Proceedings of International Symposium on Wild Fire and Carbon Management in Peat-Forest in Indonesia

13 - 14 September 2012

Novotel Bogor, West Java INDONESIA

Collaboration among

Proceeding of International Symposium on Wild Fire and Carbon Management in Peat-Forest in Indonesia

13-14 September 2012, Novotel Bogor, West Java INDONESIA

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July 2013

Preface

The importance of peat as a source of carbon emissions has gained greater recognition globally. The carbon release from tropical peatland represents a unique and predominantly Indonesian challenge, as Indonesia holds approximately 50 percent of the total tropical peat area. Currently emission from peatland represents 38 percent of Indonesia's total emissions and will continue to remain a dominant portion in 2030 (at 30 percent) if there is no siginificantly action undertaken. Under the business-as-usual scenario, emission from peatland is expected to increase by 20 percent, from 772 MtCO2e in 2005 to 972MtCO2e in 2030. Indonesia's tropical peatland covers only 5% of the global peatland area, but it contributes more than 50% of the world emission, originated from tropical peatland. Peatlands all over the world are facing similar problems, threatened by drainage and uncontrolled fires. According to available data and information, in Indonesia more than 300,000 hectares of peatlands are degrading annually, resulting in degraded peat area of approximately 10 million hectares.

The "Wild Fire and Carbon Management in Peat-Forest in Indonesia" project has been conducted by JST-JICA in conjunction with Indonesian authorities to initiate a carbon management system in the peatlands of Central Kalimantan Province since 2008. Since remarkable progress has been made on the project, the International Symposium was held to share updated information and experiences on project activities. The goal of this workshop are: (1) synthesize knowledge on past, present and future trends relating to wildfires and the carbon management of peat-forest; (2) provide information on the possible impacts of climate change, as well as guidance for stakeholders in the area of planning, implementation and scenarios (REDD-plus, etc.); and (3) compile a roadmap that provides a short to long term vision on research needs. More than 200 participants from 8 countries (Indonesia, Japan, UK, Germany, Malaysia, Myanmar, Bhutan, and South Korea)attended the International Symposium on "Wild Fire and Carbon Management in Peat-Forest in Indonesia" in Bogor representing various research institutes, universities, private companies, bilateral projects, national and local government levels.

53 oral presentations and 41 posters have been shared in the following sessions:

The 1st day: *Thursday, 13 September 2012*

- Session 1 (FF): Remote Sensing, Carbon and Ecosystem Management of Tropical Peatland
- Session 2 (CA): Evaluation of Carbon Storage and Carbon Flux of Tropical Peatland
- Session 3 (CM): Sustainable Management of Carbon, Biodiversity and Ecosystem of Tropical Peatland
- Session 4 (PM): Integrated Tropical Peatland Management
- Posters Presentation

The 2nd day: *Friday, 14 September 2012*

- Special Talk: The role of peatlands in the fight against climate change
- Special Session 1: National Policy And Demonstration Activities on REDD+ Mechanism

- Special Session 2: Policy Assessment And Evaluation Modeling On Environment And Ecosystem
- Special Session 3: Challenging Of REDD+ and Forest Management Activities In Asian Countries
- Special Session 4: Capacity Building & Kalimantan University Consortium
- Posters Presentation

During the workshop, eight awards were given to the best posters on the specific poster presentation period and selected by all of participants of the International Symposium on "*Wild Fire and Carbon Management in Peat-Forest in Indonesia*" 2012:

- The 1st Best Poster: "*The dynamic of carbon stocks in peatland forest*" by Haruni Krisnawati (Indonesia-Australia Forest Partnership, INDONESIA)
- The 2nd Best Poster: "*Tropical Peat Fire Characteristics in Kalimantan using MODIS hotspot and imagery data*" by Nina Yulianti (UNPAR, INDONESIA)
- The 3rd Best Poster: Mohammad Fathi Royyani (Research Center for Biology-LIPI, INDONESIA)
- The 4th Best Poster: "*Geologic fundamental of "Pasir Putih (PP) Formation(s)" Central Kalimantan, Indonesia (CKI)*" by Hu Sung Gi (Raax. Co., Ltd, JAPAN)
- The 5th Best Poster: "*Humic acid induces the endothelial NO syntheses activation via Hsp90 upregulation in human umbilical vein endothelial cells*" by Masato Tanaka (Hokkaido Univ., JAPAN)
- The 6th Best Poster: "*Biomass production on the Changes of Forest to Palm Oil Plantation in Hampangen, Central Kalimantan*" by Laode Alhamd (Indonesian Institute of Sciences, INDONESIA)
- The 7th Best Poster: "*Medicinal plant in Baun Bango Village-Central Kalimanntan: a local knowledge*" by Vera Budi Lestari Sihotang (Indonesia Institute of Sciences, INDONESIA)
- The 8th Best Poster: "*Moisture behavior of the surface peat layer in areas of different plant cover and ground conditions during the dry season in peatland in Central Kalimantan*" by Adi Jaya (UNPAR, INDONESIA)

Finally, we would like to extend our sincere appreciation to the invited speakers (oral and poster presentations), session chairs and all participants. We are grateful to the Indonesian Institute of Sciences, JST-JICA, Workshop`s Steering Committee and Organizing Committee; for their kindness contributions and support to the success of this important workshop.

Sapporo, 1 August 2013

Prof. Dr. Mitsuru Osaki
Editor-in-Chief

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OPENING REMARKS OF JICA SENIOR REPRESENTATIVE ON INTERNATIONAL SYMPOSIUM ON WILD FIRE AND CARBON MANAGEMENT IN PEAT-FOREST IN INDONESIA

Good morning,

On behalf of Japan International Cooperation Agency (JICA), I am pleased to deliver remarks on the occasion of "International Symposium on Wild Fire and Carbon Management in Peat-Forest in Indonesia". This symposium is held under the project of JICA-JST "Wild Fire and Carbon Management in Peat-Forest in Indonesia" with cooperation of BSN (National Standardization Agency), Palangkaraya University, LIPI and other related agencies.

This symposium's theme is "Wild Fire and Carbon Management in Peat-Forest in Indonesia" which is globally receiving remarkable attention in these days. We, JICA has dedicated climate change countermeasure with close cooperation with Government of Indonesia such as BAPPENAS, Ministry of Finance, DNPI, Ministry of Forestry, Ministry of Environment, REDD+ Task Force and other related agencies based on "Bilateral Cooperation on Climate Change Between the Government of Japan and the Government of Indonesia" issued by both governments on November 2011.

Our cooperation with Government of Indonesia on climate change is extensive and integrative to cover policy support, field activities and research collaboration both on mitigation and adaptation such as regional action plan formulation for mitigation, national action plan formulation for adaptation, vulnerability assessment in Bali, Greenhouse gas inventory, policy assessment on key issues and so forth.

We are also starting new cooperation with Ministry of Forestry on REDD+ in West Kalimantan and Central Kalimantan hopefully from January. In this project, we will attach special importance to forest fire and peat land conservation as these issues are directly connected to GHG emission especially in Kalimantan area. We realize importance of research cooperation especially on forest fire and peat land conservation in the context of climate change and REDD+ issues. In today's symposium, we welcome a wide range of Indonesian and international experts from various organizations.

I hope that today's symposium will be an opportunity to obtain further idea for promoting climate change countermeasure and enhancing the cooperation between respective organizations and projects. I wish a successful symposium today and I would like to express my special appreciation to LIPI for hosting today's symposium.

Thank you.

Japan International Cooperation Agency, Japan

INTERNATIONAL SYMPOSIUM ON WILD FIRE AND CARBON MANAGEMENT IN PEAT FOREST IN INDONESIA

The Honorable,

Minister of Japanese Embassy/ minister of Embassy of Japan, Representatives of the Japan International Cooperation Agency (JICA), Representatives of the Japan Science and Technology Agency (JST). Representatives of National Standardization Body (BSN), National Institute of Aeronautics and Space (LAPAN), Palangkaraya University, the Agency for the Assessment and Application Technology (BPPT), and Minister of Forestry. Distinguished Guests, Speakers and Participants,

Ass.Wr. Wb. and Good Morning

It is great pleasure for me to have an opportunity to join you in the opening ceremony of "International Symposium on Wild Fire and Carbon Management in Peat-Forest in Indonesia". This is a great event to the future to give the contribution to the Science especially related to the Climate Change. This symposium could also behave as the media of exchanging research knowledge, views, and technical expertise in studying, evaluating and maintaining the wetland area.

On behalf of The Indonesian Institute of Science (LIPI) allow me to welcome you all to the rainy city Bogor. Special warmth welcome is extended to the participants of the symposium; it is an honor for me to be here with you to join this symposium. I really appreciate for today symposium has received enormous supports from many National and International Institutions.

Distinguish guest ladies and gentlemen,

Natural lowland tropical peatlands are dominated by trees and become important reservoir of biodiversity, carbon and water. Tropical peat swamp forests in their natural state make an important contribution to regional and global biodiversity and provide vital, but undervalued habitat, for rare and threatened species, especially birds, fish, mammal, amphibians and reptiles. The increased awareness of CO2 emission has created strong political support for reducing deforestation and peatland degradation (REDD: Reducing Emission from Deforestation).

We realize that the lack of scientific data on the wild Fire and Carbon in the peat forests in Indonesia is crucial in order to combat climate change. Therefore we develop research collaboration project in wetland especially on forestry, carbon and various research topics that wish to contribute to forests worldwide.

