 meters instead of every 500-1000 meters) and quicker to perform. If Merang becomes a CDM or REDD pilot, it is strongly recommended to assess peat carbon stock using this method.

Peat loss and correlated CO₂ emissions due to peat fires should be also monitored closely. It is desired to reduce uncontrolled fires to a minimum. The burn depth of fire in peat soils relates to a complex set of factors, such as humidity of the organic soil, organic content, location, and depth of the water table; peat fire burn depths are therefore very difficult to estimate due to the unavailability of data and the variability of the peat ecosystem. Nevertheless, it is necessary to monitor ongoing processes. For peat loss due to peat fires, it is recommended to pound sticks of mild steel into to the organic floor, evenly-spaced on a regular grid of known positions. After each fire event, the degree of peat loss can be measured by the height of the steel posts above the ground.

Peat decomposition due to oxidative processes is mainly related to the depth of the water

table in the organic soil layer. The anthropogenic regulation (decrease) of the water table, as in drainage for plantations, has an impact on the hydrology of the whole peat dome. This process can only be roughly estimated using published data from other peat ecosystems. *In situ* measurements will improve these estimates and it is therefore recommended that the project regularly monitor the level of the water table.

The above ground carbon stock also requires a detailed assessment in the field. To meet Tier 3 requirements, necessary for a REDD project, as requested by IPCC Guidelines (IPCC, 2007), a forest inventory has to be conducted and permanent forest plots have to be established.

The above ground biomass and the 3D surface topology of the peat dome can be determined in much more detail by using LIDAR measurements. This approach uses an airborne system that radiates laser pulses to the ground and records first and last reflections from its surface. The spatiotemporal pattern of each measured location on the ground, as well as reflections from the surface of the vegetation are recorded. These measurements are captured at a very high spatial resolution (depending on the laser system and altitude – with 1 to 16 measurements per m²).

The aerial survey should be conducted in transects, as the topography of the peat dome is very regular and can be interpolated by spatial modeling. This also reduces the costs of such a survey and analysis. The aboveground biomass can be calculated from the difference between the surface and terrain model using the forest inventory data as reference. Using LIDAR it will also be possible to measure peat loss after fire over larger areas using field measurements as a reference. This advanced approach was validated in peat domes in Kalimantan and is recommended in the event of large fires.

Table of content:

Introduction	13
1. Driving factors for changes in land use management practice under the baseline scenario that contribute to carbon stock changes in the project area	15
2. Carbon dioxide emission estimation of the Merang-Kepayang ecosystem based on remotely sensed data and field measurements	18
2.1. Data Sources	18
2.1.1. GIS Data	18
2.1.2. Peat extent, thickness and carbon stock	18
2.1.3. Landsat TM	20
2.1.4. Landuse BPKH	20
2.1.5. Hot Spot	20
2.2. Analysis	21
2.3. Above ground carbon stock	21
2.4. Calculation of carbon loss due to drainage and land cover conversion	24
2.5. Emissions from peat burning	26
2.6. Total emissions and carbon content of the Merang Peat Dome	27
3. Estimations of future CO ₂ emissions on the basis of a “business as usual scenario” and after the implementation of emissions reduction measures implemented by the project	31
3.1. Business as usual scenario	34
3.2. Implementation of a small project for reducing emissions	36
3.3. Implementation of a large project for reducing emissions	36
3.4. REDD	37
Deliverables	40
References	41
ANNEX I	43
ANNEX II	46
ANNEX III:	49
ANNEX IV	52

List of Figures:

Figure 1: Location of the Merang peat dome (combination of different map sources (Ballhorn, 2007)).....	13
Figure 2. MPDF degradation from 1989 to 2007 in percentage	15
Figure 3. Pristine Peat Swamp Forest with closed canopy closure, superimposed on Landsat TM of the year 1989	16
Figure 4. Disturbed Peat Swamp Forest with open canopy closure, superimposed on Landsat TM of the year 2007	16
Figure 5. Map from RTRWN (National Spatial Planning Agency) stating, that the Merang Peat Forest is allocated to Hutan Lindung (protected forest) (Peraturan Pemerintah no 26 tahun 2008)	17
Figure 6. Available peat depth corings (green dots) for Merang peatland.	19
Figure 7. 3D peat model - Merang bedrock model (Mott, 2006).....	19
Figure 8. Landsat TM; taken on 09/06/1989.....	20
Figure 9. Landsat TM; taken on 01/09/1999.....	20
Figure 10. Landsat TM; taken on 27/06/2007	20
Figure 11. Land cover distribution on peat soil in the Merang Kepayang project area....	22
Figure 12. Annual CO ₂ emission in relation to land cover	25
Figure 13. CO ₂ emissions due to peat fires and affected areas, from 1997 to 2007.....	27
Figure 14. Calculation of net emission in Mt of CO ₂ due to of land cover changes on organic soil; values below zero indication sequestration of organic material... ..	28
Figure 15. Calculation of net emission in Mt of CO ₂ due to land cover changes on organic soil and mineral soil	29
Figure 17. Concession borders within the area Merang.....	31
Figure 18. Palm oil concessions (status 28/08/08)	33
Figure 19. "Business as usual" scenario, land changes of remaining 78,000 ha (Rücker, 2008)	34
Figure 20. Small project scenario and potential REDD relevant annual CO ₂ saving of 1.74 Mt	38
Figure 21. Large project scenario and potential REDD relevant annual CO ₂ saving of 3.98 Mt	38
Figure 22: Different Scenarios and related emission factors on an annual basis	39

List of Tables:

Table 1. Land cover classes, area in ha and biomass in tonnes C on peat soil within the area Merang-Kepayang.....	23
Table 2. Emission factors from peat decomposition (organic matter).....	25
Table 3. Calculation of net emission in Mt of CO ₂ due to land cover changes on organic soil.....	28
Table 4. Calculation of net emission in Mt of CO ₂ due to land cover changes on organic soil and mineral soil.....	29
Table 5. Concessions within the area Merang and status of concession (status 28/08/08).....	32
Table 6. Status of palm oil concessions within the area Merang-Kepayang (status 28/08/08).....	33
Table 7. Distribution of land use classes, considering different scenarios (Rücker, 2008); arrows indicate the tendency in land change (up = increase; down = decrease).....	34
Table 8. Predicted changes until 2015 in ha (Rücker, 2008).....	35
Table 9. "Business as usual" Scenario and related CO ₂ emissions in Mt.....	35
Table 10. Small project scenario and related CO ₂ emissions in Mt.....	36
Table 11. Large project scenario and related CO ₂ emissions in Mt.....	37

Fact Sheet

C and CO₂ related values and their sources:

Value	Unit	Material	Class	Source
281	t/ha	CO ₂	Peat Swamp Forest rather closed canopy	See Annex II
234	t/ha	CO ₂	Peat Swamp Forest medium open canopy	See Annex II
62	t/ha	CO ₂	Peat Swamp Forest very open canopy	See Annex II
104	t/ha	CO ₂	Acacia Plantation	See Annex II
109	t/ha	CO ₂	Oil Palm Plantation	See Annex II

Biomass values were determined from published forest inventories, see Annex II.

Based on the field measurements in Central Kalimantan, a peat loss of 30 cm after fire was assumed.

One m³ of organic peat soil contains 58 kg C, an average 58% dry matter of 1.04 g/cc⁻¹ (Neuzil, 1997)

C to CO₂ conversion:

The molecular weight of C to CO₂ (C + O₂ = CO₂) equals 12 g/mol of C + 32 g/mol of O₂ = 44 g/mol CO₂. Dividing 44 g/mol CO₂ by 12 g/mol of C, results in a C to CO₂ conversion factor of 3.6667 or rounded up to **3.67**.

Introduction

Peat domes are under special focus lately due to their importance as carbon sinks and stores and their role in the carbon cycle between the earth's surface and the atmosphere (Immirzi et al., 1992; Hooijer et al., 2006). Forested peat lands in South East Asia store at least 42,000 Megatonnes (C content of 58 kg/m³) of soil carbon, covering an area of about 26 Million hectares (corresponding to 70% of all tropical peatlands) (Rieley et al., 1996). About 76% of this peat coverage is located in Indonesia.

Peats and their related vegetation above ground represent a sensitive ecosystem, which has undergone severe changes in the last 20 years due to anthropogenic influences; the changes have resulted in the emission of the green house relevant gas CO₂ and a severe loss of biodiversity. Two major reasons for this manmade ecosystem alteration, peat degradation, are:

1. aerobic decomposition of the peat material caused by a change in the ratio of water to organic matter, due to anthropogenic disturbance, such as land use change, and,
2. peat fires, occurring in degraded peat lands, emitting CO₂.

The province of South Sumatra / Indonesia has 24 peat domes with an overall estimated below ground biomass of 3.23 Gt C, covering an area of about 6130 km². The Merang peat dome is the largest in South Sumatra, covering an area of 1400km² with an estimated carbon content of 0.1 Gt (Ballhorn, 2007).

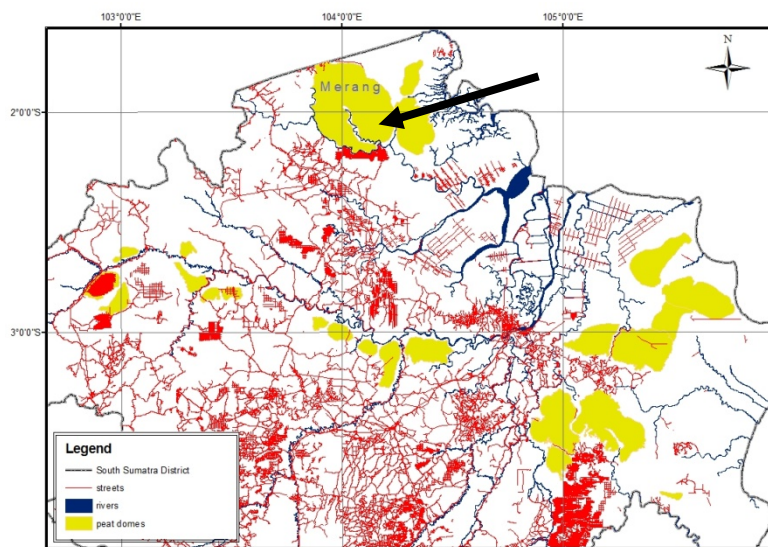


Figure 1: Location of the Merang peat dome (combination of different map sources (Ballhorn, 2007))

Importance of Carbon Emission Calculation

The UNFCCC Conference in Bali in 2007 established the political framework for the policy process “Reducing emissions from deforestation and degradation in developing countries” (REDD). Participating parties confirmed the urgent need to take further action to reduce emissions from deforestation and forest degradation and adopted a work program for further methodological work. That program focuses on assessments of changes in forest cover and associated greenhouse gas emissions, methods to demonstrate reductions of emissions from deforestation and the estimation of the amount of emission reductions from deforestation. REDD itself is considered to be an important component of a future climate change regime beyond 2012, in terms of mitigation and adaptation. In this way, REDD can be seen as a tool not just for mitigating climate change, but also for conserving biodiversity and a range of ecosystem services of global and local interest.

The recent passage by the Indonesian Ministry of Forestry of a law implementing procedures for reducing emissions from deforestation and degradation, demonstrates the seriousness of the Indonesian Government to implement the REDD mechanism for their forests. The regulation governs implementation procedures for REDD, location requirements, proponents, implementation procedures, accounting, monitoring, reporting, verification, and certification issues for REDD projects in Indonesia. REDD projects, however, will start from the year 2012; meanwhile, pilot projects will be established for testing mechanism procedures.

This study focuses on the analysis of the existing carbon stock for the Merang Kepayang area, the driving factors of carbon losses and development of a core estimation of how much carbon might be saved by extending the project activities in this area, by SSFFMP or an equivalent organization.

1. Driving factors for changes in land use management practice under the baseline scenario that contribute to carbon stock changes in the project area

The Merang Peat Dome Forest (MPDF) underwent intense changes in land cover over the last 20 years. The forest itself has been selectively logged since the late 70s as a limited production forest (HPH). The timber concessions extracted tradable timber with a diameter above 60 cm. These activities were stopped in the late 90s due to limited profitability.

The existing infrastructure established by the HPHs led to increased activity by illegal loggers, due to facilitated access. Rafts carrying both processed and unprocessed logs (non sinking and sinking in combination) have been observed in the Sungai Merang, the Sungai Beruhun, and Sungai Buring for several years now. Small rivers such as the River Buring have been dammed to facilitate transport, and hence, it is possible to float the timber even in the dry season.