I am very confident that this symposium will be an important meeting to increase our expertise as well as to strengthen our networking for the fruitful cooperation among experts. I am sure it will lead to the improvement of carbon and wild fire data resources in Indonesia and support the International data especially for climate change.

On this occasion I wish to stress this symposium is also significant for the young experts to have opportunities to hone their skills and gain addition knowledge in their field of expertise.

Distinguish guests, ladies and gentlemen,

Finally, on behalf of the Indonesian Institute of Sciences, I would like to acknowledge the generous support from Japan International Cooperation Agency (JICA), Japan Science and Technology Agency (JST), Hokkaido University and Palangkaraya University. I would also like to express my gratitude to the Deputy of Life Science and the head of Research Center for Biology to organize and host this course. My deep appreciation is extended to all participants. I hope the members of the symposium will continue to communicate and strengthen the collaboration to increase our understanding on the wetland management and to protect biodiversity especially in the wetland ecosystem.

Conclusively, I do hope the symposium would be rewarding and success. And through this occasion, please allow me officially to declarethe commencement of the “International Symposium on Wild Fire and Carbon Management in Peat Forest in Indonesia”.

Thank You

Wass. Wr. Wb.

Chairman of Indonesian Institute of Sciences

Prof. Lukman Hakim.

RELATING GROUND FIELD MEASUREMENTS IN INDONESIAN PEAT SWAMP FOREST WITH MULTI-TEMPORAL AIRBORNE LIDAR MEASUREMENTS

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In August 2007 and 2011 we mapped by helicopter the main research transect from the Center for International Cooperation in Sustainable Management of Tropical Peatland (CIMTROP) with airborne Light Detection And Ranging (LiDAR) Technology (LMS-Q560) in Central Kalimantan, Indonesia. In this study, our main objectives were to report some of our activities during the multi-temporal LiDAR survey and to attempt the retrieval of above ground biomass (AGB) with LiDAR measurements. Preliminary results show that in this relative undisturbed peat ecosystem the average tree-height increased from 15.32m to 17.18m during the four years interval. Relative peat subsidence has been verified during the period by analyzing the bi-temporal digital elevation models (DTMs). Relative forest degradation by illegal logging and hunting were also identified by the visual interpretation of high-resolution orthorectified photographs and canopy height models (CHMs). AGB were retrieved satisfactory using cloud point analysis, allometric equations and *in-situ* measured ground measurements. The presented LiDAR-methodology can be promising in the frame of the REDD+ (Reducing Emissions from Deforestation and forest Degradation) knowledge of tropical peat swamp forests. The LiDAR technology supports the MRV aspect of REDD+ (Monitoring, Reporting, and Verification).

Keywords**:** Peat Swamp Forest, LiDAR, airborne laser scanning, REDD and EMRP

Introduction

Tropical Peat Swamp Forests (PSF) are known for their rich biodiversity and underground carbon reservoirs (Page et al., 2002). Oil palm plantation, forest logging and excessive drainage have been contributing for the decreasing of this particular ecosystem in Indonesia. The increasing interest for understanding these endangered environments in an ecological point of view is due to the high release rates of CO_2 into the atmosphere by degradation (Sorensen 1993, Jaenicke et al. 2008). Furthermore, degraded ecosystems and large deforested areas of PSF have been also reverted to different succession forest stages.

According to Hyde et al. (2007) airborne Light Detection and Ranging (LiDAR) is nowadays the best single sensor to characterize vertical structure of vegetation and to retrieve with relative good accuracy the ground surface under dense vegetated areas. Additionally, with a good characterization of the ground surface and the upper surface of the vegetation some biophysical parameters (e.g. tree height) can be characterized (Hajnsek et al., 2009).

In PSF areas the great variety of tree species and its ecological rule is still not fully understood. The influence of selective logged areas on global change issues also remain a big challenge. Consequently, a better understanding of how LiDAR measurements can be used for ecological studies in such critically endangered forests is still necessary.

In August 2007 and 2011 we mapped by helicopter different PSF locations with LiDAR Technology (LMS-Q560) in Central Kalimantan, Indonesia. In this study, our objectives were: a) to report some of our activities during the multi-temporal survey; and b) to attempt the retrieval of above ground biomass (AGB) with LiDAR measurements.

Study Area Description

Our study area consists on the main research transect from the Center for International Cooperation in Sustainable Management of Tropical Peatland (CIMTROP) (Figure 1). This transect is located inside the *Sabangau* National Park (SNP). The main CIMTROP transect was surveyed by airborne LiDAR technology during August 2007 and 2011. The PSF over the region were impacted with extensive logging activities in the 90s and by the implantation of the Ex-Mega Rice Project (EMRP). The failed EMRP with its 4000km channel system leads to severe peat damages with reasonable amount of carbon released to the atmosphere, especially during peat fires in 1994, 1997, 2002, 2006 and 2009.

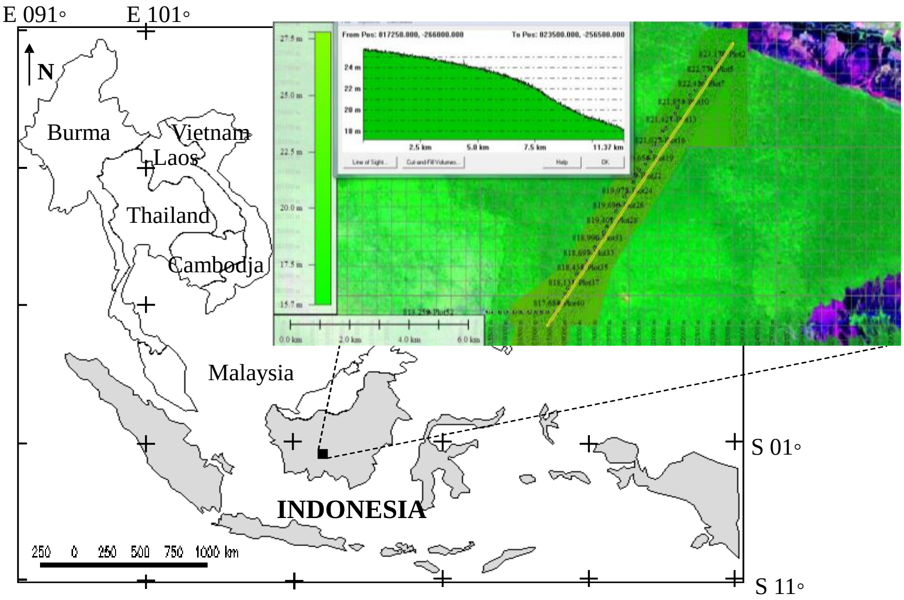

Figure 1. Study area location with detail to the main CIMTROP transect surveyed by LiDAR. The subset shows a Landsat image with the overlay of the LiDAR datasets. A profile of the digital terrain model (DTM) is shown in the upper left part of this figure.

According to MODerate Imaging Spectroradiometer (MODIS) products, the leaf area index (LAI) of the logged peat swamp forest at the region is in average $5m^2 \cdot m^{-2}$ what is coincident with the *in-situ* derived measurements with hemispherical photographs. Burnt scars, small agricultural fields, small villages and actual degraded forest resultant from selective logging can be also observed in the surroundings.

Material and Methods

LiDAR data processing

The main CIMTROP' transect was surveyed by airborne LiDAR on August 2007 and 2011. The number of laser beams per square meter ranged from 1.4 to 3. The flight altitude was 500m with a scan angle of 60° and a swap-width of 500m (Boehm et al. 2007, 2008, and 2012). In this analysis only the first and last pulse echoes were recorded. The Laser scanner had a pulse rate varying from 66kHzto 100kHz with a beam divergence of 0.5mrad giving therefore a footprint of ca. 0.25m. The ground backscattering in PSF through the canopy was responsible for 1 to 3% of the 0.5mrad laser beams. The Riegl LMS-Q560 airborne Laser scanner system itself allows height measurements with an accuracy of ±0.02m. After the correction of the attitude of the helicopter, the elevation accuracy of each Laser beam was ±0.15m with a root mean square error (RSME) of ±0.5m in both x- and y-direction.

Since the echoes were not labelled as belonging to either first or last pulse echo, all echoes were considered under the Kraus and Pfeifer (1998) classification method. After exhaustive tests and parameters configuration settings as well as residual analysis (i.e. residual vegetation) the results were finally divided into ground surface and non-ground surface points. The heterogeneous and complex nature of the peat surface characterization using LiDAR data has also been reported by Kronseder et al. (2012). The processed points were then interpolated using the inverse distance weighting (IDW) and converted in order to digital terrain model (DTM) and digital surface model (DSM), respectively, at a spatial resolution of 1m.

A canopy height model (CHM) was determined by subtracting the DSM and the DTM. By subtracting the two DTMs and CHMs (i.e. 2011 minus 2007), temporal changes in both peat surface and canopy height could be assessed. The CHM representative for 2011 was smoothed and submitted to the local maximum filtering method (Hyyppä et al., 2001). Different windows sizes were experimented ranging from 3×3 to 11×11. Smaller windows size of 3×3 and 5×5 were more efficient for the retrieval of individual trees in the CMH. However, a better assessment with aerial orthorectified high resolution photographs still has to be performed.

Field Measurements

Field survey was performed coincident to the LiDAR acquisition in 2011. A total of 52 sample plots were inventoried and characterized mainly in terms of tree height and diameter at the breast height (DBH). The information was used to evaluate relationships between these two parameters for different PSF physiognomies (Figure 2). In this figure, the relationship between tree height and DBH are shown for three sample plots measured in different locations of the transect.

The relationship between tree height and DBH was then applied over the extracted trees. With this procedure, a simulated DBH for each single extracted tree could be determined. The LiDAR' derived tree height and DBH were then used as input parameters for the calculation of the AGB. Since there is little information available in the literature about the best allometric equation for PSF, we decided to analyze the two main allometric equations employed in humid tropical environments (Table 1).

Table 1. Allometric equation evaluated for humid tropical rain forest environments

Allometric Equation	Author	Eq.
$AGB = \rho \times exp^{[-1.499+2.14\ln(DBH)+0.207(\ln(DBH^2)-0.0281(\ln(DBH^3))]}$	Chave et al. (2005)	1
$AGB = exp^{[-2.13+2.53\times\ln(DBH)]}$	Brown (1997)	2

Note: AGB is above ground biomass. ρ is the wood specific gravity factor ($g \cdot cm^{-3}$).

In order to solve this difficulty, we selected the equation proposed by Chave et al. (2005) rather than that one proposed by Brown (1997) (Table 1). This is because of the exponential increase in biomass after a DBH of 20cm (Figure 3). As a result, AGB values would be higher than 500 $Mg \cdot ha^{-1}$ in certain areas that seems unrealistic for the local condition. Hence, the Chave formulation allows the computation of both tree height measurement and DBH. Whereas the Brown' formulation accounts only for DBH. However, a better assessment based on destructive methods was beyond of the Scopus of this research. A flowchart of the proposed methodology can be found in Figure 4.

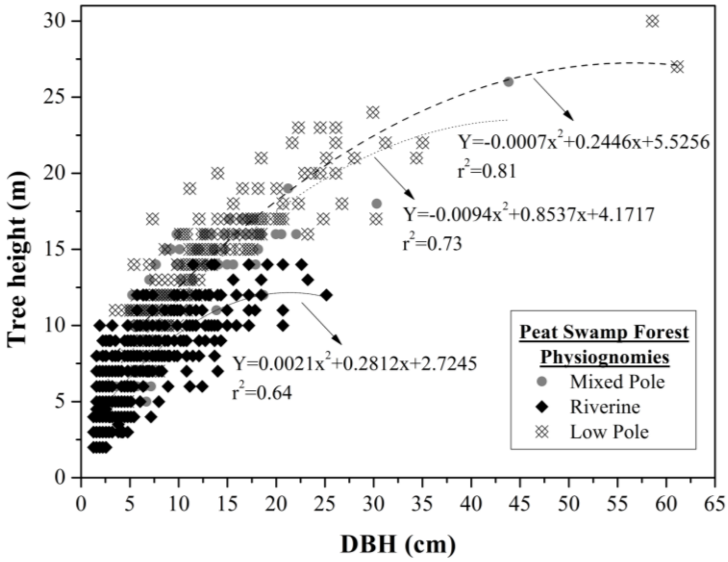

Figure 2. Relationships between the *in-situ* measured tree height and DBH for three different PSF physiognomies

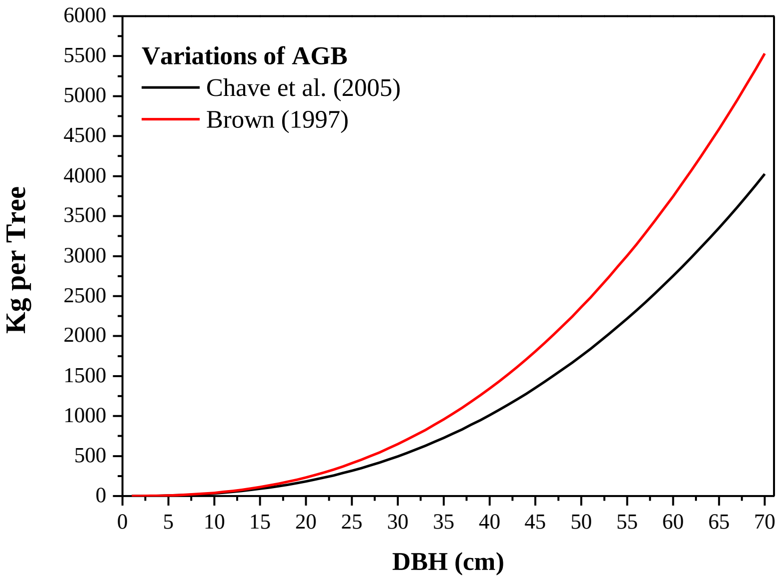

Figure 3. Variations of the individual biomass value according to the increasing of DBH for two different allometric equations. The above AGB represents the dry biomass (kg·tree^{-1})

Results and Discussion

Figure 4 shows the spatial distribution of the LiDAR extracted single trees over a selected CHM subset. In general, the number of *in-situ* measured trees is much higher to those measured by LiDAR. This is most probably due to the canopy architecture introduced usually by three well-structured canopy layers that makes a direct relationship with the *in-situ* ground measured trees a challenge. The use of emergent trees, dominant trees and DBH thresholds are therefore necessary. In summary, the comparison of the number of LiDAR detected trees with the field measurements revealed an error of up 23% per ha when a DBH threshold of 15cm is applied (Figure 4). However, a better assessment is still necessary.

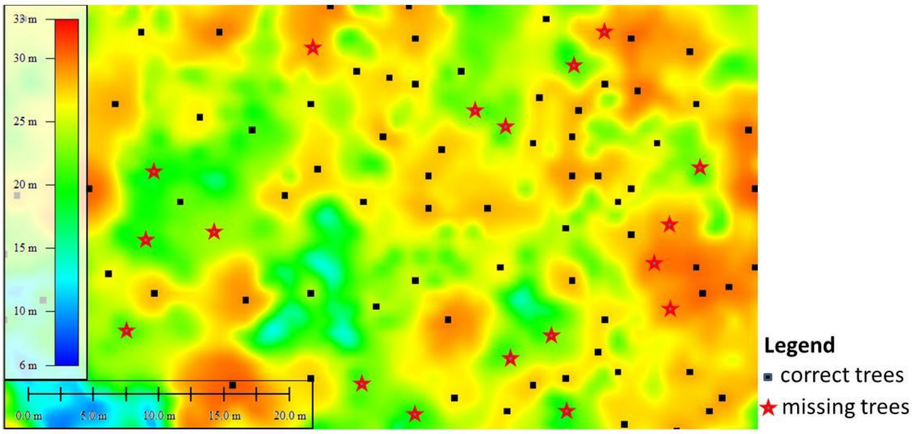

Figure 4. Spatial distribution of the LiDAR derived trees over a selected CHM

Figure 5 shows the AGB for the study area in 2011. The lowest values of AGB were found parallel to the former railway track used in the past for selective logging exploitation (Figure 5). As a result of the extensive log exploitation only small trees with low tree height and DBH values were most probably left. On the other hand, the highest AGB values were encountered in the middle part of the LiDAR transect. This region accounts for the highest slope of the peat dome where a considerable number of medium and tall trees are found. Ecological insights and hydrological aspects are under development by the authors and should be release soon.

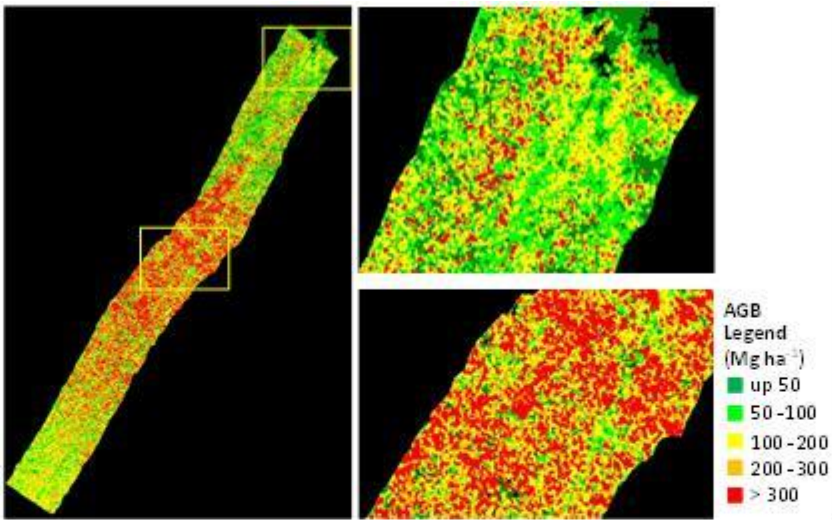

Figure 5. Spatial distribution of the above ground biomass (AGB) over the main CIMTROP research transect for the year 2011. The detailed spatial distribution of the AGB is shown in two selected subsets

The forest regrowth was in average 1,9m in the period of four years (e.g. 17.2m in August 2011 minus 15.3m in August 2007) (Boehm et al. (2012). The significant regrowth of the PSF is most probably due to the construction of small dams and rewetting initiatives inside the SNP. However, visual interpretation with RGB images acquired simultaneously with the LiDAR survey in 2011 reveal that there are tree dieback most probably caused by small illegal logging activities. Consequently, continuous PSF monitoring is still necessary. Yet, a better assessment of AGB and their dynamics over time will be performed in this transect for the different PSF physiognomies.

Conclusion and Future Work

LiDAR has been shown to provide useful information concerning the current status of the PSF. Since peatlands act usually as a carbon sink, human interventions due to drainage practices for agriculture and selective logging of the peat swamp forest may have a stronger impact in the carbon release to the atmosphere. Such aspects still have to be investigated in all surveyed LiDAR transects.