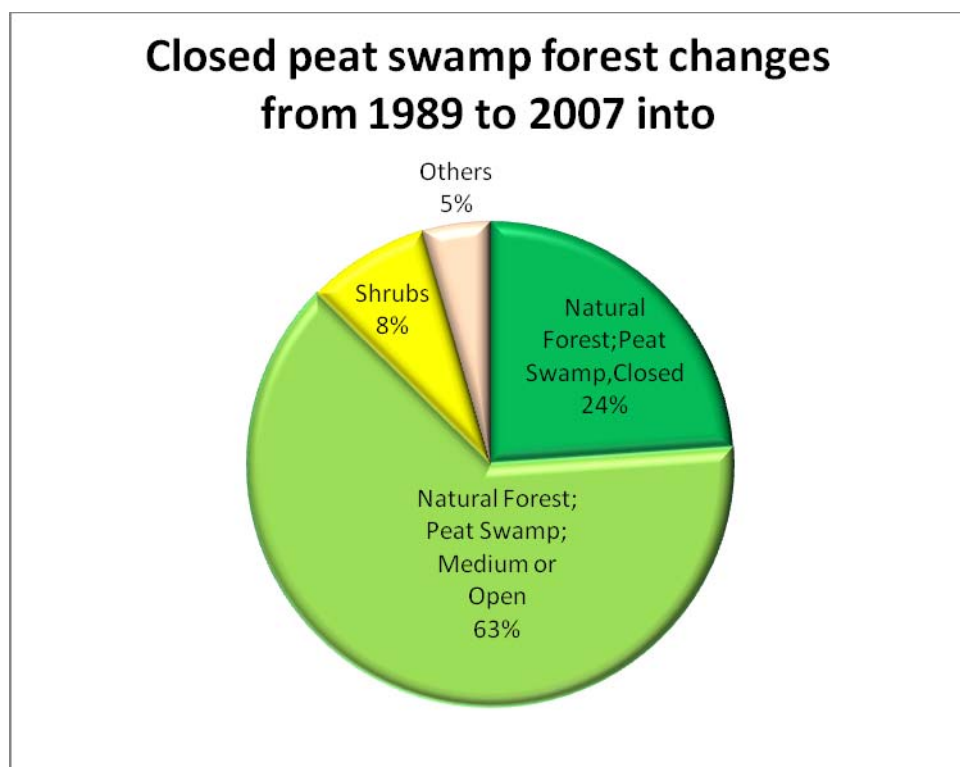


Figure 2. MPDF degradation from 1989 to 2007 in percentage

Almost 75% of the closed canopy peat swamp forest has been degraded. The conversion of Peat Swamp Forest with a closed canopy structure to Peat Swamp Forest, with a medium or even open canopy structure has resulted from illegal logging activity, timber extraction and thinning of canopy closure.

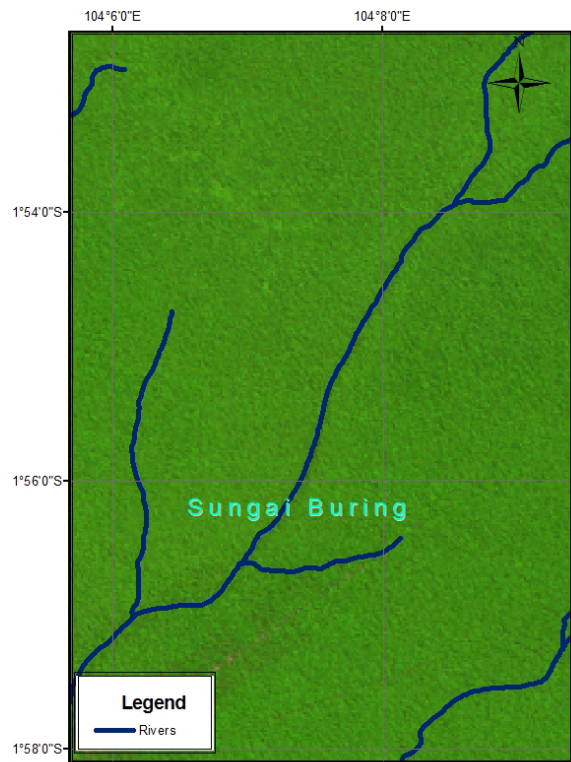


Figure 3. Pristine Peat Swamp Forest with closed canopy closure, superimposed on Landsat TM of the year 1989

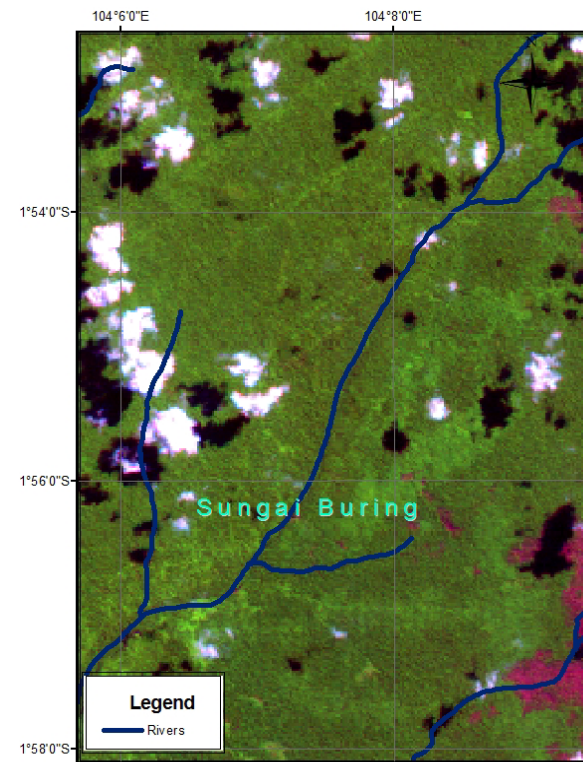


Figure 4. Disturbed Peat Swamp Forest with open canopy closure, superimposed on Landsat TM of the year 2007

Fire

Prior to human intervention, peat fires generally did not occur in pristine peat swamp forest ecosystems (Saharajo, 1999), likely as a result of the high humidity; however, during the past 20 years fires have been occurring with increasing frequency in all land cover types. Many of these fires, ignited to clear land, spread uncontrolled (Wetlands International, 2004).

A lower water table abets peat fires. Drainage, deforestation, and/or severe dry seasons caused by El Niño or La Niña years are responsible for a decrease in the water table. The organic layer dries out progressively and becomes fuel for fires. Those peat fires causing severe haze threaten human health, affecting both the national and international economy (ADB, 1999), emit huge amounts of CO₂ and other gases into the atmosphere.

With increasing degradation and human exploitation of the peat forest, fires are becoming more likely, due to easier access and the disturbed peat ecosystem.

Another important driver of land cover change is the existence of concessionaires, especially those with oil palm and forest concessions (HTI), located in the Merang Kepayang area. According to Keputusan Presiden (Presidential Decree), the release of concessions on peat can only be permitted, if the peat is deeper than 3 meters. Local

authorities (e.g. RTRWP) consider the Merang Peat dome as a peat with less than 3 meters depth on which concessions can be issued. To date, land clearing for palm oil concessions on the western part of the MPDF have already begun and forest concessions have been released on almost the whole MPDF; only small pieces have yet been unallocated (status as of August 2008).

Peat domes do not provide optimal growing conditions for palm oil and forest plantations; however, they are the favoured choice due to their unclaimed land use status. Mineral soils, correlated to higher production, often underlay areas of severe land use conflicts, forcing the concessionaires to provide costly community development programs to generate alternative incomes for local inhabitants.

Unclear, and partly incompatible, land use planning triggers land use conflicts. There seems to be little or no coordination between different departments such as Dinas Kehutanan (responsible for Forest Concessions), Dinas Pertanian (responsible for Palm Oil Concessions), and RTRWN (National Spatial Planning Agency) on both a district as well as a governmental level. The land use status itself is partly unclear and concessions released by local authorities are non-compliant with decrees published in Jakarta (see **Figure 5** page 17). The map of RTRWN shows the Merang Kepayang Area as “Hutan Lindung” (protected forest), whereas the authorities (RTRWP) on the district level consider it as “Hutan Produksi” (production forest) and allocated several concessions in the MPDF area. This contradictory land use planning may occur because the map of RTRWN has not yet been affirmed by a decision letter of the Ministry in Jakarta, which is necessary to implement the status stated in the map by RTRWN.



Figure 5. Map from RTRWN (National Spatial Planning Agency) stating, that the Merang Peat Forest is allocated to Hutan Lindung (protected forest) (Peraturan Pemerintah no 26 tahun 2008)

2. Carbon dioxide emission estimation of the Merang-Kepayang ecosystem based on remotely sensed data and field measurements

The estimation of carbon stocks and related assessment of carbon losses follows the 2006 IPCC Guidelines for National Greenhouse Gas Inventories in order to provide a comparable study in accordance to international standards. To estimate current carbon stocks, all quantifiable losses of carbon should be considered (dependent on the existence of data and field surveys conducted).

The following analysis steps have been undertaken:

1. Calculation of above ground biomass based on the years 1989, 1999 and 2007 based on satellite imagery
2. Determination of CO₂ emissions from different land uses on peat soil
3. Determination of CO₂ emissions due to peat fires

2.1. Data Sources

The study was carried out using available spatial and quantitative data collected during the consultancy and previous studies of the SSFFMP project.

2.1.1. GIS Data

For this analysis, GIS data sources representing different sources and points in time were provided, including:

- RTRWP 2006 – Provincial Spatial Plan;
- RTRWP SK 76 2001 – Provincial Spatial Plan from 2001 until 2006;
- RTRWK Muba: forest part of current district level;
- HTI 2007: Covering forest concessions (current status); and,
- HPH 1990: Covering oil palm concessions.

2.1.2. Peat extent, thickness and carbon stock

The peat extent and thickness was derived from studies conducted in 2007 (Ballhorn, 2007) and 2006 (Mott, 2006) by RSS. The maps of peat dome thickness and peat soil were compiled from different sources. The peat soil and peat dome map of South Sumatra province produced by Repprot formed the base map for the study. Repprot was a development project, funded by Great Britain, whose objective was to assist the transmigration effort of the Indonesian government.

The extent of the peat soil and the peat dome of Repprot were compared with a peat land map of South Sumatra province produced by Wetlands International. Wetlands International is the biggest non-profit organization dedicated solely to

wetland conservation and its sustainable management. Both sources were delineated using remote sensing data, such as SRTM, Landsat and Spot images of the South Sumatra province and the mapped peat extent combined with peat depth corings (conducted by the University of Palembang).

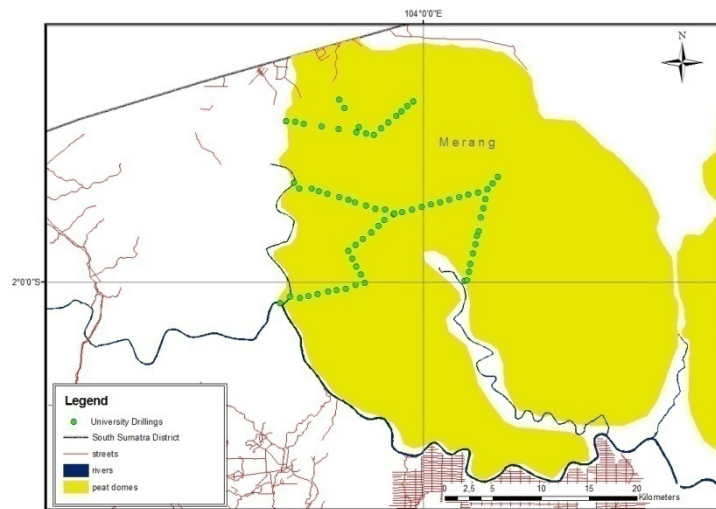


Figure 6. Available peat depth corings (green dots) for Merang peatland.

Below ground carbon stock was calculated using a three-dimensional bed rock model for the year 2007 and about 80 peat corings undertaken by the University of Palembang (Ballhorn, 2007). The result showed that the Merang peat dome has a volume of about 1.79 km³, corresponding to 102 Mt of carbon. The maximum peat depth is about 6 m, while the average depth is approx. 1.3 m. The current unequal distribution of drilling samples lead to an underestimation of the total carbon amount because depth measurements are missing for significant parts of the peat dome. The 3D model assumes for these areas to be shallow peat.

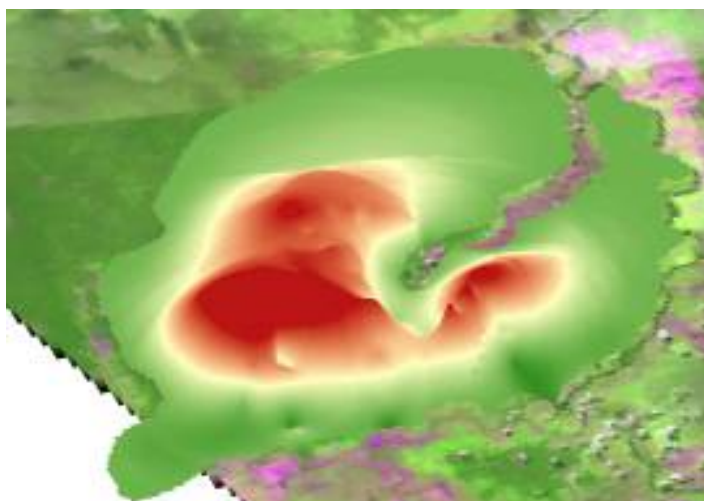


Figure 7. 3D peat model - Merang bedrock model (Mott, 2006)

2.1.3. Landsat TM

Three different subsets of Landsat TM images for the same corresponding area were analyzed for the year 1989, 1999 and 2007. The spatial resolution of Landsat TM is 30 by 30 m. The image for the year 1989 has a data gap of 12% and 1999 of 4% within the Merang peat footprint.

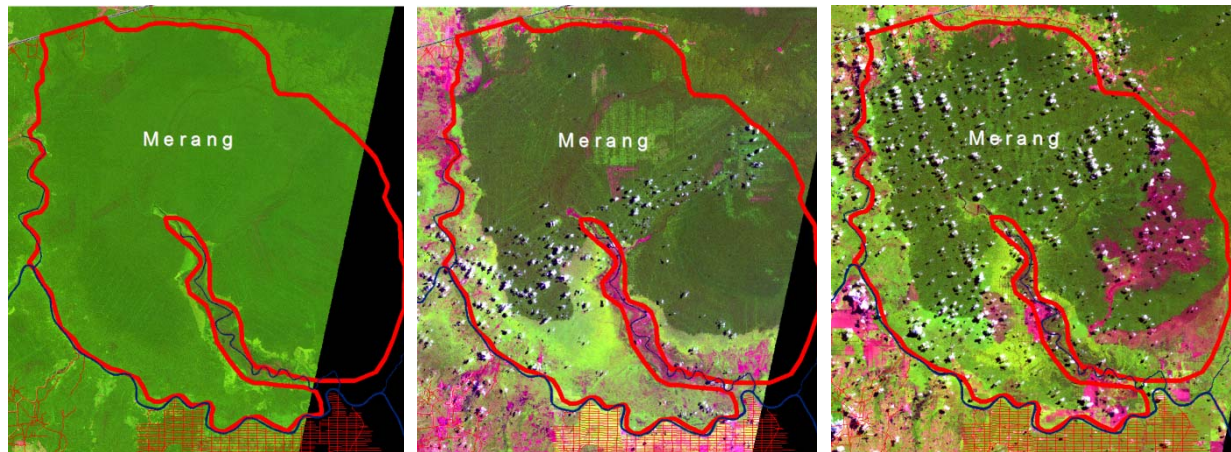


Figure 8. Landsat TM; taken on 09/06/1989

Figure 9. Landsat TM; taken on 01/09/1999

Figure 10. Landsat TM; taken on 27/06/2007

2.1.4. Landuse BPKH

Land use data for the year 2003 was provided by BPKH (Balai Pemantapan Kawasan Hutan). It was and validated/updated using Landsat scenes as a reference.

2.1.5. Hot Spot

Hotspot data of the NOAA AVHRR and MODIS sensors were analyzed in order to estimate the affected area of the MPDF on peat soil. Those systems detect active burning fires with a spatial resolution of about 1 km². To estimate the fire-affected area each recorded hotspot coordinate was converted to an area of 1 km² equivalent to the approximate spatial resolution of the sensor and was intersected with the land cover classification for the year 2007. This does not mean that the resulting burnt area is necessarily the same size; fires may cover the entire square km or only a small fraction. It has been shown, however, that there is a good correlation between burnt areas determined from hotspots and burnt areas derived from high resolution Landsat imagery (Langner et al., 2007, Mettinen et al., 2007). The area estimate is conservative, because the burnt area is often underestimated using the hotspot approach:

- 1.) fires are detected only once or twice a day, and rapidly spreading fires escape recording;
- 2.) smoke from the fire often impedes the detection of hotspots;
- 3.) and ground fires within forests are sometimes not hot enough to be detected from

space. Areas of overlapping hotspots were considered to have been burned only once.

2.2. Analysis

The existing carbon stock of the Merang peat dome has been calculated using the data described in 2.1 Data Sources2.1 (page 18). Project data was used in order to distinguish between vegetation on peat and non-peat, as well as to estimate the peat oxidation and determine the outline of the peat dome and the peat soil.

IPCC suggests three approaches to estimate emissions/removals of greenhouse gases, referred as "Tiers". The tiers are numbered from 1 to 3, and correlated with increasing data requirements and complexity. All three tiers conform to IPCC's desired good practice conceptions of transparency, completeness, consistency, comparability and accuracy.

Tier 1 is the most basic, and is related to predefined biomass stocks, mean annual increment of tree growth (MAI), and continental forest types. These values may be obtained from the IPCC Emission Factor Data Base; however, they provide a restricted resolution of biomass estimation due to the simplified assumption that the emission is directly emitted after deforestation. A gain-loss approach is applied by using default equations.

Tier 2 differs from tier 1 in that MAI and biomass values are taken from existing, *in situ* forest inventories. All nonforest relevant biomass data may be obtained from the EFDB.

Tier 3 can be described as the strictest approach, due to the fact that the biomass estimates must be derived from long term measurements of trees on permanent plots and calibrated models. For all other classes, region-specific stratified data can be used.

2.3. Above ground carbon stock

IPCC defines good practice as using the highest possible tier. This study applies Tier 2 level criteria by using country-specific emissions factors and carbon changes for forest biomass estimation. These data were determined by using the median of published biomass values and were calibrated / verified by field survey data collected in the target area. This approach does contain uncertainties due to variations in growing conditions, the underlying resolution of the satellite images, and the accessibility of certain regions. Lidar data and aerial photos would provide a better estimation, however, their use would necessitate higher cost and a much more time-consuming evaluation due to the higher information content of the underlying data.

The assessment of existing carbon stock was based on a land cover classification for the year 2003 provided by BPKH. The classification was validated and supplemented by SSFFMP using Landsat TM images from the years 1989, 1999 and 2007, this was necessary to update the classification of the corresponding images. In a second step, the

BPKH classification had been adapted to the Land Cover Classification System (LCCS) developed and recommended by the Food and Agriculture Organization (FAO). This was done in order to correlate the land cover type and biomass estimation (see ANNEX III). The land cover classes were adjusted to the needs of LCCS (Gregorio et al, 2000). LCCS has the added advantage in that its class names correlate with many other classification results and therefore allow for further use. This is important due to the fact, that land use classifications will be reused in subsequent work to detect changes; in light of the need for sustainable geo data management, this is a good standard to maintain. Further, all country specific biomass specifications are related to this classification definition. They were implemented to quantify the carbon content and the potential/occurred CO₂ release of land conversions and fire.

The land cover classification of the year 2007 shows the following distribution of land classes for the Merang peat dome. The area of each land cover class was calculated in hectares (see Figure 11, page 22).

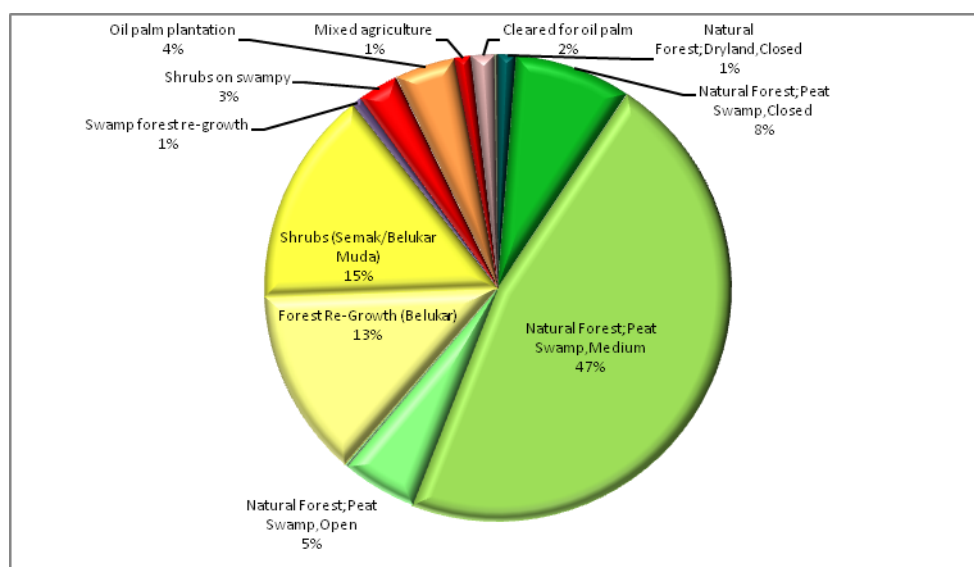


Figure 11. Land cover distribution on peat soil in the Merang Kepayang project area

IPCC Guidelines for National Greenhouse Gas Inventories does provide standard values for the carbon content of different land use classes. Experience showed, however, that those values are too coarse in order to meet the specific characteristics of peat swamp ecosystems in Indonesia. Detailed research was conducted to gain reliable carbon values for different land cover classes of peat ecosystems in South East Asia. The biomass values used were derived for the GMES Forest Monitoring program, in which RSS develops a service case for tropical rainforest monitoring, and compiled from a thorough literature review of biomass measurements of various tropical land covers for Indonesian and Southeast Asian forest ecosystems (see ANNEX II).

The median biomass value for each land cover was determined for specific classes in order to adjust the estimation with *in situ* data and compensate for regional variation.

The carbon fraction of dry matter was chosen to be 50%, as recommended by IPCC. This was the maximum effort feasible within the short time frame of this consultancy. A more detailed and precise calculation would require long term measurements and detailed forest inventories. An additional uncertainty is that the resolution of the remote sensing data used (about 30 by 30 m) doesn't permit a more detailed assessment. Alternatively, Lidar and near infrared aerial images could be used in order to achieve higher accuracy.

The following equation was used to calculate the biomass for a certain point of time (2007) (simplified from IPCC, 2006):

$$C = \sum\{A \times V \times BCEF \times CF\}$$

Where:

- C = total carbon in biomass, in t
 A = area of land of certain land use class, in ha
 V = merchantable growing stock volume, in m³/ha
 BCEF = biomass conversion and expansion factor
 CF = carbon fraction of dry matter

This resulted in the following carbon content of the MPDF in the year 2007 (see Table 1):

Table 1. Land cover classes, area in ha and biomass in tonnes C on peat soil within the area Merang-Kepayang

Land Cover	Summe von Area_ha	Total Carbon (tonnes C)
Natural Forest; Dryland,Closed	13,749	2,522,937
Natural Forest; Dryland,Open	22	793
Natural Forest; Peat Swamp,Closed	18,959	2,663,746
Natural Forest; Peat Swamp,Medium	110,294	12,904,344
Natural Forest; Peat Swamp,Open	11,714	363,120
Natural Forest; Swamp,Open	511	11,235
Natural Forest; Mangrove,Medium	11,672	817,032
Forest Re-Growth (Belukar)	39,958	599,368
Shrubs (Semak/Belukar Muda)	58,515	877,718
Swamp forest re-growth	5,755	86,322
Shrubs on swamp	7,826	117,388
Acacia plantation	1,615	83,984
Oil palm plantation	23,072	1,257,430
Rubber plantation	8,703	957,332
Mixed agriculture	11,943	334,414
Cleared for Acacia	4,969	0
Cleared for oil palm	4,636	0

Cleared	1,121	0
Burnt	4,034	0
Water body	1,849	0
	340,915	23,597,161

The data in Table 1 clearly show where the major portion of the carbon is stored. The largest class, "Natural Forest, Peat Swamp Medium Closed", with an overall area of about 110,000 ha (47% of the MPDF), contains 12.9 Mt of biomass (about 57% of the overall carbon content). Next largest is Natural Forest; Peat Swamp Closed class, with an area of 19,000 ha and biomass of 2.7 Mt, even though the area is comparably small. This is indicative of the high biomass content of nearly undisturbed forest.

2.4. Calculation of carbon loss due to drainage and land cover conversion

Peat undergoes oxidation processes when exposed (deforested) and drained. Decomposition of the organic material is only possible when aerobic conditions prevail, created by lowering the water table. The peat, however, undergoes temporally-limited natural variations of water saturation. Land cover conversion or drainage reduces the sustainability of the water table, leading to a decomposition process and subsequent CO₂ emission.

The formula for calculating CO₂ emissions due to the oxidation of organic matter is given by IPCC. The simplified formula is as follows:

$$L_{Organic} = \sum(A \times EF)$$

where:

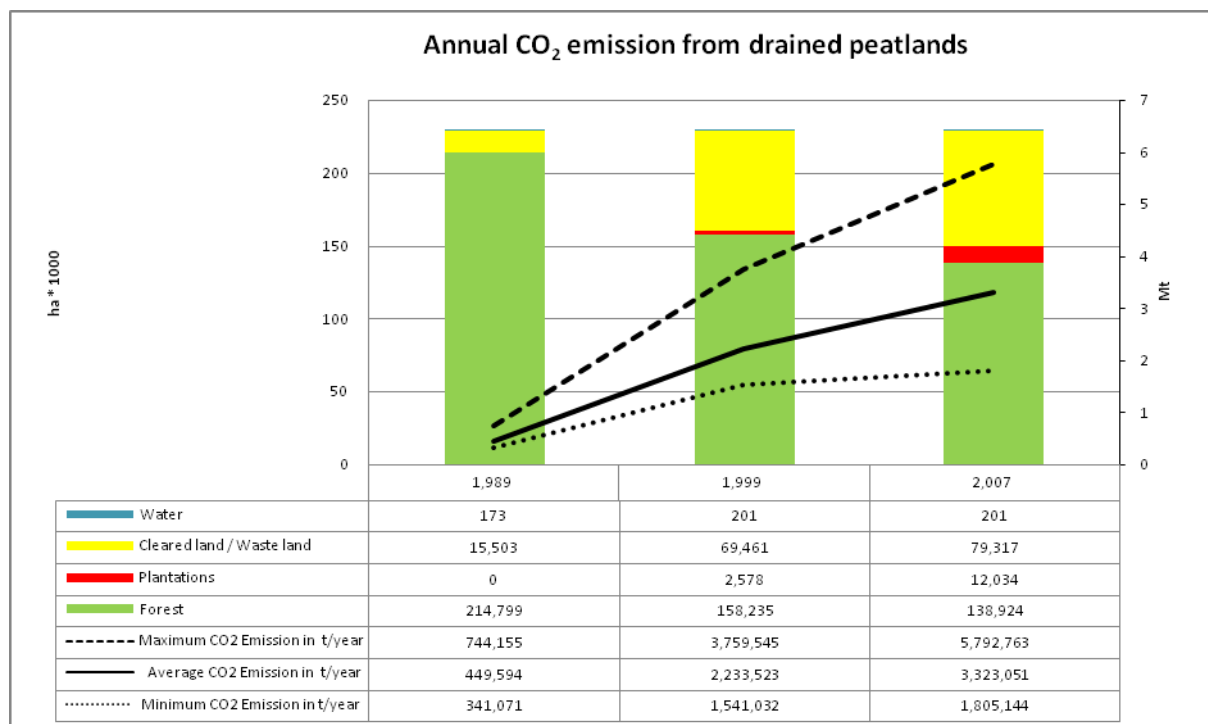
- L = annual organic content lost from drained organic soils, in t CO₂/ha/y
- A = land area of drained organic soils, in ha
- EF = emission factor, in t CO₂/ha/y

In order to estimate the peat decomposition, emissions factors for different land cover classes were estimated. Those emission factors were correlated with different land cover classes and drainage regimes, based on literature reviews and results of long-term studies in Sarawak and Central Kalimantan (Uryu, Y. et al. 2008) in relation to the drainage depth. The emission values were averaged and assigned to perspective land cover cases.