The apparent forest regrowth in the four year period shows the resilience capability of the peat swamp forest when policy activities are being undertaken. This is a clear sign for the establishment of new conservation units as well as a continuous forest monitoring by means of remote sensing technology.

Nonetheless, further research is still going on by our team in order to understand better the retrieve of biophysical parameters in different PSF using both single trees detection and LiDAR metrics derived by point cloud. We also intend to analyse feature selection techniques for LiDAR data.

Additionally, we want to analyse change detection techniques as well as seasonal characterization with multi-temporal synthetic aperture radar (SAR) data for the estimation of such parameters in large areas. LiDAR-methodology showed promising results in the frame of the REDD knowledge of tropical forests (Reducing Emissions from Deforestation and forest Degradation).

Acknowledgement

We would to thank Prof. Dr. Tatsuo Sweda from the Ehime University (Japan) for the 2011 dataset. Additionally we would to thank Milan Geoservice GmbH for the good cooperation during the LiDAR flight campaign. The second author is supported by CNPq/Brazil at TU Freiberg for PhD research and was responsible for the *in-situ* measurements.

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RECENT FOREST FIRE TRENDS IN INDONESIA

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The purpose of this study was to elucidate fire prone areas, their fire intensity, and monthly change of fire occurrence by using a grid system with one degrees latitude and longitude cell size and MODIS hotspot data for ten years (2002-2011) covering the whole of Indonesia.

Keywords**:** fire period, hotspot, MODIS, MRP, peat fire.

Introduction

Indonesia ranks eighth of the world's largest forest and has the largest peatland in Southeast Asia. Total forest area covers 50% of Indonesia land (~940,000km^2) and approximately 12% of the land is peatland (~200,000km^2). Both tropical rainforest and tropical peatland are able to sinking about 25,500Mt and 55,000Mt carbons, respectively (Hooijer *et al.*, 2006; FAO, 2010; Gibbs *et al.*, 2007; Page *et al.*, 2011). Since 1950s, legal and illegal logging contributed on 30% of tropical forests loss in Indonesia. For instance, the Mega Rice Project (MRP) converted large peat swamp forest (PSF) in the southern part Kalimantan (>10,000km^2) in mid-1990's. Continued to mid-2000s, total deforested area reached 28,600km^2 together in Sumatera and Kalimantan because extensive agriculture growth (FWI/GWF, 2002; Broich *et al.*, 2011; Hansen *et al.*, 2009). However, newest report stated that deforestation rate was declined from 1.75% of 1990's to 0.51% of 2000's (FAO, 2010) but its adverse effects on the environment was severe until now. The change of ecology after forest loss result such uncontrolled forest and peat fire in lasts century. Instead of deforestation issue, the fires became one of big problem for an execution of Reducing Emissions from Deforestation and Forest Degradation plus (REDD+) in Indonesia. This mechanism asked Indonesia should be enhancing its carbon storage sources and decreasing carbon emission. To support REDD+ goal, the comprehensive study related to fire and its characteristics is needed.

Fires are not a part of natural processes in the tropics but it has a long history in Indonesia. The fire occurrence in Indonesia could divide into three phases. Firstly, the ancient fire was between BC 6400 years to 700 year ago that strongly related to climate variability (Yulianto *et al.*, 2004; Hope et al., 2005; Goldammer & Seibert, 1989; Haberle *et al.*, 2001). Secondly, fire-caused El-Nino Southern Oscillation (ENSO) incident occurred in 1982/83, 1987, 1991, 1994, and 1997/98 (Woster *et al.*, 2011; Dennis, 1999; Field *et al.*, 2009). Lastly, the 21th century fire that closer to human influences and more frequently (Langner & Siegert, 2009; Putra *et al.*, 2008; Page *et al.*, 2009). These fires tend to produce an excessive amount of carbon dioxide (CO_2), carbon monoxide (CO) and others Greenhouse Gasses. The worst 1997 fire released about 810-2 570Mt Carbon (C). Further, CO_2 emission from peat fire only in MRP was estimated about 10-320Mt. The assessment of Carbon Dioxide Analysis Center (CDAIC) showed total CO_2emission in Indonesia in 2008 was 406.029Mt, increasing about 280% compare than from 1990's includes CO_2 emission from fuels consumption, deforestation, and forest fire (Heil et al., 2006; Putra, 2010; Page et al., 2002; UN Statistics 2011). As a result, Indonesia has ever recorded as one of top carbon emitter after China and US. In addition, dense haze during annual fire was responsible to serious air pollutant across Southeast Asia.

Nevertheless, the awareness of tropical burning problem was yet obtains considerable attention due to lack of updates, accurate, and detailed data. The oldest fire data of Ministry of Forestry (MoF) such burn area in forest area were started from 1984 (Putra *et al*., 2008). The limitation to conduct an fire detection and monitoring because many difficulties during or after fire event such as hazardous conditions, un- accessible areas, limited human resources, time consuming, and costly. The use of satellite-based likely more able to comprehend thoroughly fire activities inside forest areas and also in large peatland areas. Since 1997, NOAA-AVHRR satellite detected hotspot occurrence across western Indonesia under cooperation of MoF and JICA- FFPMP (Japan International Cooperation Agency-Forest Fire Prevention and Management Project) (Dennis, 1999). One pixel of NOAA hotspot is about 1.1×1.1 km^2; indicates a fire and fire within area. Then, Siegert and Hoffmann (2000) using this device to studied forest fire in East Kalimantan in ENSO 1998 but they found little disappointing result related to false alarming and low detection-caused clouds.

In 2002, the MODIS on board TERRA and AQUA satellite started to cover the whole Indonesia. The daytime and nighttime active fire detection of both satellite (MOD14 and MYD14) developed using contextual algorithm of brightness temperature from 4μm and 11μm channels. The method possible to observe a small flaming and smoldering combustion nearly $50m^2$ hotspot under calm weather, homogeny land surface, near nadir and in pristine condition (Justice *et al*., 2002; Giglio *et al*., 2003; Giglio, 2010). Further, NASA collaborated with University of Maryland used two online systems to facilitate the data globally as follows MODIS Rapid Response and Fire Information for Resources Management System (Davies *et al*., 2003). So far, only a few studies focused to use this device particularly in tropical countries. Csiszar *et al*. (2005) and Giglio *et al* (2006) only investigated global fire distribution in early MODIS coverage whereas other studies emphasized fire activities more regionally and locally as well (Hoscillo *et al*., 2011; Langner & Siegert, 2009; Tansey *et al*., 2008). Then, our study used time series of MODIS hotspot data to grasp fire tendency from national to local scale in Indonesia intensively.

We will use analysis using several grids of latitude and longitude for various analysis purposes. However, in this preliminary analysis, one degrees grid was used to grasp recent fire trend in Indonesia. We discussed fire distribution, fire season, and effect of weather factor on fire for yearly and monthly. The final results will not only support pilot project of the initial phase of REDD+ but also help future strategies in order to both reduce CO_2 emission and design wise land use in Indonesia.

Methods

Study Region and Analysis Grid Cells

The study used 10 years of MODIS data covering the area from north latitude 6^o to south latitude 11^o and from east longitude 95^o to 142^o. A map of the area of the study, the whole of Indonesia, with the forest and peat distribution superimposed, is shown in Figure 1. Several cell sizes were used in this analysis, all utilizing latitudes and longitudes as the basis for the grid in the identification of locations across Indonesia. Cell sizes with side lengths from 1 to 0.01 degrees were evaluated as shown in Table 1. For simplicity, the cell side lengths were based on latitude and longitude, and the area of cells differs depending on latitude. Representative lengths and areas for various cell sizes are detailed in Table 1. The actual size of various grid cells is shown on the map of MRP (Mega Rice Project in Central Kalimantan) in Figure 2, where the five blocks of the MRP (A, B, C, D, and E) are colored differently.

By using this analysis grid cell scheme, hotspots were tallied depending on their latitude and longitude. In this paper, the hotspot density unit uses “cell” instead of km^2, “hotspots/cell” was used to enable a simple comparison with various hotspot values such as annual, monthly, and mean number of hotspots in various regions composed by multiple cells. Conversion from hotspots/cell to a general hotspot density unit of "hotspots/km^2" can be obtained by dividing the number of hotspots in one cell by the cell area of around 12,300km^2. The inter-cell difference in Indonesia is small less than about 1.5% difference between cell areas at the equator and at 10^o south latitude.