Table 2. Emission factors from peat decomposition (organic matter)

Land Cover Class	Avg. Drainage Depth (cm)	Mean (in t CO ₂ /ha/y)	Median (in t CO ₂ /ha/y)	SD (in t CO ₂ /ha/y)	Max (in t CO ₂ /ha/y)	Min (in t CO ₂ /ha/y)
Acacia plantation	53	85	84	41	165	5
Oil palm plantation	53	85	84	41	165	5
Smallholder oil palm plantation	53	85	84	41	165	5
Cleared land	21	29	26	9	48	22
"Waste" land	21	29	26	9	48	22
Other land covers	21	29	26	9	48	22

Estimated CO₂ emissions from peat oxidation were calculated using emission factors from Table 2 for three different land cover classifications (see 2.1.4 Landuse BPKH) from the years 1989, 1999 and 2007. Missing areas were extrapolated excluding water bodies. The accumulated emissions of the last 18 years from the Merang peat dome is estimated to be 26 Mt, with a potential maximum emission of 43 Mt CO₂. This corresponds to an average loss of 350,000 t C of peat per year, with a potential maximum loss of 590,000 t C due to oxidative processes.

**Figure 12. Annual CO₂ emission in relation to land cover**

Uncertainties in these emissions calculations due to peat decomposition are:

- The weather phenomena, El Niño and El Niña, cause interannual variations in the water table height;
- All CO₂ measurements were taken on the surface, so the carbon sequestration by regrowth was not considered;
- The published and project survey measurements of CO₂ fluxes represent a single snapshot in time for drainage.

Few long term studies of carbon flux in peat domes exist, however, the variability of published values is high (standard deviation). Nonetheless, the applied method and underlying assumptions / data represent a reasonable starting point.

2.5. Emissions from peat burning

The spatio-temporal occurrence of peat fires and their affected areas were analyzed for the years 1997 to 2007. All hotspots of the medium resolution satellite system MODIS and NOAA AVHRR sensors were superimposed on the Landsat TM images and the land cover classification. The spatio-temporal occurrence was analyzed by comparing the affected land class and the land class resulting from the fire event.

The emission due to peat fires was calculated as follows:

$$L_{Fire} = \sum(A \times D \times C)$$

where:

- L = annual organic content lost from burned organic soils, in kg C/ha/y
- A = land area of burned organic soils, in m²
- D = affected depth of organic soil, in m (using a constant value of 0,3 m)
- C = C content of organic soil, 58 kg/m³ (Neuzil, 1997)

The hotspot data is provided in coordinates of longitude and latitude. To calculate the area affected by fire, a 1 by 1 km buffer was allocated around each validated hotspot; in this way, the annual affected area of peat fire was estimated. Several measurements taken in Tumbang, Nusa Taruna, Kalamangan and Sebangau showed that an average of 30 cm in depth of the peat layer is affected during a peat fire. The affected fire area and the resulting CO₂ emissions were calculated. The average carbon content of one cubic meter of peat is 58 kg Carbon (Neuzil, 1997).

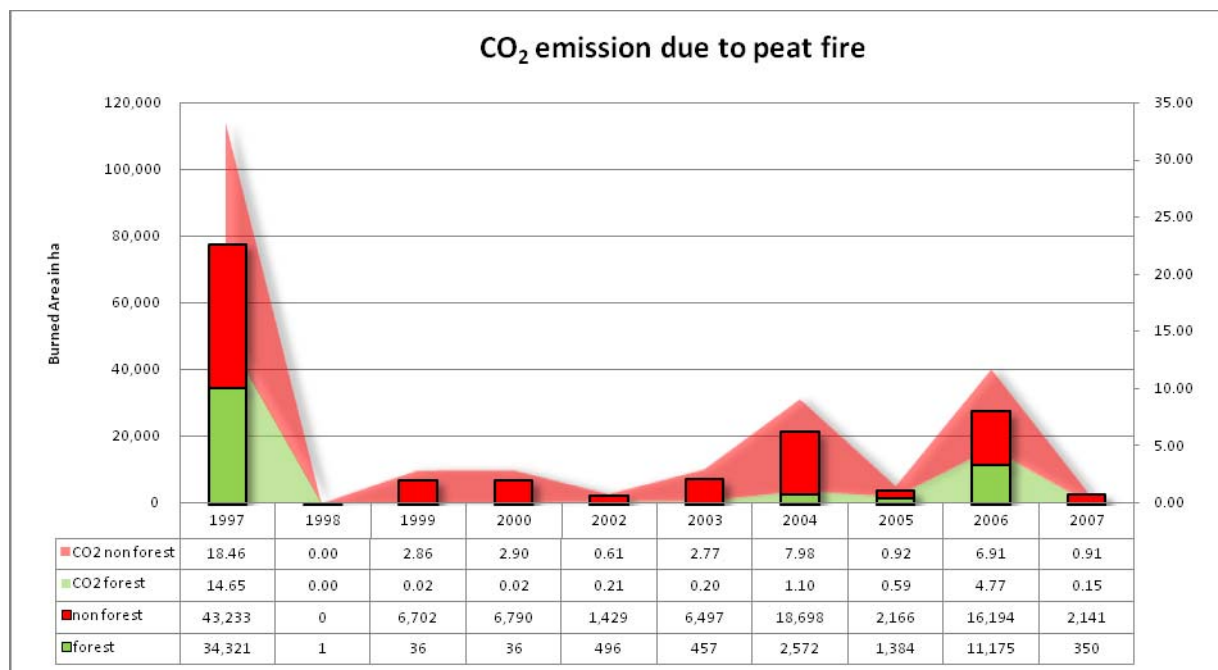


Figure 13. CO₂ emissions due to peat fires and affected areas, from 1997 to 2007

1997 was an “El-Niño” year, which can be seen in the extent of the affected burned peat area. About 38.000 ha of peat soil was burned, causing a CO₂ release of 33 Mt. Most of the burned area had been covered by forest.

2.6. Total emissions and carbon content of the Merang Peat Dome

The total emissions and carbon content of the MPDF was summed up as previously described using relevant factors, whereas emissions due to vegetative fires were not considered. Changes in carbon stocks of biomass were calculated by applying the Stock-Difference method provided by IPCC (IPCC, 2006).

The formula looks like this:

$$\text{Stock-Difference Method } \Delta C = \frac{(C_{t2} - C_{t1})}{(t_2 - t_1)}$$

where:

- ΔC = Difference in C content
- C = C content
- t = certain point of time

Results of the calculation:

Table 3. Calculation of net emission in Mt of CO₂ due to land cover changes on organic soil

	1989 - 1999	1999 - 2007	1989 - 2007
Emission by deforestation/degradation	41.27	0.00	41.27
Emission by non forest degradation	0.00	4.27	4.27
Emission by peat decomposition	4.50	21.19	25.69
Emission by peat fire	33.00	33.40	66.40
Total emissions	78.77	58.86	137.63
Sequestration	-3.42	-11.05	-14.47
Net emissions	75.35	47.81	123.16

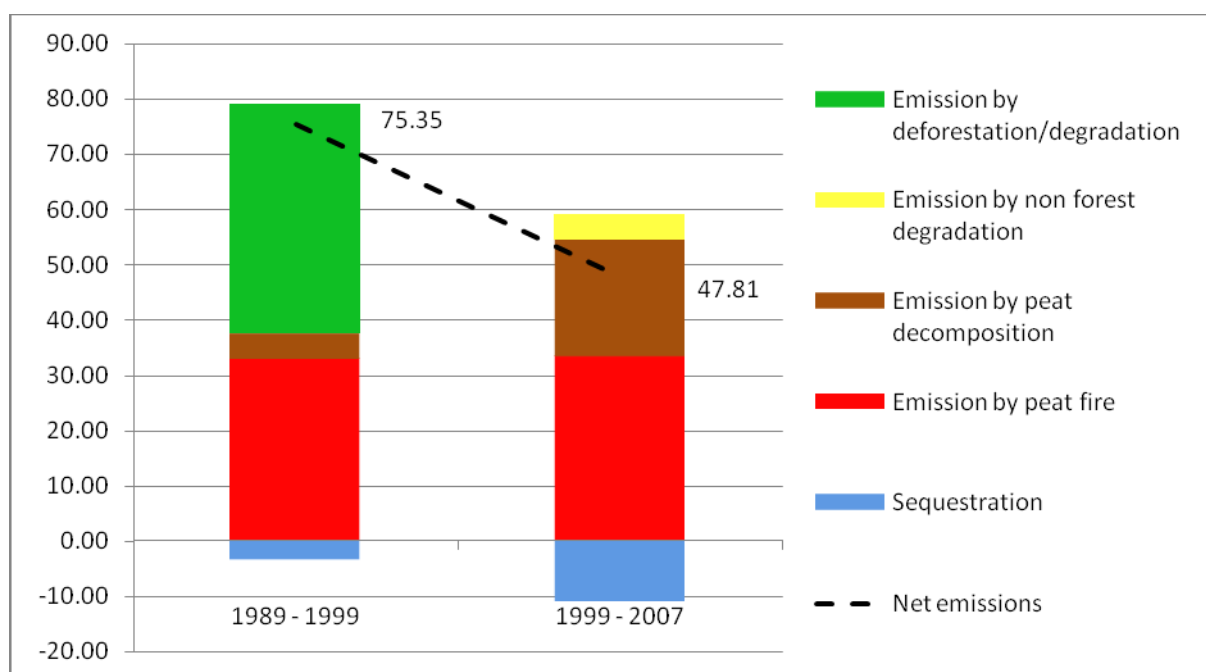
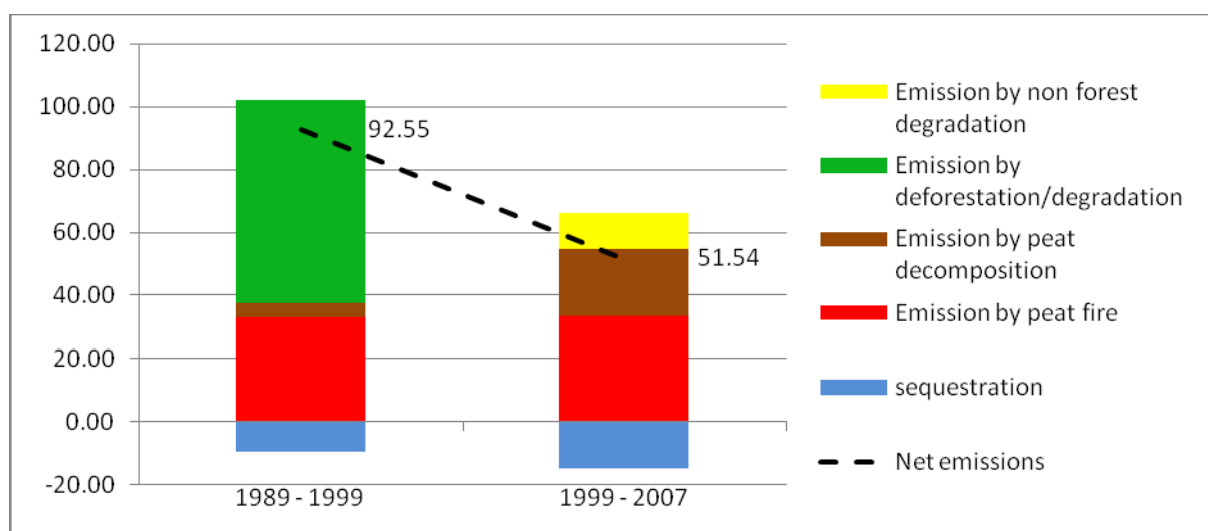


Figure 14. Calculation of net emission in Mt of CO₂ due to of land cover changes on organic soil; values below zero indication sequestration of organic material

The emission from the Merang Kepayang area sums up as in the next table (including organic soil + mineral soil).

Table 4. Calculation of net emission in Mt of CO₂ due to land cover changes on organic soil and mineral soil

	1989 - 1999	1999 - 2007	1989 - 2007
Emission by deforestation/degradation	64.52	0.00	64.52
Emission by non forest degradation	0.00	11.60	11.60
Emission by peat decomposition	4.50	21.19	25.69
Emission by peat fire	33.00	33.40	66.40
Total emissions	102.01	66.19	168.20
Sequestration	-9.47	-14.65	-24.12
Net emissions	92.55	51.54	144.09

**Figure 15. Calculation of net emission in Mt of CO₂ due to land cover changes on organic soil and mineral soil**

Emissions of peat fires and peat decomposition, compared across both Figures remain the same, due to the fact that Figure 15 does contain the emissions of Figure 14 which is already located on peat soil. The emissions from forest degradation in the period of years 1999 – 2007 in both Figures remains zero because the sequestration is larger than the emission itself, despite a loss of forested land. Large patches of forest recovered in comparison to the time period 1989 to 1999.

Uncertainties are due to:

- Missing data and extrapolation of the years 1989 and 1999
- Interpretation of the map
- Classification algorithms
- Haze and clouds

The data from 1989 and 1999 should be considered carefully, caveated by the

uncertainties mentioned prior, however, the calculation of 2007 itself is considered to be representative as requested by the tender of the project.

3. Estimations of future CO₂ emissions on the basis of a “business as usual scenario” and after the implementation of emissions reduction measures implemented by the project

The estimation of future CO₂ emissions of the Merang Kepayang area was predicted as far as the year 2015. This prediction uses the current status of land cover distribution and land use for the year 2007 as a starting point.

Two additional scenarios of land cover distribution and their related changes were calculated besides the “business as usual” scenario. The scenarios differed in terms of the extent and land use practice of the potential protected area under the contribution of the BMU project in cooperation with concessionaires (see Rucker, 2008).

All scenarios assume that the forest will be converted to plantations because they are already allocated to the concessionaires as described in Table 5.

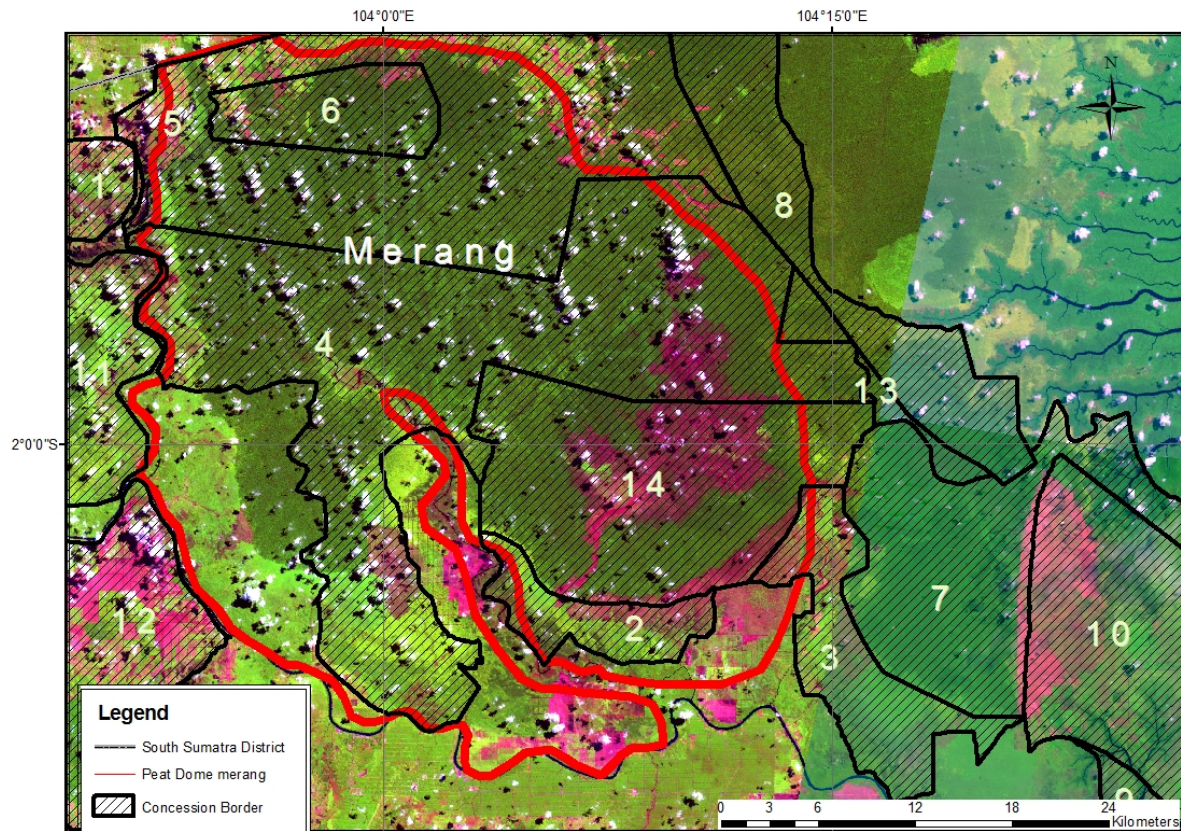


Figure 16. Concession borders within the area Merang

Notice: Block numbers of HPH and HTI are given in this report individually; they do not correspond to public identification tags.

Table 5. Concessions within the area Merang and status of concession (status 28/08/08)

Block Number	Concession Name	Status
1	Pakerin	allocated
2	Wahana Lestari Makmur	allocated
3	Rimba Hutani Mas	allocated
4	Rimba Hutani Mas	allocated
5	Rimba Hutani Mas	SK in process
6	Tiesico Cahaya Pertiwi	allocated
7	Paramitra Mulia Langgeng	allocated
8	Wahana Lestari Makmur	No SK
9	Paramitra Mulia Langgeng	allocated
10	Sumber Hijau Permai	allocated
11	-	unallocated
12	Bumi Persada Permai	allocated
13	-	unallocated
14	-	unallocated

Block 4 is already allocated to Rimba Hutani Mas (RHM), a member of the Sinar Mas Group. RHM stated that 15,000 ha of Block 4 will be kept as a conservation area (about 22% of the allocated area). Degraded peat forest will be combined with enrichment planting.

For the northern Block 5, a recommendation has been already published to assign the concession to RHM as well. Consequently, the RHM concession will cover the major area of the MPDF itself.

Indonesian law requires allocation of at least 10% of a concession to forest conservation and use of a maximal production area of 70%. The remaining 20% contains community forest, infrastructure, etc. RHM must lower the water table by 30 to 40 cm in order to optimise the growing conditions for *Acacia Crassicarpa*. The drainage will be not as severe, as it is necessary, for *Acacia Mangium*, which needs much drier growing conditions.

The rotation period is about 5 to 8 years. Further channels of 3 m depth and about 8 m width for timber extraction are planned. The annual conversion rate to plantation will be around 15,000 ha/year including final opening and planting. As a result, the complete conversion of the Block 4 is planned to take about 4 years and should be completed by 2012.

Block 5 is smaller and overlaps with already existing smallholder agriculture and oil palm plantations; however, the remaining forests, excluding small holder farming areas that are already in existence will be converted at the same speed as Block 4.

In addition to acacia plantations, palm oil plantations will be established in the non-forest area. This conversion is already underway; however, documents of the RTRWP indicate an expansion of the palm oil plantations on peat soil.

The allocation of concessions in the Merang Kepayang area are considered in the scenario design to be a static input quantity; all scenarios differ in terms of land use practice and intensity.

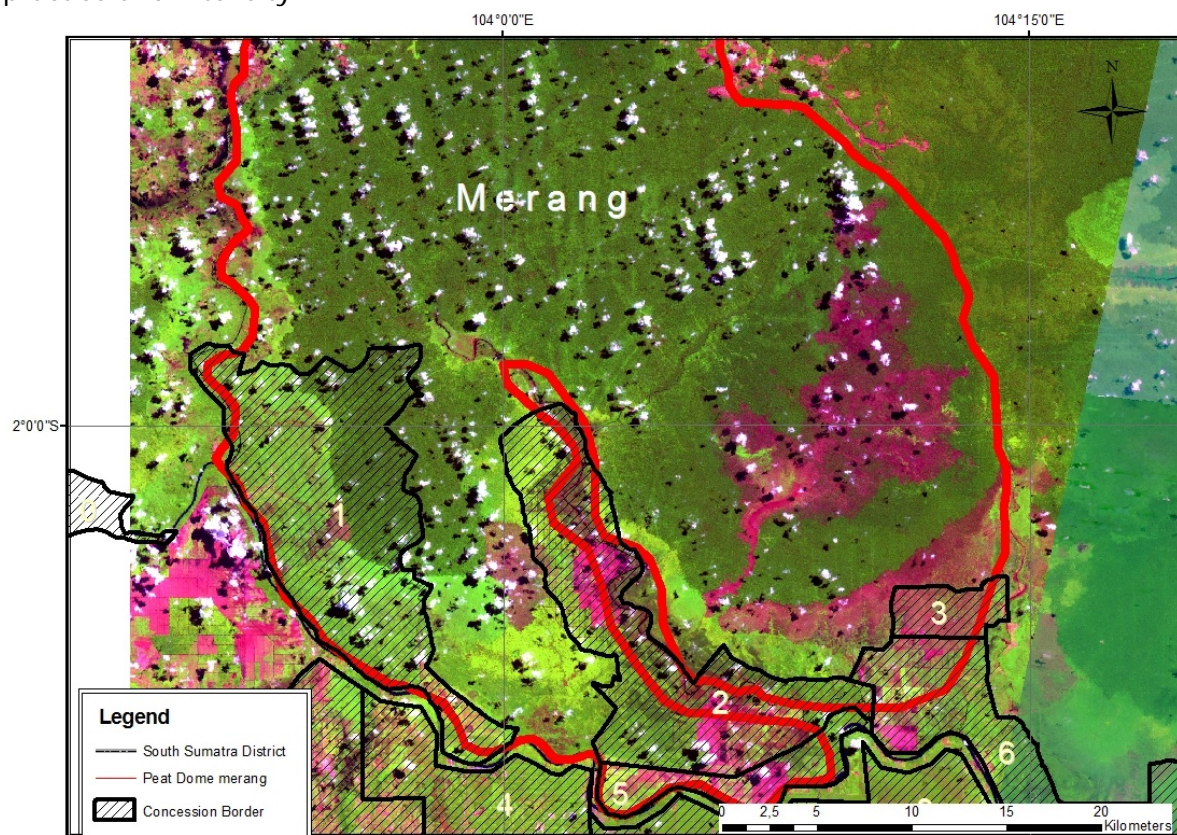


Figure 17. Palm oil concessions (status 28/08/08)

Table 6. Status of palm oil concessions within the area Merang-Kepayang (status 28/08/08)

Number	Concession Name	Status
1	PT. SWADAYA BAKTI NEGARAMAS	allocated
2	PT. MENTARI SUBUR ABADI	allocated
3	PT. MENTARI SUBUR ABADI	allocated
4	PT. PANCA TIRTA BUDI AGUNG	allocated
5	PT. PANCA TIRTA BUDI AGUNG	allocated
6	PT. PANCA TIRTA BUDI AGUNG	allocated

The changes in each land cover and their driving forces were described and analyzed (Rücker, 2008). The foci of the calculations in Table 7 were to estimate potential carbon emissions and carbon savings for the different scenarios, in the event of project implementation.

Table 7. Distribution of land use classes, considering different scenarios (Rücker, 2008); arrows indicate the tendency in land change (up = increase; down = decrease)

Land Cover	annual change	Status 2007	"Business as usual"	Project Impact (ha)		Project small	Project large
			2015	Project small	Project large	2015	2015
Mixed agriculture + Rubber	7%	16,628	↑ 23,414	-2,011	-2,343	↻ 21,402	↻ 21,071
Oil palm plantation	0%	4,002	↔ 4,002	0	0	↔ 4002	↔ 4,002
Natural Forest; Dryland, Closed	-25%	1,986	↓ 0	790	983	↓ 790	↓ 983
Natural Forest; Peat Swamp, Closed + Medium	-4%	29,935	↓ 19,535	5,130	7,065	↻ 24,665	↻ 26,600
Natural Forest; Peat Swamp, Open	5%	8,755	↑ 11,955	-404	-2,122	↑ 11,552	↻ 9,834
Non Vegetation	0%	2,245	↔ 2,245	-1,367	-2,125	↻ 877	↓ 120
Secondary Re-growth	2%	14,935	↑ 17,335	-2,138	-1,459	↻ 15,197	↻ 15,877
		78,485	78,486			78,486	78,486

3.1. Business as usual scenario

The previously described changes apply to all scenarios, however, the business as usual scenario assumes that the remaining area (as opposed to the concession area) is undergoing similar changes and threats as they occurred within the last 20 years. Those types of developments were projected into the future through the year 2015. Illegal timber extraction and peat fires occur at the same intensity and temporal regularity as they did in the past 20 years. Police investigation into illegal logging is non-existent and "business as usual" resumes. The deforestation speed stays the same as between 1999 and 2007. The peat itself will undergo severe decomposition and fires.

In accordance to the existing spatial planning, the surrounding landscape was converted in accordance to the existing spatial planning, such as oil palm and acacia plantations.