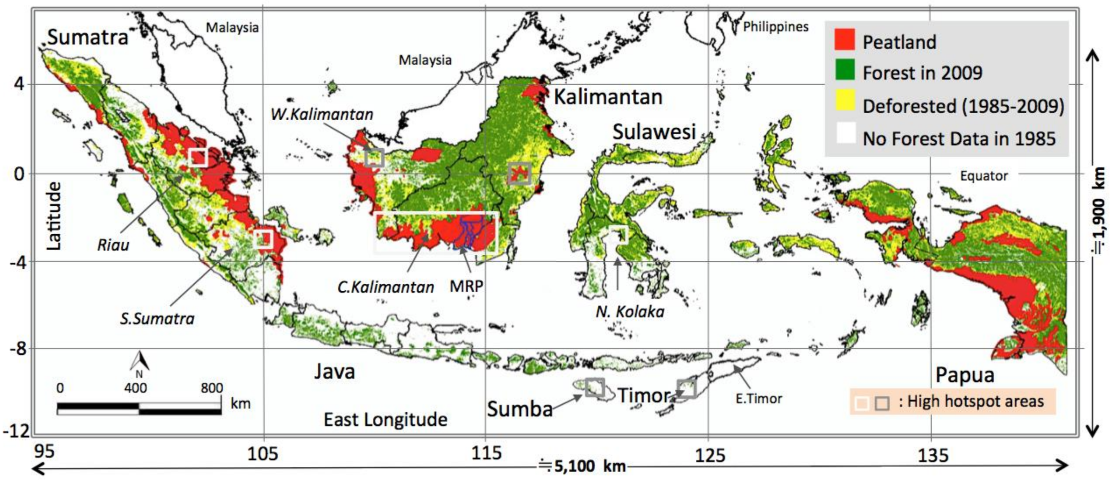

Figure 1. Peat, forest, and deforested area distribution map for Indonesia (Map data derived from GWI/GFW, FAO, Wetland, and BAKORSURTANAL)

Table 1. Summary of analysis grid cells

Grid Cell Size (Degree of Lati. & Long.)	Representative Length & Area (One Degree at Equator)		Target	Maximum Number of Grids
	Length (km)	Area (km^2)		
1 x 1	111.3	12,387.7	Whole Indonesia	846
0.5 x 0.5	55.7	3,096.9	Kalimantan, etc.	3,384
0.1 x 0.1	11.1	123.9	MRP, etc.	84,600
0.05 x 0.05	5.6	31.0	Village, etc.	338,400
0.01 x 0.01	1.1	1.2	Plantation, etc.	8,460,000

*Note that the center of cell locate at grid intersects, for example, centered on 1^o N and E 101^o covers the area north latitude 0.5^o-1.5^o and east longitude 100.5^o -101.5^o

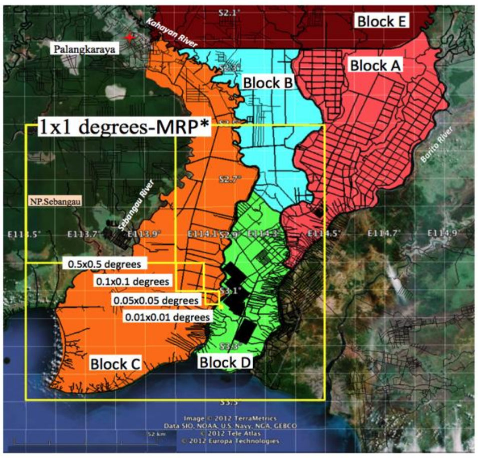

Figure 2. Five grid cell sizes on the map of MRP

MODIS Daily Hotspot Data

To grasp recent forest and peat fire trend in Indonesia is very important not only to establish the fire fighting strategy but also to execute forest protection activities like REDD+. For this purpose, NASA MODIS daily hotspot was used because there is no other suitable fire data for whole Indonesia and long-term (10 years, 2002-2011). MODIS daily hotspot data (Collection 5.1 active fire product) was extracted through FIRMS (Fire Information for Resources Management System, http://maps.geog.umd.edu/firms/). The hotspot was composite data of Terra and Aqua and contains 12 items such as latitude, longitude, brightness, confidence, acquisition date, etc. Single pixel hotspot could represent a single fire or fire within 1 × 1 km^2 (Giglio, 2010).

As the hotspot data provided by NASA MODIS contained data of neighboring countries, we excluded or included them by introducing approximate country and region border. Six major regions in Indonesia were putted such names like "Sumatera+, Java+, Sumba+ and so on. Their names with under line and boundaries with white and yellow dashed lines were shown like in Figure 3. This analysis treatment was simply because selection of hotspot near country border was time consuming for manual work. The temporary boundaries could different in each level of analysis depending on their grids. It may the finer grids have more accurate boundary or nearly same to original border. Thus, the annual average number of hotspot in Indonesia from 2002 to 2011 was about 60,000 hotspots/yr. (refer Figure 4)

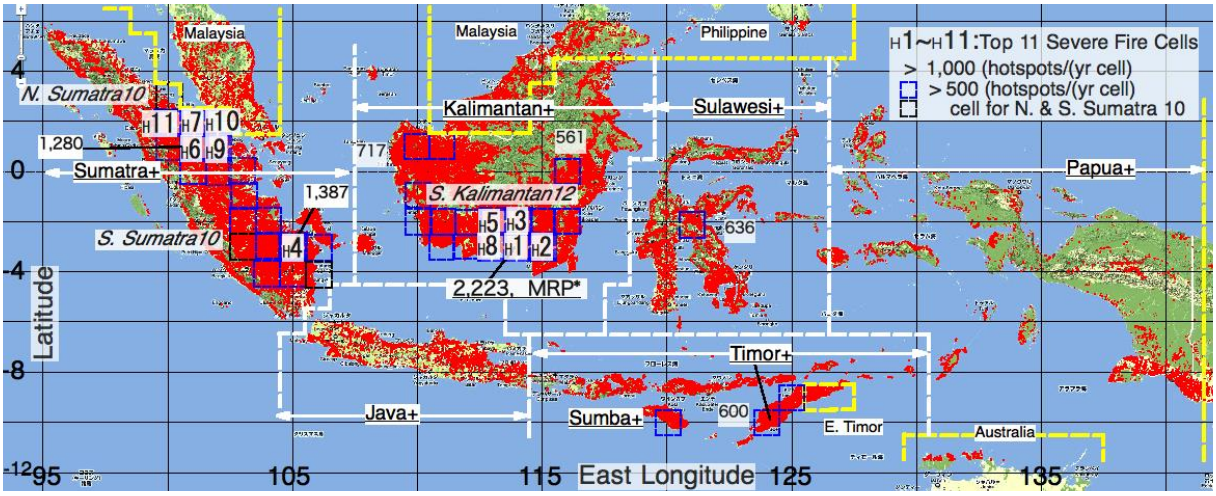

Figure 3. Hotspot distribution and 11 highest hotspot areas in Indonesia, 2002-2011

Results and Discussions

Fire Distribution in Indonesia

The MODIS hotspot data provided by NASA for 2002-2011 was plotted as shown in Figure 3. A total of 631,529 hotspots were recorded in the region covered by the study (N 6^{o} - 11^{o}, E 95^{o} to 142^{o}). About ninety percent of the hotspot cells in Figure 3 fall fully within the borders of the grid cells covering only areas of Indonesia, the remaining is in the cells overlapping the surrounding countries like shown in Figure 3. The limits of the cells extending outside Indonesia are an artifact of the one degree sized grid cells used in the analysis here. This paper ignores administrative boundaries to simplify the analysis and for the ease of the data treatment.

In Figure 3, all coordinate points of MODIS hotspots are indicated with the smallest size of dots. The resulting map shows areas of dense red color regions in Indonesia (regions with high incidences of hotspots) and these can be simply identified in the map in Figure 3**.** To show fire prone areas more clearly, several cells with the number of hotspots are marked at the cells like shown in Figure 3. Eleven cells overlaid by white in Figure 3 shows cells with fire occurrences above 1,000 hotspots/(yr cell). There are five such cells in south Kalimantan, five in north Sumatera, and one in south Sumatera. From here, these cells will be named H-1 to H-11 (in descending order with H-1 showing the cell with the highest fire incidence: H-1, H-2, H-3, H-5, and H-8 in Kalimantan (more details in Figure 6), H-4 in south Sumatera, and H-6, H-7, H-9, H-10, and H-11 in north Sumatera (more details in Figure 9).

The cell with the most fires in south Kalimantan, H-1 (also named MRP*), covering south latitude 2.5^o to 3.5^o and east longitude 113.5^o to 114.5^o (see Figure **2** for the exact position of this cell) had a mean 2,223 hotspots/yr and a maximum of 5,382 hotspots in 2006. To evaluate the fire incidence in this cell objectively the concept hotspot density will be introduced. The 2,223 hotspots/yr for this cell was converted to an annual mean hotspot density of 0.182 hotspots/km^2 (dividing the number of fires with the area of the cell in km^2) and to a daily hotspot density of 0.497 NASA fire pixels/ (1,000km^2 day) (see more detail in the NASA Earth Observations, *http://earth observatory. nasa.gov/*). This 0.497 figure is not a very high hotspot density in the NASA scale but it becomes 1.8 pixels/ (1,000km^2 day) when considering that fires only occur during about 100 fire days in July, August, and September. This high daily hotspot density shows that the fire incidence in this particular cell in south Kalimantan is among the most intense fire incidences of any area in the world.

There are a further four cells among the cells with the very highest fire incidence in Kalimantan, the second and third (H-2 and H-3) are adjacent to H-1 discussed above. The H-2 cell is to the west of H-1 and H-3 is to the north of H-1.

Six of the cells with the highest fire incidences (>1.000 fires/(yr cell)) were in Sumatera, H-4, H-6, H-7, H-9, H-10, and H-11. The H-4 cell covers the area of south latitude 2.5^o-3.5^o and east longitude 104.5^o-105.5^o and had 1,387 hotspots/yr or hotspot density of 0.113 hotspots/(km^{2}yr). This cell is located in middle of the south Sumatera area that includes Palembang (capital of South Sumatera Province, detail in Figure 9). The H-6 area is at north latitude 0.5^o-1.5^o and east longitude 100.5^o-101.5^o, the middle of north Sumatera, and is close to Pekan Baru (capital of Riau Province, detail in Figure 9) and it had 1,280 hotspots/yr (hotspot density: 0.104 hotspots/(km^{2}yr)). The H-7, H-9, H-10, and H-11 areas are all around the H-6 cell, as shown in Figure 3.

Based on the eleven H-1 to H-11 cells with the highest fire incidences in Indonesia, the authors defined three fire prone areas “South Kalimantan 12”, “South Sumatera 10”, and “North Sumatera 10” as shown in Figure 3. The numbers in Figure 3 for these three areas show the number of fires in the cells with the highest incidence in its area. There were eight further areas with fire incidences higher than 500 hotspots/(yr cell) ß∑ and these are shown as blue rectangles with dotted outlines in Figure 3. Three were in West Kalimantan, one in central East Kalimantan and the final four in central Sulawesi, Sumba, and Timor (two).

Finally, you will notice the above mentioned cells with high fire incidence (H-1 to H-12) coincide with peatland areas in Kalimantan, Sumatera, and Papua by comparing Figure 1 and Figure 3. Peat fire is one of big environmental issues not only for Indonesia but also for the world. Because fires in peatland will emit larger amount of CO_2 and other air pollutants due to low temperature combustion or smoldering (Usup *et al*., 2004). Other two high fire areas in Sumba and Timor are due to savanna fire (Fisher *et al*., 2006).

Fire Occurrence Trends in Indonesia

Annual Fire Occurrence

The annual fire occurrence in the six major regions of Indonesia (see Figure 3) during the most recent ten years (2002-2011) is shown in Figure 4. An unit of Y-axis in Figure 4 and also in all other Figures. (Figure 5,7,8,10, and 11) related to hotspot in this paper is a number of hotspots. The bar graph in Figure 4 shows the number of fires in the six regions, from top to bottom: Papua+, Java+, Sulawesi+, Sumba+ and Timor+, Sumatera+, and Kalimantan+. Thus, this paper ignores administrative boundaries to simplify the analysis and for the ease of the data treatment and has put "+" after each region name like "Sumatera+" to show the expanded region defined in this paper. The bottom section of the bars for Kalimantan distinguishes the number of fires in a cell of Mega Rice Project (H-1 or MRP*). The total number of cells in the regions were 513: 198 for Papua+, 37 for Java+, 91 for Sulawesi+, 66 for Sumba+ and Timor+, 101 for Sumatera+, and 86 including the MRP* cell for Kalimantan+. The annual mean numbers of fires in the six regions were averaged and the rightmost bar, to the right of the bar for 2011, shows the average annual incidence of fires in the six regions.

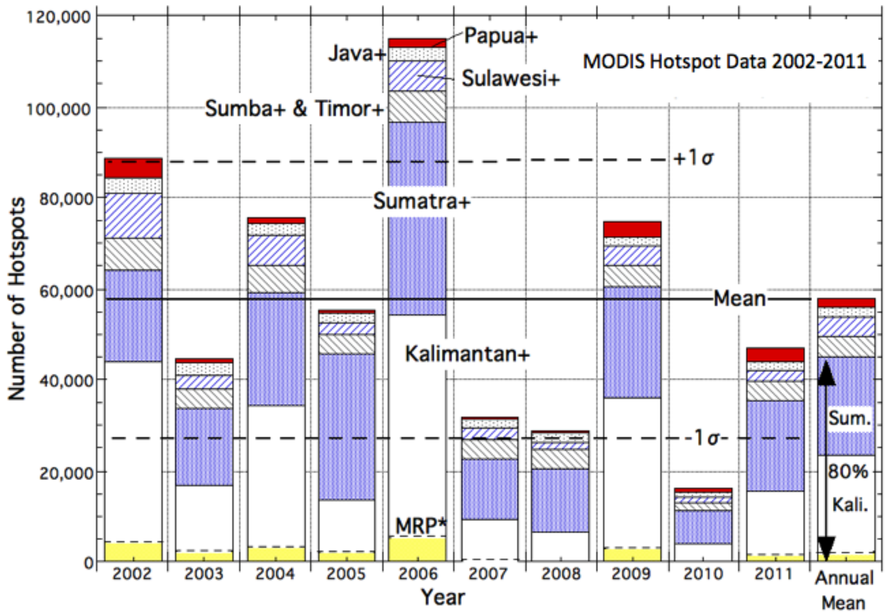

Figure 4. Annual fire occurrence in the whole Indonesia (2002 – 2011)

The rightmost bar in Figure 4 shows that the annual mean number of hotspots in Indonesia was about 58,000. About 80% of these fires occurred in only two of the regions, Kalimantan+ and Sumatera+, which were responsible for 23,460 and 21,488 fires (40.6% and 37.2%) respectively. The fire incidence in the other four regions is Sumba+ and Timor+ with 4,774 fires (8.3%), Sulawesi+ 4,084 (7.1%), Java+ 2,226 (3.8%), and Papua+ 1,799 (3.1%). Fire occurrence in the MRP* cell is at the bottom of this annual mean bar in Figure 4, and the 2,223 fires in the MRP* cell were very similar to the number in Java+ (an area nearly 40 times larger) and larger than that of Papua+ (area about 200 times larger).

The most fires in the six major regions occurred in two different years, 2006 (Kalimantan+ and Sumatera+) and 2002 (Sumba+ and Timor+, Sulawesi+, Java+, and Papua+). In 2006, there were 54,302 fires in Kalimantan+ and 42,361 Sumatera+. These two regions contribute 84.1% of the total fires in 2006. In 2002, the fire numbers were 9,761 for Sulawesi+, 7,146 for Sumba+ and Timor+, 4,440 for Papua+, and 3,398 for Java+ but their contribution to the total fire numbers of Indonesia was only 27.9%. The proportion of fires occurring in Kalimantan+ was high in both 2006 (47.2%) and 2002 (49.7%). Active fires in 2006 and 2001 were simply occurred under the drought conditions related to the El Nino event. Detail discussion about relationship between fire activities and drought will be elucidated in chapter 3.3 by using precipitation data.

The number of hotspots in the ten years varied greatly with an about seven times difference between the year with the most fires, 114,977 in 2006 and the year with the fewest, 16,335 fires, in 2010. For a more objective discussion of the fire occurrence, a statistical approach will be used in the following. The fire occurrences in seven out of the ten years were within $\pm 1\sigma$ (=68.26%). The remaining three years had $\pm 1\sigma$ values of 1.01 for 2002, 1.87 for 2006, and –1.36 for 2010. Statistically, the probability of the occurrence of a year with a high number of fires like in 2006 is about 6%, suggesting that a year with the number of fires in 2006 will occur roughly every 17 years, if the fire occurrences are assumed to follow a normal distribution.

Seasonality of Fires

This chapter will discuss the times that fires occur with monthly means for the whole ten years period from 2002 to 2011, and Figure 5 shows the average fire incidence for each month in the ten years in the different regions of Indonesia. As suggested by Figure 5 the period of the most frequent fire occurrence in the whole of Indonesia are the three months August, September, and October where the number of fires reached 13,890, 14,589, and 11,264 respectively, for a three month total of 39,743, representing about 70% of the average annual hotspot number (57,800).

From Figure 5 it is possible to determine the month(s) with the highest fire incidence of the different regions in Indonesia. In Kalimantan+ fires were most frequent in the three months August, September, and October. The months with the most fires for Sumatera+ were August and September, and Sumatera+ had a noticeable number of fires in six other months but only very few fires in April, November, and December.The months with the highest fire incidence for the remaining four regions are also seen in Figure 5, for Java+, August, September, and October, and for the three regions of Sulawesi+, Timor+ & Sumba+, and Papua+, the highest fire incidence was October. The detail fire trends with the focus on Kalimantan and Sumatera will be discussed in the next chapter.

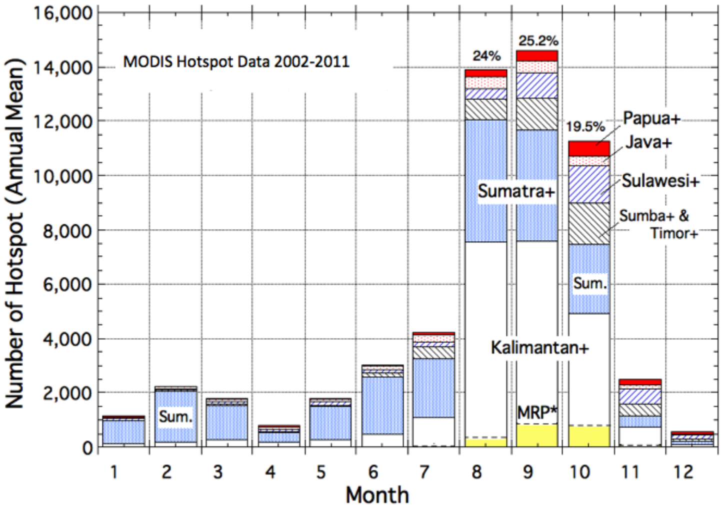

Figure 5. Fire period in six regions in Indonesia (2002 -2011)

Fire Occurrence in Kalimantan and Sumatera

Fires in Kalimantan

Kalimantan was divided into the following five regions for the detailed discussion on fire distribution, the annual changes in fire incidence, and fire period in the main island of Kalimantan (“Kalimantan+” in previous chapter “Fire Occurrence Trends in Indonesia” covers a wider area) using the one by one degree cells. The regions were “South Kalimantan 12”, West- and East- Kalimantan, South 5, and Central 5, with the number at the end of the name showing the number of cells in its region. West- and East- Kalimantan has 16 and 25 cells, respectively. The boundaries of the five regions are shown with white and yellow broken lines in Figure 6 the extents of these regions is different from the four provinces of West, East, Central, and South Kalimantan. This occurs because the “South Kalimantan 12” cells comprise three cells from West Kalimantan (rectangles numbered with 656, 634, and 932 hotspots/(yr cell) shown in Figure 6), one cell from South Kalimantan (with 1,489 hotspots/yr, and one cell from East Kalimantan (with 508 hotspots/yr). Before the discussion, please note the MRP region surrounded by a black dotted line in Figure 6. The “South Kalimantan 12” covers the entire MRP regions with its three cells, H-1 (MRP*), H-2, and H-3 located as shown in Figure 6.