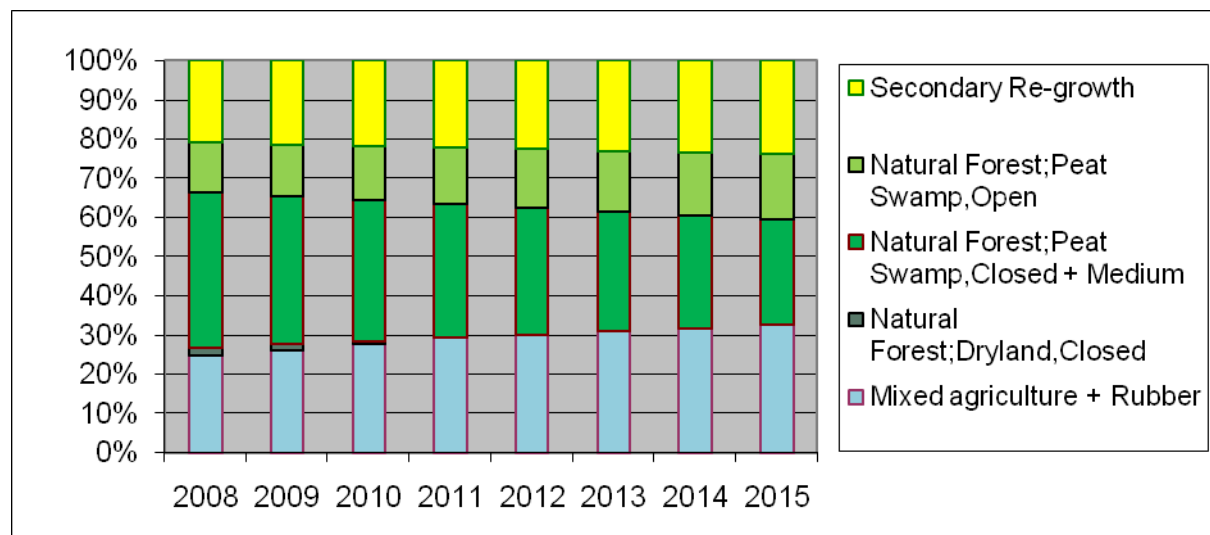


Figure 18. "Business as usual" scenario, land changes of remaining 78,000 ha (Rücker, 2008)

Table 8. Predicted changes until 2015 in ha (Rücker, 2008)

Land Cover	annual change	2007	2015
Mixed agriculture + Rubber	7%	16,628	23,414
Oil palm plantation	0%	4,002	4,002
Natural Forest; Dryland, Closed	-25%	1,986	0
Natural Forest; Peat Swamp, Closed + Medium	-4%	29,935	19,535
Natural Forest; Peat Swamp, Open	5%	8,755	11,955
Non Vegetation	0%	2,245	2,245
Secondary Re-growth	2%	14,935	17,335
		78,485	78,486

The calculation results in the following final land cover distribution:

57,000 ha under conservation
 132,000 ha conversion to HTI
 76,000 ha conversion to oil palm
 79,000 ha unmanaged area

344,000 ha

From this:

149,270 ha will undergo severe drainage (30 cm and deeper)
 14,650 ha will undergo drainage (less than 30 cm)

This leads to the following calculation of CO₂ emissions, by applying the method introduced in the chapter Analysis page 21).

Table 9. "Business as usual" Scenario and related CO2 emissions in Mt

Base - Line Scenario	1989 - 1999	1999 - 2007	2007 - 2015
Emission by deforestation/degradation	64.52	0.00	40.57
Emission by non forest degradation	0.00	11.60	0.00
Emission by peat decomposition	4.50	21.19	104.00
Emission by peat fire	33.00	33.40	33.00
Total emissions	102.01	66.19	177.58
Sequestration	-9.47	-14.65	-32.07
Net emissions	92.55	51.54	145.50

3.2. Implementation of a small project for reducing emissions

This scenario differs from "business as usual" by assigning unallocated block 14, containing about 25,000 ha, to the project. It was assumed, that the logging activities in the area can be gradually reduced and stopped completely within 3 years. The same was assumed for the protected area of the concession. Fires and lowering of the water table were reduced to a minimum in order to avoid sustainability impacts. The burned scars originating from the year 2006 in Block 15 are assumed to have been replanted and combined with enrichment planting. Further assumption is that This process will be completed by the year 2015, when the area is covered by peat forest, of open and mainly medium crown closure.

The estimation of land cover classes is as follows:

83,000 ha under conservation
 132,000 ha conversion to HTI
 76,000 ha conversion to oil palm
 53,000 ha unmanaged area

344,000 ha

From this:

149,270 ha undergo severe drainage (30 cm and deeper)
 14,650 ha will undergo drainage (less than 30 cm)

Based on the land cover distribution, CO₂ emission is estimated to be as follows:

Table 10. Small project scenario and related CO₂ emissions in Mt

Small Project	1989 - 1999	1999 - 2007	2007 - 2015
Emission by deforestation/degradation	64.52	0.00	37.66
Emission by non forest degradation	0.00	11.60	0.00
Emission by peat decomposition	4.50	21.19	103.35
Emission by peat fire	33.00	33.40	22.00
Total emissions	102.01	66.19	163.02
Sequestration	-9.47	-14.65	-31.45
Net emissions	92.55	51.54	131.57

3.3. Implementation of a large project for reducing emissions

Block 15 of 25,000 ha will have the same conditions as the small project scenario, under control of the BMU project. This area will have been combined with the 17,000 ha of RHM, allocated as protected forest, on which partly enrichment planting will take place.

Illegal logging will have been reduced to a minimum, due to strong law enforcement and in the interest of the private company, because of concern for its reputation and resulting economic losses. Effective fire management of both the protected, as well as the plantation area will be assumed and the occurring peat fires are limited to two fire events, promoted by the weather phenomena "El Niño". The pressure on the peat forest in the north by smallholder farmers will be reduced to a minimum due to an effective community development program.

Estimated distribution of land cover of a large project in the year 2015:

123,000 ha under conservation
 115,000 ha conversion to HTI
 76,000 ha conversion to oil palm
 30,000 ha unmanaged area

344,000 ha

From this:

132,670 ha undergo severe drainage (30 cm and deeper)
 14,910 ha will undergo drainage (less than 30 cm)

Based on the land cover distribution CO₂ emission is estimated to be as follows:

Table 11. Large project scenario and related CO₂ emissions in Mt

Large Project	1989 - 1999	1999 - 2007	2007 - 2015
Emission by deforestation/degradation	64.52	0.00	36.82
Emission by non forest degradation	0.00	11.60	0.00
Emission by peat decomposition	4.50	21.19	92.26
Emission by peat fire	33.00	33.40	16.00
Total emissions	102.01	66.19	145.07
Sequestration	-9.47	-14.65	-31.40
Net emissions	92.55	51.54	113.67

3.4. REDD

REDD aims to reduce emissions by implementing CO₂-saving schemes. The CO₂ saving is calculated by comparing the emissions of the "Business as usual" scenario, also called the "Base-line" scenario, with the effects of CO₂ emissions implemented by the project. In the study conducted for SSFFMP, two scenarios were designed (see sections 3.2 **Implementation of a small project for reducing emissions**, page 36, and 3.3 **Implementation of a large project for reducing emissions**, page 36). Both of these are compared with the "Base-line" scenario. The difference of CO₂ emissions between the

“Base-line” scenario and the Project scenario (small or large) is the reduction in emissions, which can be traded.

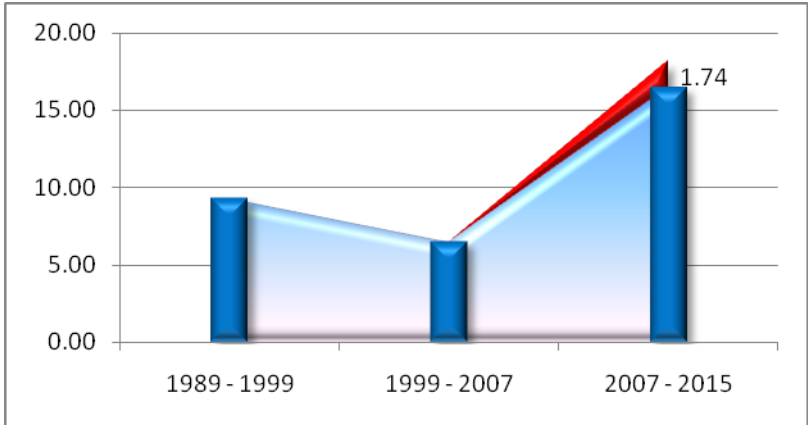


Figure 19. Small project scenario and potential REDD relevant annual CO₂ saving of 1.74 Mt

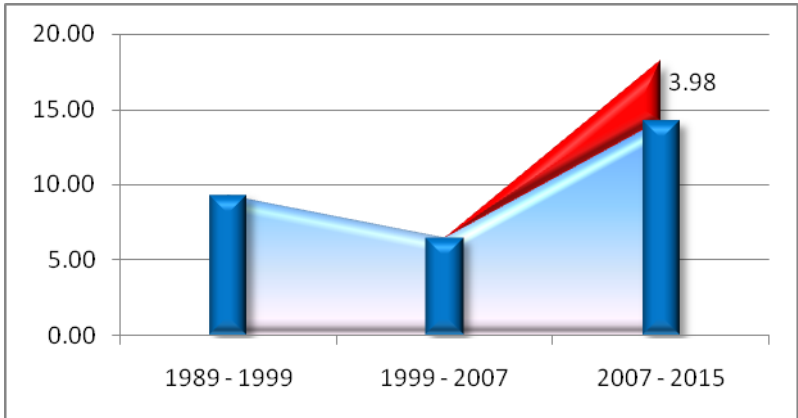


Figure 20. Large project scenario and potential REDD relevant annual CO₂ saving of 3.98 Mt

Implementation of a small project, with all its limitations, may produce an annual emissions reduction of 1.74 Mt.

This value is a estimation, based on the available data and current policy. For a REDD implementation, a much more detailed estimation is necessary. Please refer to the recommendations (page 5).

By comparing all three scenarios, a potential project impact becomes visible. Figure 21 on page 39, demonstrates that the peat decomposition due to oxidative processes comprises the lion’s share of the overall emissions. To reduce sustainable the emission, it is necessary avoiding of lowering the water table, resulting from any forest to plantation conversion (forest as well oil palm). This is indicated in tentative numbers of the last bar in the chart, titled “Total Protection”.

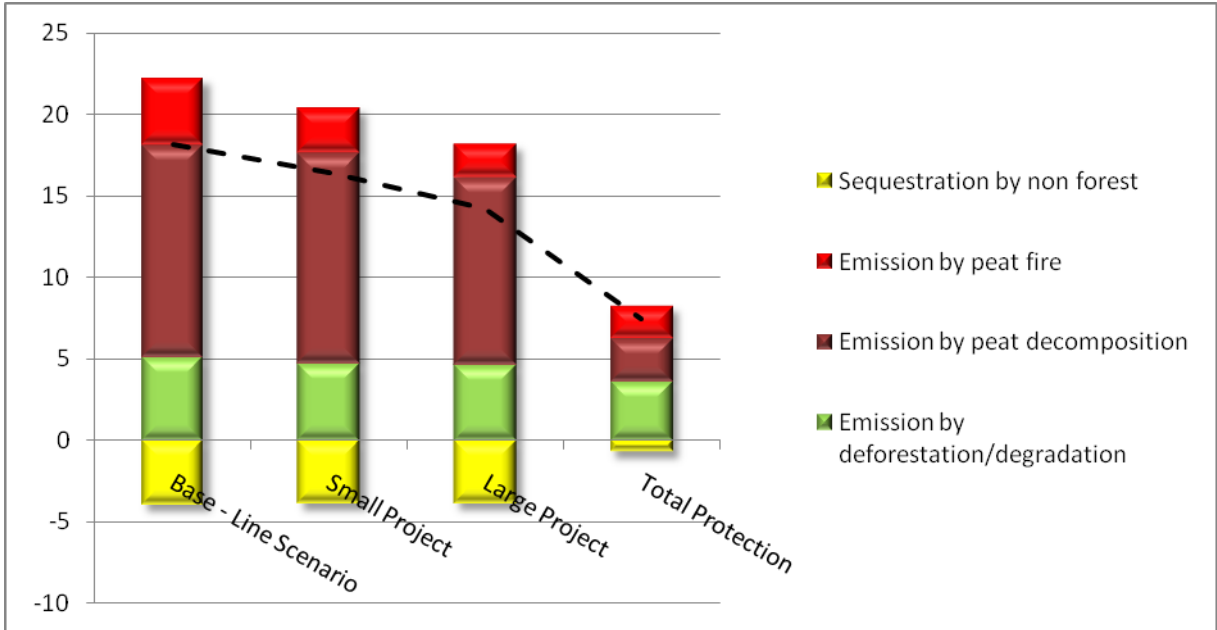


Figure 21: Different Scenarios and related emission factors on an annual basis

All original and processed / analyzed data and GIS data on CD-ROM

Deliverables

Draft report comprising major findings and recommendations agreed upon with the Teamleader of the SSFFMP Project Management Unit (PMU) in electronic and printed version

Presentation of Approach & Results in a Powerpoint presentation

Final report in electronic and printed (6 pcs.) version and Time Sheets

References

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ANNEX I

Powerpoint Presentation on the compilation of the projects peat land and dome data.