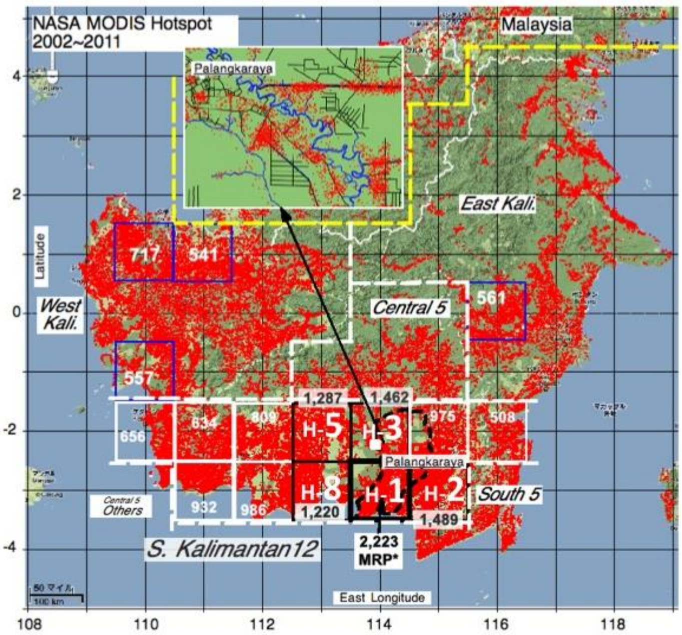

Figure 6. Hotspot distribution, 5 regions, and 5 highest hotspot areas in Kalimantan

The fire occurrence from 2002 to 2011 is shown with red dots in Figure 6. The denseness of the dots means that the fire distribution is not very clear but it provides a better picture than Figure 3. Several noticeable fire and fire free areas can be observed in Figure 6 and in the enlarged insert of the area around Palangkaraya near the top of Figure 6. Most of fires here are human-caused, and occur along canals, roads, and at the seacoast. Such fires form linear patterns and are simply identified Figure 6. The areas with dense hotspots suggest high human activity with deforestation, slash and burn clearing, and plantations. There are 16 cells with more than 500 hotspots/(yr cell) in Figure 6 that deserve special attention. One is south of Palangkaraya in the enlarged inserting in Figure 6. There are fire free areas even in H-1 (MRP*), the cell with the highest fire incidence in MRP. In the left upper side of the H-1 cell, there is a fire free area. This area was corresponds to a tropical swamp forest south of Palangkaraya (the dense green area in Figure 2).

Figure 7 shows the annual number of fires in the above mentioned five regions of Kalimantan from 2002 to 2011, the bars for a year show, from top to bottom the fire incidence in the South 5, East, West, Central and other areas, and finally in South Kalimantan 12 which includes the H-1 cell with the highest number of fires in the MRP area. The rightmost bar shows the average of the annual fire occurrences. Figure 7 also shows the annual total precipitation of driest three months from July to September measured at Palangkaraya Airport by using the inversely drawn bars from the top line of Figure 7 to discuss relationship fire activity and rainfall.

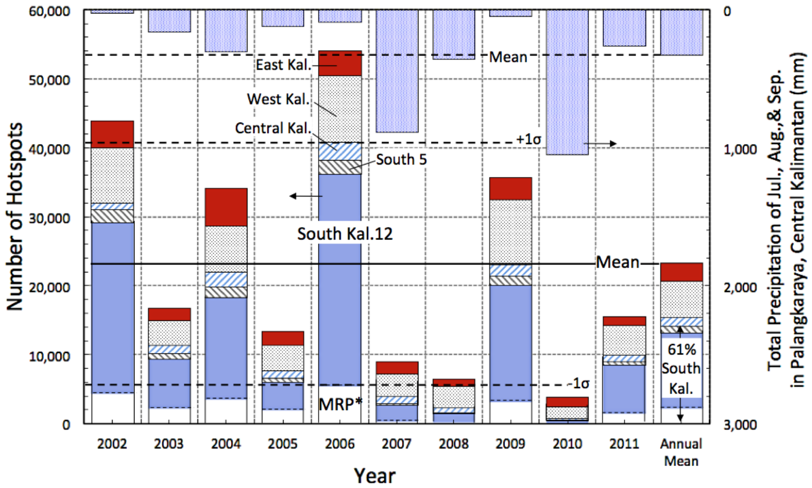

Figure 7. Annual fire occurrence in Kalimantan and MRP, and dry season precipitation in Palangkaraya (Central Kalimantan)

From Figure 7, the annual average is 23,250 hotspots/yr. The annual averages show that 61% of the fires occurred in the South Kalimantan 12 and South 5, with 57.2 % (13,183 hotspots) and 3.9% (897) respectively. Fires in West Kalimantan accounted for 23.1% (5,314), East Kalimantan for 11.1% (2,567), and Central and others had 5.6 % (1,289) annual fires on average. The average number of fires in the MRP cell, 2,223, very nearly matches the number in all of East Kalimantan, which covers a far larger area (25 cells).

The largest number of fires in the different areas occurred in two different years, in 2004 in East Kalimantan (5,440 fires); and in the other four Kalimantan areas in 2006: South Kalimantan12 with 36,101 fires, West Kalimantan with 9,631 fires, South 5 with 2,076 fires, and Central 5 and others with 2,652 fires. In 2006 the ratio of fires reached a very high 66.9% in South Kalimantan12 (including the MRP* cell).

The above mentioned fire activities in Kalimantan could be partially explained by using precipitation measured at Palangkaraya. Figure 7 clearly showed active fires in 2002, 2004, 2006, and 2009 occurred when total precipitation amount of three driest months in Palangkaraya (Putra *et al*., 2011) became less than around 100 mm. Largest fires in 2006 mainly due to South Kalimantan 12 could be explained by extended drought until October. The precipitation amount October in 2006 was only 12.6 mm and lowest monthly precipitation among last 10 years.

The time of occurrence of fires in Kalimantan will be discussed with Figure 8, which shows the average monthly fire incidence in the ten years surveyed here. In Figure 8, monthly mean precipitation of last 10 years in Palangkaraya is also shown with the inversely drawn bars from the top line of Figure 8. Figure 8 clearly shows that fires are most common in three months: August, September, and October, similar to the most intense fire period for all of Indonesia (Figure 5). The number of fires in these three months reached 19,895 (7,471 in

August, 7,543 in September, and 4,881 in October), 85.5% of the annual hotspot average (23,250 fires).

Throughout Kalimantan, September was the month with most fires except in West Kalimantan. In South Kalimantan 12 and South 5, the number of fires in September reached a total of 5,320 fires or 70.5% of the total number of fires in this month. In West Kalimantan, the peak was 3,184 fires in August with only 882 fires in September. Fire numbers in the one H-1 (MRP*) cell were larger than in all of East Kalimantan (24 cells). The number of fires in the H-1 (MRP*) cell from August to October were 3,617, 8,931, and 8,064. These numbers clearly show the need to pay more attention to the very large number of fires in MRP* in September and October.

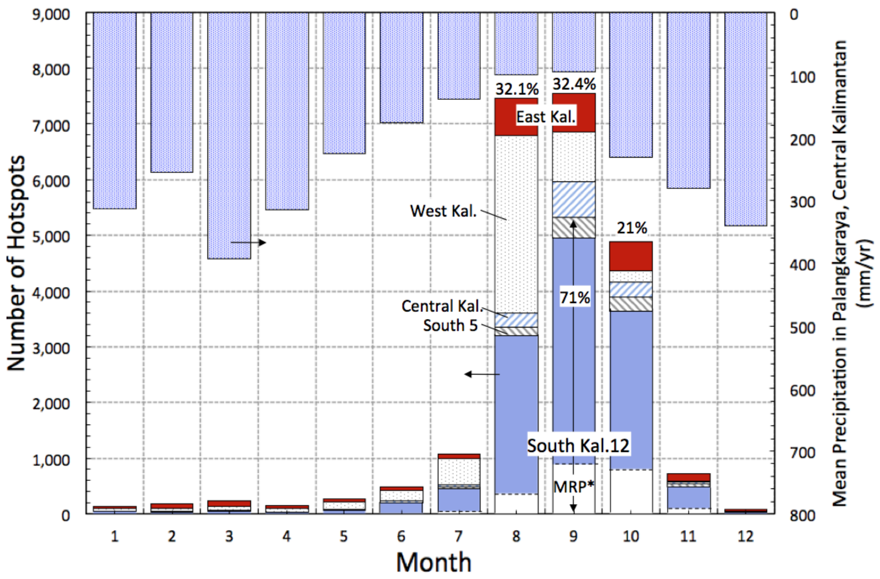

Figure 8. Fire period in Kalimantan and MRP, and monthly mean precipitation in Palangkaraya (Central Kalimantan)

Monthly mean precipitation trend in Figure 8 supported active fires in driest two months, August and September. Fires in October could be explained by the ground water level. As the average lowest ground water level was observed from the bottom of September to the top of October, peat fire could continue active even in October (Putra *et al*., 2011). South Kalimantan 12 and MRP* remarkably showed this fire trend related to the ground water level in Figure 8.