South Sumatra Forest Fire Management Project (SSFFMP)

Pengkajian Cadangan Karbon di kawasan Merang Kepayang

Consultancy provided by RSS GmbH
03/09/2008

Delegation of the European Commission to Indonesia,
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Estimasi Karbon yang Ada

- Sesuai dengan Panduan IPCC 2006 untuk Inventarisasi Gas Rumah Kaca Nasional
- Panduan IPCC tersedia 3 cara untuk estimasi karbon (Tier)
 - Tier 1
 - Biomasa dan rata-rata riap tahunan yang telah ditentukan sebelumnya dari pertumbuhan pohon
 - Di tingkat nasional, dapat diperoleh dari IPCC Emission Factor Data Base
 - Tier 2
 - Menggunakan nilai biomasa dari inventarisasi hutan atau sumber data lainnya.
 - Data Biomasa non hutan dapat diperoleh dari EFDB
 - Tier 3
 - Pendekatan yang sangat tegas
 - Nilai biomasa harus diperoleh dari pengukuran jangka panjang melalui plot ukur permanen dan model kalibrasi

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Langkah-Langkah Analysis

- Penghitungan biomasa di atas tanah untuk tahun 1999, 1989 and 2007 berdasarkan Remote Sensing data
- Menentukan tingkat kedalaman drainase di berbagai tipe tutupan lahan dan emisi CO₂ terkait
- Menentukan pengurangan karbon serta emisi CO₂ terkait dengan kebakaran lahan gambut
- Summarize

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Data Sources

1989
1999
2007
Land Cover
Peat Soil
Hot Spot

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Land Cover 2007 di lahan gambut

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Penghitungan Biomasa Tier 2

Land Cover	Luas (ha)	Carbon Stock (tC/ha)
Natural Forest, Dryland, Closed	11,748	2,522,991
Natural Forest, Dryland, Open	22	791
Natural Forest, Peat Swamp, Closed	18,959	2,463,749
Natural Forest, Peat Swamp, Medium	122,294	12,404,144
Natural Forest, Peat Swamp, Open	11,714	361,121
Natural Forest, Swamp, Open	511	11,291
Natural Forest, Swamp, Medium	11,672	837,701
Natural Forest, Swamp, Closed	39,058	339,369
Swamp, Open (Belukar)	36,513	617,728
Swamp Forest, regrowth	3,795	86,521
Shrub on swamp	7,628	127,589
Acacia plantation	1,812	83,864
Oil palm plantation	28,072	1,257,432
Water plantation	8,702	307,132
Wood agriculture	11,843	324,424
Stand for Acacia	4,869	1
Stand for oil palm	4,636	1
Stand	1,121	1
Open	4,054	1
Other	1,642	1
Total	388,001	33,147,141

Ketersediaan karbon untuk vegetasi - 2007

- Data Biomasa berdasarkan review literatur dan data survey
- Perbandingan dengan tahun 2 sebelumnya → Penyerapan dan emisi (CO₂) dapat dihitung

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Kebakaran lahan gambut

- Kebakaran menyebabkan penurunan ketebalan gambut hingga 30 cm di setiap musim kebakaran
- Hot Spots of NO AA dan MODIS dibuffer 1 km² → volume gambut terbakar dan carbon yang dilepas dapat dihitung.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO2 from forest	18.41	0.00	1.83	1.88	1.61	2.77	7.36	0.52	0.89	0.91			
CO2 from soil	14.61	0.00	0.32	0.32	0.21	0.29	1.10	0.29	4.78	0.10			
Net forest	40.23	0	2.15	2.20	1.82	3.06	8.46	0.81	5.67	1.01			
Net soil	34.22	0	34	34	408	437	2,372	2,384	11,170	352			

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Oksidasi gambut

- Perubahan vegetasi di lahan gambut menyebabkan oksidasi
 - Drainase gambut (→ penurunan air tanah)
 - Perubahan vegetasi
- Drainase gambut dengan kedalaman 53 cm menyebabkan rata-rata emisi 85 t CO₂/ha/year

Year	1999	2001	2007
Water	172	201	201
Drained land / Water land	15,245	69,462	76,217
Peatland	0	2,979	22,224
Forest	214,770	138,228	133,824
Peatland CO2 Emission in Gt/year	744,023	3,729,243	3,792,743
Average CO2 Emission in Gt/year	449,394	2,233,523	2,523,871
Peatland CO2 Emission in Gt/year	492,013	2,094,262	2,400,349

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Summarize

- Terjadi degradasi hutan gambut alam dalam 20 tahun terakhir
- Kejadian kebakaran tahun 1997 and 2006 melepas CO₂ dalam jumlah sangat besar
- Emisi akibat dekomposisi gambut meningkat secara drastis akibat drainase di plantation

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Uncertainties

- Estimasi karbon di atas tanah, tergantung dari keakuratan klasifikasi
- Adanya variasi biomasa baik dalam ruang, spesies maupun tingkat suksesi/deforestasi, dll.
- Emisi CO₂ dari dekomposisi gambut (variasi water level di dalam ruang dan waktu)
- Emisi CO₂ dari gambut terbakar (variasi kedalaman, pembakaran, dll.)

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Rekomendasi untuk REDD

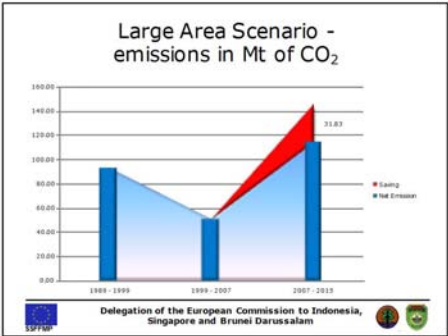
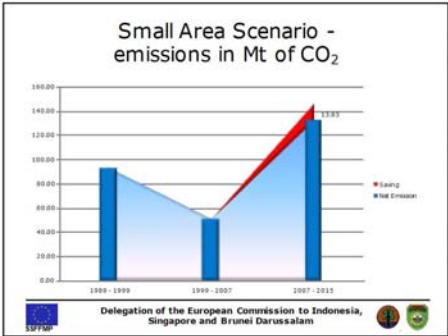
- Melakukan pengeboran gambut di daerah selatan Merang peatdome
- Membentuk petak ukur permanen untuk penghitungan riap pohon (IPCC Tier3 Level)
- Monitor karbon yang hilang akibat kebakaran gambut (dengan tongkat besi)
- Monitor variasi permukaan air akibat drainase walaupun di luar project area

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Thank you for your attention!

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Carbon Stock Estimation of Merang Kepayang Area



ANNEX II

Land Cover Class	Class description	Region	Literature Source	Biomass Specifications [t/ha]	Biomass used for Calculations [t/ha]
Dry Lowland Forest rather closed canopy	mixed dipterocarps-dense stocking, flat to undulating	Sarawak	Brown (1997)	355,0	367
	mixed dipterocarps-medium stocking, flat to mountainous	Sarawak	Brown (1997)	305,0	
	old-growth dipterocarp	Philippines	Brown (1997)	445,0	
	closed-broadleaf tropical forest	Indonesia	Lasco (2002)	508,0	
	natural forest	Indonesia	Hairiah et al. (2001)	508,0	
	medium humus podzol	Sarawak	Bruenig (1977)	452,0	
	shallow humus podzol	Sarawak	Bruenig (1977)	350,0	
	evergreen needleleaf forest	Asia	Michel et al. (2005)	367,0	
	evergreen broadleaf forest	Asia	Michel et al. (2005)	233,5	
	deciduous needleleaf forest	Asia	Michel et al. (2005)	189,0	
	deciduous broadleaf forest	Asia	Michel et al. (2005)	200,0	
	mixed forest	Asia	Michel et al. (2005)	222,5	
	tropical forest	Malaysia	Brown and Gaston (1996)	230,0	
	primary forest	Central Kalimantan, Barito Ulu	Brearily et al. (2004)	358,0	
	primary forest	East Kalimantan	Prakoso (2006)	155,5	
	lowland forest	Indonesia	Garzuglia et al (2003)	240,0	
	lowland evergreen rainforest	Malaysia, Pasoh	Mackinnon et al. (1996)	664,0	
	lowland evergreen rainforest	Malaysia, Pasoh	Mackinnon et al. (1996)	475,0	
	lowland evergreen rainforest broad ridge crest	Sarawak, Mula	Mackinnon et al. (1996)	650,0	
	lowland evergreen rainforest valley alluvium	Sarawak, Mula	Mackinnon et al. (1996)	250,0	
lowland evergreen rainforest over limestone	Sarawak, Mula	Mackinnon et al. (1996)	380,0		
lowland evergreen rainforest heath forest	Sarawak, Mula	Mackinnon et al. (1996)	470,0		
kerangas	Borneo	Mackinnon et al. (1996)	470,0		
mixed dipterocarp	Borneo	Mackinnon et al. (1996)	650,0		
limestone	Borneo	Mackinnon et al. (1996)	380,0		
Asia tropical forest undisturbed	Asia	Brown et al. (1993)	438,0		
tropical rain forest Asia insular	Asia	IPCC (2006)	350,0		
Dry Lowland Forest medium open canopy	forest fallow	Malaysia, Peninsular	Brown (1997)	140,0	264
	logged dipterocarp	Philippines	Brown (1997)	335,0	
	commercial logging	Indonesia	Hairiah et al. (2001)	300,0	
	logged forest	Sumatra, Pasir Mayang	Prasetyo et al. (2000)	310,4	
	old secondary forest	Central Kalimantan, Barito Ulu	Brearily et al. (2004)	264,0	
	secondary forest	East Kalimantan	Prakoso (2006)	89,0	

Carbon Stock Estimation of Merang Kepayang Area

	Asia tropical forest disturbed	Asia	Brown et al. (1993)	248,0	
Dry Lowland Forest very open canopy	burnt primary forest	East Kalimantan	Prakoso (2006)	73,0	73
Peat Swamp Forest rather closed canopy	mixed swamp forest	central Kalimantan	Waldes and Page (2001)	312	281
	low pole forest	central Kalimantan	Waldes and Page (2001)	249	
	tall interior forest	central Kalimantan	Waldes and Page (2001)	643	
	shallow peat bog	Sarawak	Bruenig (1977)	246	
Peat Swamp Forest medium open canopy	-	-	-	-	234
Peat Swamp Forest very open canopy	-	-	-	-	62
Swamp Forest rather closed canopy	freshwater swamp	Malaysia, Peninsular	Brown (1997)	220,0	220
	swamp forest	Indonesia	Garzuglia et al (2003)	211,0	
	alluvial	Borneo	MackKinnon et al. (1996)	250,0	
Swamp Forest medium open canopy	disturbed freshwater swamp	Malaysia, Peninsular	Brown (1997)	285,0	173
	logged freshwater swamp	Malaysia, Peninsular	Brown (1997)	185,0	
	logged freshwater swamp forest	Malaysia	Brown et al. (1989)	161,7	
	disturbed freshwater swamp forest	Malaysia	Brown et al. (1989)	99,2	
Swamp Forest very open canopy	-	-	-	-	44
Mangrove Forest rather closed canopy	mangrove forest	Indonesia	Garzuglia et al (2003)	187	187
Mangrove Forest medium open canopy	-	-	-	-	140
Mangrove Forest very open canopy / Young Mangrove	-	-	-	-	37
Accacia Plantation / Young Accacia Plantation	broadleaf plantation	Asia	IPCC (2006)	220	207
	Acacia decurrens Willd (12 years)	Indonesia	Suharlan et al. (1993)	194	104
Coconut Plantation	coconut plantation	Malaysia	Henson (2005)	80	80
Rubber Plantation	broadleaf plantation	Asia	IPCC (2006)	220	220
Small Holder Rubber					
Paraserianthes	Paraserianthes falcataria (12 years)	Indonesia	Suharlan et al. (1993)	242	242
Oil Palm Plantation / Young Oil Palm Plantation	oil palm plantation	South East Asia	IPCC (2006)	136	109
Small Holder Oil Palm / Small					

Carbon Stock Estimation of Merang Kepayang Area

Holder Young Oil Palm Plantation						
Forest Re-growth (Belukar) / Forest Re-growth on Swampy / Grassland / Hutan Kota / Mixed Garden / Overgrowing	Imperate cylindrica	Indonesia	de Groot et al. (2005)	5	30	
	Grassland	Sumatra, Pasir Mayang	Prasetyo et al. (2000)	12		
	Grassland	tropics	Murdiyasso and Wasrin (1995)	30		
Clear cut-Shrubs / Shrubs (Semak/Belukar Muda) / Shrubs on Swampy	Grassland	Asia	Michel et al. (2005)	13		
	Woodland	Asia	Michel et al. (2005)	100		
	Wooded grassland	Asia	Michel et al. (2005)	33		
	Closed shrubland	Asia	Michel et al. (2005)	72		
	Open shrubland	Asia	Michel et al. (2005)	16		
	Savannah	tropics	Murdiyasso and Wasrin (1995)	80		
	Savannah	tropics	Murdiyasso and Wasrin (1995)	200		
	Bush/shrub	Sumatra, Pasir Mayang	Prasetyo et al. (2000)	30		
Swamp Grasses / Fernland	-	-	-	-	44	
Mixed Agriculture / Paddy Field	Cropland	Asia	Michel et al. (2005)	51,0	56	
	Cultivated lands and secondary vegetation in,	Sumatra, Pasir Mayang	Prasetyo et al. (2000)	71,0		
	Upland rice/bush fallow rotation	Indonesia	Hairiah et al. (2001)	148,0		
	Cash crops plantation	Sumatra, Pasir Mayang	Prasetyo et al. (2000)	56,0		
	Paddy field	Sumatra, Pasir Mayang	Prasetyo et al. (2000)	15,0		
Water Body	-	-	-	-	-	
Cleared / Cleared post Accacia harvested / Cleared, for Oil Palm Plantation / Airport / Sand Mining / Sediment / Settlement / Town / Factory	-	-	-	-	-	

ANNEX III:

VegType	ForestType	Canopy Closure	LCCS Closure	%	Land coverClassName	Land coverClassDescription	LCCS_Code	LCCS_Level
Natural Forest	Dryland	Closed	closed	>65%	Natural Forest; Dryland, Closed	Closed Forest	20005	A3A10
Natural Forest	Dryland	Medium	open	65-15%	Natural Forest; Dryland, Medium	Open Forest (Woodland)	20013	A3A11
Natural Forest	Dryland	Open	sparse	15-5%	Natural Forest; Dryland, Open	Sparse trees	20052	A3A14
Natural Forest	Peat Swamp	Closed	closed	>65%	Natural Forest; Peat Swamp, Closed	Forest - Peatswamp Soils: Subsurface: Histosols	40003-N1114	A3A12-N1114
Natural Forest	Peat Swamp	Medium	open	65-15%	Natural Forest; Peat Swamp, Medium	Woodland - Peatswamp Soils: Subsurface: Histosols	40007-N1114	A3A13-N1114
Natural Forest	Peat Swamp	Open	sparse	15-5%	Natural Forest; Peat Swamp, Open	Sparse - Peatswamp Soils: Subsurface: Histosols	40027-N1114	A3A16-N1114
Natural Forest	Swamp	Closed	closed	>65%	Natural Forest; Swamp, Closed	ClosedShrubs - Swamp Soils: Subsurface: Histosols	40009-N1114	A4A12-N1114
Natural Forest	Swamp	Medium	open	65-15%	Natural Forest; Swamp, Medium	OpenShrubs - Swamp Soils: Subsurface: Histosols	40011-N1114	A4A13-N1114
Natural Forest	Swamp	Open	sparse	15-5%	Natural Forest; Swamp, Open	Sparse - Swamp Soils: Subsurface: Histosols	40029-N1114	A4A16-N1114
Natural Forest	Mangrove	Closed	closed	>65%	Natural Forest; Mangrove, Closed	Forest - Mangrove: Water Quality: Brackish	40003-R2	A3A12-R2
Natural Forest	Mangrove	Medium	open	65-15%	Natural Forest; Mangrove, Medium	Woodland - Mangrove: Water Quality: Brackish	40007-R2	A3A13-R2
Natural Forest	Mangrove	Open	sparse	15-5%	Natural Forest; Mangrove, Open	Sparse - Mangrove: Water Quality: Brackish	40027-R2	A3A16-R2
Natural Forest	Mangrove			>65%	Young Mangrove	Closed Shrubs - Mangrove: Water Quality: Brackish	40009-R2	A4A12-R2
Secondary Re-growth					Forest Re-Growth (Belukar)	Closed Shrubland (Thicket)	20017	A4A10
Secondary Re-growth				>65%	Shrubs (Semak/Belukar Muda)	Closed Shrubland (Thicket)	20017	A4A10
Secondary Re-growth					Swamp forest re-growth	ClosedShrubs - Swamp Soils: Subsurface: Histosols	40009-N1114	A4A12-N1114

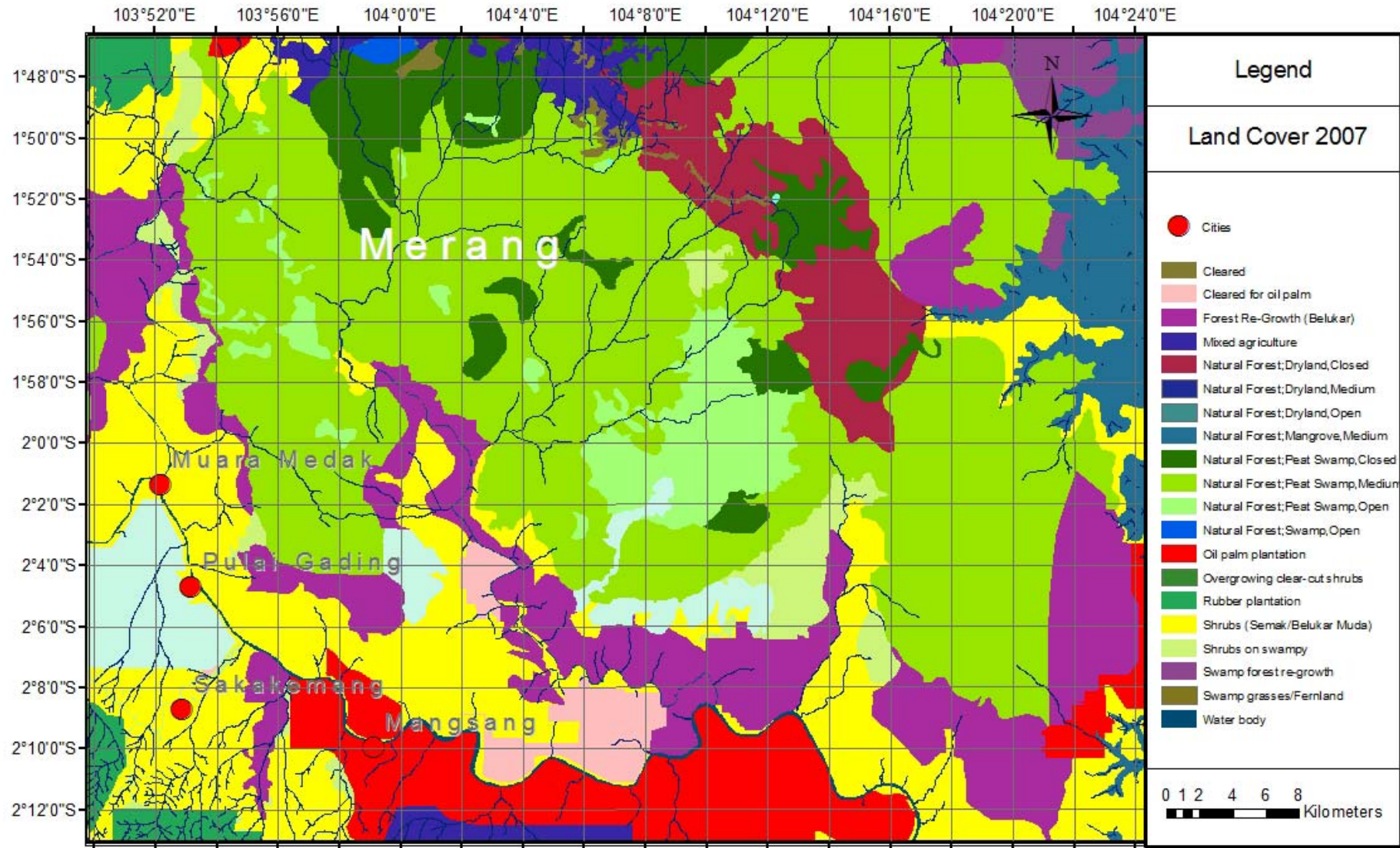
Carbon Stock Estimation of Merang Kepayang Area

Secondary Re-growth					Shrubs on swampy	Closed Shrubs - Swamp Soils: Subsurface: Histosols	40009-N1114	A4A12-N1114
Secondary Re-growth			>65%		Swamp grasses/Fernland	Closed Grasslands Soils: Subsurface: Histosols	40017-N1114	A6A12-N1114
Secondary Re-growth					Overgrowing clear-cut shrubs	Sparse Shrubs	20055	A4A14
Secondary Re-growth			>65%		Grassland	Closed Grasslands	20033	A6A10
Cultivated					Young Acacia plantation	Shrub Crop(s): Acacia: Crop Cover: Plantation(s)	10013-S1001W7	A2-S1001W7
Cultivated					Acacia plantation	Tree Crop(s): Acacia: Crop Cover: Plantation(s)	10001-S1001W7	A1-S1001W7
Cultivated					Young oil palm plantation	Shrub Crop(s): Oil Palm: Crop Cover: Plantation(s)	10013-S0909W7	A2-S0909W7
Cultivated					Oil palm plantation	Tree Crop(s): Oil Palm: Crop Cover: Plantation(s)	10001-S0909W7	A1-S0909W7
Cultivated					Small holder oil palm	Tree Crop(s): Oil Palm: Crop Cover: Orchard(s)	10001-S0909W8	A1-S0909W8
Cultivated					Small holder young oil palm plantation	Shrub Crop(s): Oil Palm: Crop Cover: Orchard(s)	10013-S0909W8	A2-S0909W8
Cultivated					Mosaic of small holder oil palm and rubber	Tree Crop(s): Dominant Crop: Hevea: 2nd Crop: Oil Palm: Crop Cover: Orchard(s)	10001-S0905S0909W8	A1-S0905S0909W8
Cultivated					Rubber plantation	Tree Crop(s): Hevea: Crop Cover: Plantation(s)	10001-S0905W7	A1-S0905W7
Cultivated					Small holder rubber	Tree Crop(s): Hevea: Crop Cover: Orchard(s)	10001-S0905W8	A1-S0905W8
Cultivated					Coconut plantation	Tree Crop(s): Coconut: Crop Cover: Plantation(s)	10001-S1001W7	A1-S1001W7
Cultivated					Mixed agriculture	Herbaceous Crop(s)	10025	A3
3 5 Cultivated					Mixed garden	Small Sized Field(s) Of Herbaceous Crop(s) (2 add. Crops: Tree and Shrub Crops with Simultaneous Period). Crop type: Food Crops	10110-12663--S1	A3B2B5C2-C4C9C17C14C17-S1
3 6 Cultivated					Paddy field	Graminoid Crop(s): flooded	3001	A1
						Graminoid Crop(s): flooded: Rice	3001-S0308	A1-S0308
3 7 Non Vegetation					Cleared for Acacia	Consolidated Material(s)	6001	A1
3 8 Non Vegetation					Cleared for oil palm	Consolidated Material(s)	6001	A1
3 9 Non Vegetation					Cleared	Consolidated Material(s)	6001	A1

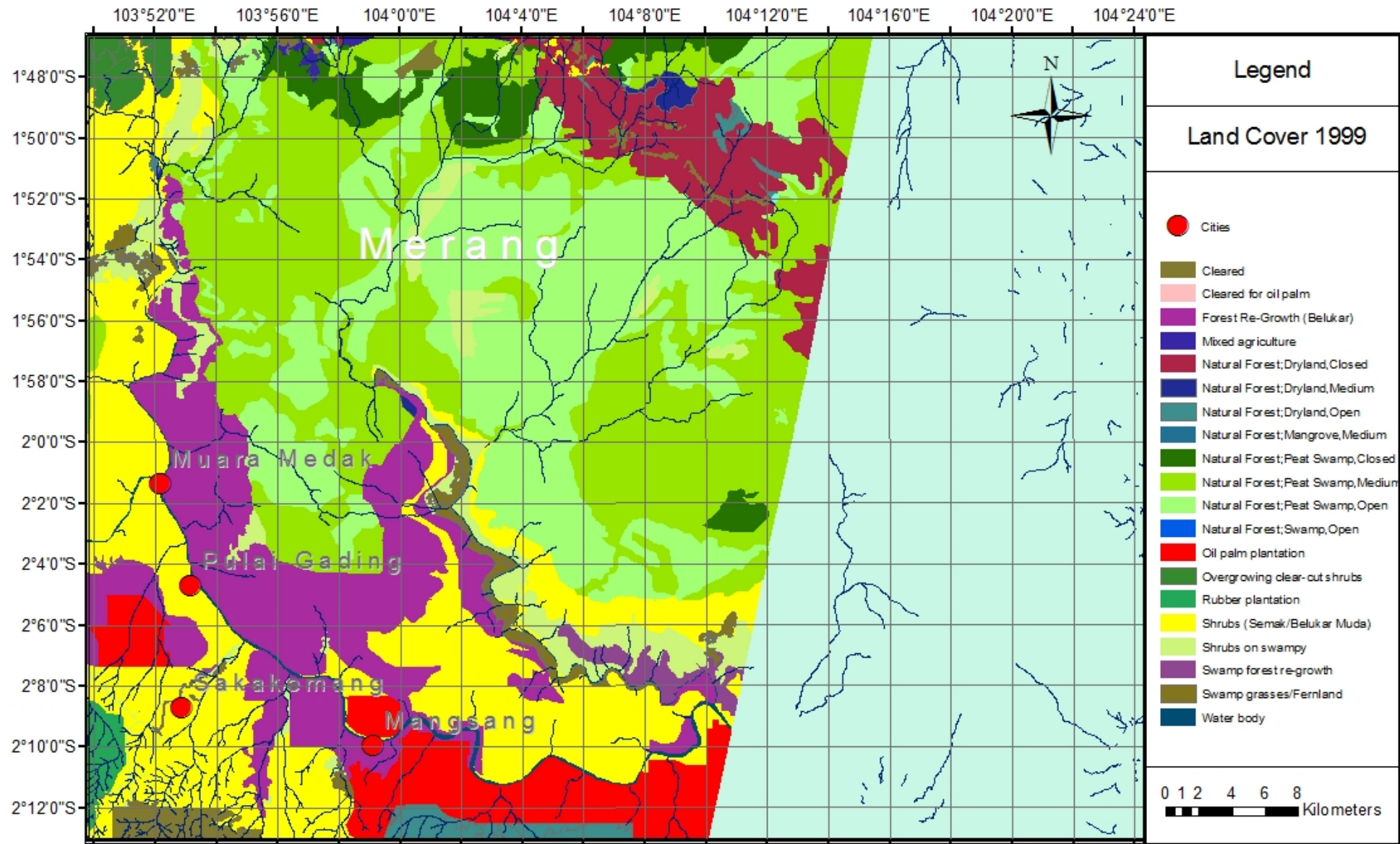
Carbon Stock Estimation of Merang Kepayang Area

4 0 Non Vegetation					Sand mining	Non-Built Up Areas: extraction site	5004-2	A2-A6
4 1 Non Vegetation					Burnt	Consolidated Material(s)	6001	A1
4 2 Non Vegetation					Sediment	Consolidated Material(s)	6001	A1
4 3 Non Vegetation					Water body	Natural Waterbodies	8001	A1
4 4 Non Vegetation					Town	Built Up Areas: town = medium density	5003-14	A4-A13A15
4 5 Non Vegetation					Settlement	Built Up Areas: settlement = low density	5003-15	A4-A13A16
4 6 Non Vegetation					Factory	Built Up Areas: heavy industry	5003-8--A21	A4-A12-A21
4 7 Non Vegetation					Airport	Built Up Areas: airport	5003-8--A30	A4-A12-A30
4 8 Non Vegetation					Fishpond	Artificial Waterbodies: shallow (fishpond?)	7013-5	A1B1C2-A5
4 9 Non Vegetation					Mill-oil	Built Up Areas: light industry	5003-8--A27	A4-A12-A27
5 0 Non Vegetation					No data	No Data	No Data	No Data

ANNEX IV



Carbon Stock Estimation of Merang Kepayang Area



Carbon Stock Estimation of Merang Kepayang Area