Fires in Sumatera

Sumatera was divided into the following four regions for the detailed discussion of the fire distribution, the annual changes in fire incidence, and period with the most fires in the main island of Sumatera ("Sumatera +" in 3.2 covers a wider area) using one by one degree cells like the discussion for Kalimantan above. Sumatera was divided into four regions simply as the ten provinces in Sumatera are too small for the analysis using one by one degree cells, the four regions in Sumatera were "South Sumatera 10", "South Others", "North Sumatera 10", and "North Others", with the numbers at the end of the names showing the number of cells; the number of cells for "South Others" and "North Others" 19 and 20, respectively. The boundaries of the four regions are shown with white and yellow broken lines in Figure 9; Sumatera is divided into two by the equator, and North and South Sumatera will be used here after. South Sumatera has the H-4 cell, the cell with the fourth highest number of fires in South Sumatera 10 and shown with the number 1,387 (hotspots/yr) in Figure 9, this cell was also named Palembang to make the fire incidence in this cell more easily comparable with the

"MRP*" cell in Kalimantan. Five other "high fire incidence cells," H-6, H-7, H-9, H-10, and H-11 with 1,280, 1,231, 1,152, 1,080, and 1,001 hotspots/(yr cell) respectively lie in North Sumatera 10, mainly in Riau Province. Among these the H-10 cell had 4,906 hotspots in 2005 and the total for these five cells exceeded 5,700 hotspots/(yr cell). Fires in this region may be partially related to the tens years activities of two companies, Asia Pulp and Paper (APP) and Asia Pacific Resources International Limited (APRIL). They have several pulp mills and paper plants in Riau, Jambi, and South Sumatera Province.

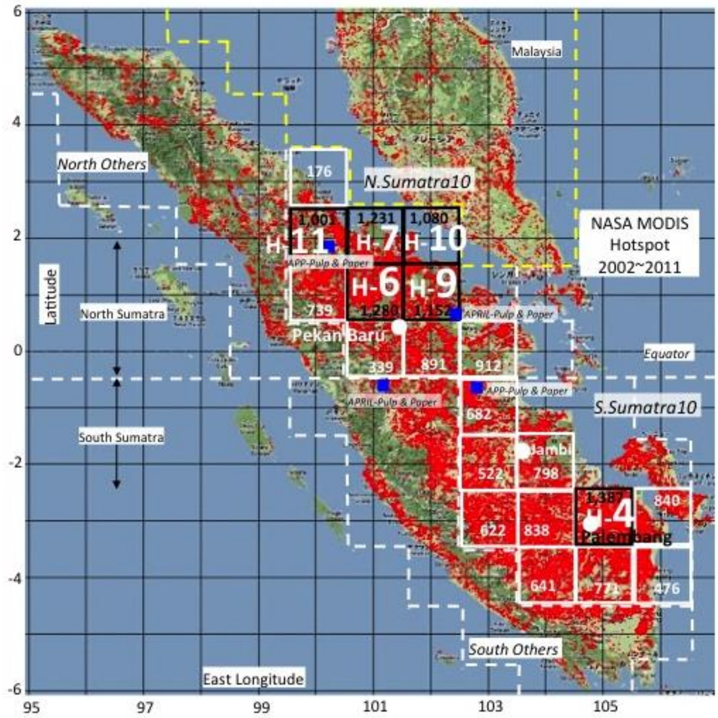

Figure 9. Hotspot distribution, 4 regions, and 5 highest hotspot areas in Sumatera

The fire distribution from 2002 to 2011 shown with red dots in Figure 9, but due to the density of the dots, the fire distribution was not completely clear. Most fires appear to occur on the low-lying peatland areas of east Sumatera (see Figure 3 & Figure 9). There are also other characteristics of the fire distribution that can be observed in Figure 9. Human-caused fires tend to occur along canals, roads, and the seacoast like it is also the case in Kalimantan. There is an area of dense fires near Palembang in the H-4 cell in Figure 9 (marked with the fire incidence there, 1,387). This H-4 cell was named "Palembang" and may be seen to be like MRP* near Palangkaraya, Kalimantan. There are fire free areas in Sumatera in high mountain areas and peatland areas near the coast like Kalimantan.

Figure 10 shows the annual number of fires in the four regions of Sumatera distinguished above, from 2002 to 2011, the bars for a year show, from top to bottom, the fire incidence in North others, North Sumatera 10, South others, and South Sumatera 10 which includes the H-4 cell with the highest number of fires in the Palembang area. The rightmost two bars show the average of the annual fire occurrences and the annual largest fire occurrence in Kalimantan in 2006.

The inversely drawn two different bars from the top line of Figure 10 shows the annual total precipitation of dry three months from June to August measured at Jambi (South Sumatera, shown by a white circle located in the northeast of "H-4" in Figure 9) and two separated dry months in February and August observed at Pekan Baru (Riau, shown by a white circle located in the south of "H-6" in Figure 9).

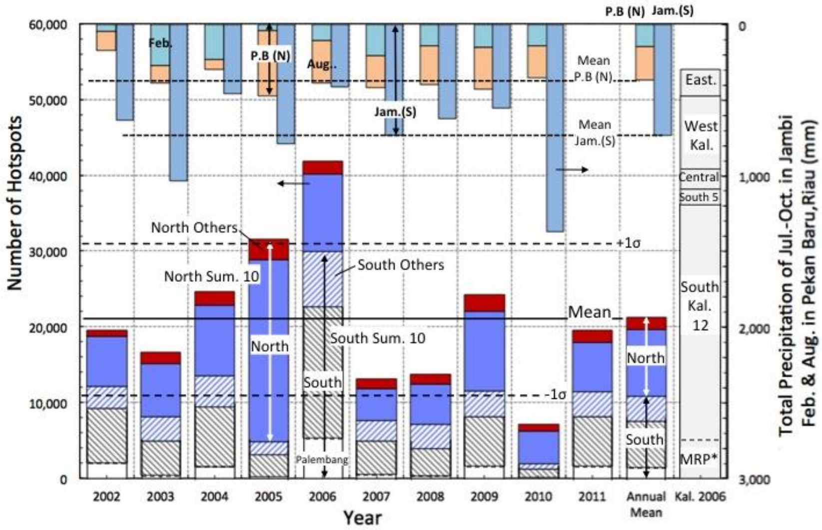

Figure 10. Annual fire occurrence in Sumatera, and dry season precipitations in Jambi and Pekan Baru (Riau)

From Figure 10, the annual average was 21,200 hotspots/yr and just smaller than the 23,250 hotspots/yr in Kalimantan. The annual averages show that 51% of the fires occurred in south Sumatera (South Sumatera 10 and South others) and 49% of the fires occurred in north Sumatera (North Sumatera 10 and North others). Fires in North Sumatera 10 accounted for 41.5% (8,799), South Sumatera 10 for 35.7% (7,578), South others for 15.3% (3,249), and North others for 7.5% (1,581). The number of fires in the Palembang cell is 1,387 and very nearly matches the number in North others, which covers a far larger area (20 cells).

The two years with the most fires in Sumatera occurred in 2005 and 2006 however with very different fire distributions within the island. In 2006, the year with the most fires, the total number of fires reached 41,895 and most occurred in south Sumatera, 71.5%, with 22,675 (54.1%) fires in South Sumatera 10 and 7,269 (17.4%) fires in South others. In 2005, the year with the second largest number of fires, the total number exceeded 31,500, most occurring in north Sumatera, 84.6%, with 23,998 (76.2%) in North Sumatera 10 and 2,640 (8.4%) in North others.

The most right hand bar in Figure 10 allows a direct comparison with the 2006 Kalimantan fire incidence. Comparing the two 2006 bars, both south Kalimantan and south Sumatera show very high fire incidences under the drought conditions due to the El Nino event in that year, 2006. Looking at the two cells, H-1 (MRP*, 5,382 fires in 2006) and H-4 (Palembang, 5,361 fires in 2006) shows that the fire incidences in 2006 here were very similar.

The above mentioned very high fire incidences in Sumatera could be explained by using precipitation measured at Jambi (south Sumatera) and Pekan Baru (Riau). Figure 10 clearly showed two active fire years in 2005 and 2006. In 2005, most fires occurred in North Sumatera 10. On the contrary, most fires occurred in South Sumatera 10 and South Others in 2006. Two different fire trends in 2005 and 2006 may be explained by dry season trends in north and south Sumatera.

2005 fires in North Sumatera 10 (north Sumatera) could become active due to low precipitation in February (39mm, lowest monthly precipitation of latest 9 years from 2002 to 2010) and other dry months. Actually, our analysis results showed total number of hotspots in North Sumatera 10 in 2005 reached 20,365. Largest monthly number of hotspots was 5,313 in February. Second and third were 4,694 in March and 3,183 in August. 2006 active fires in

Jambi (south Sumatera) also may be due to lowest precipitation in dry four months from July to October (411mm, lowest four months precipitation of latest 9 years from 2002 to 2010).

The times of occurrence of fires in Sumatera will be discussed with Figure 11 which shows the average monthly fire incidence in the ten years surveyed here. The rightmost bar in Figure 11 shows the September fire occurrence in Kalimantan.

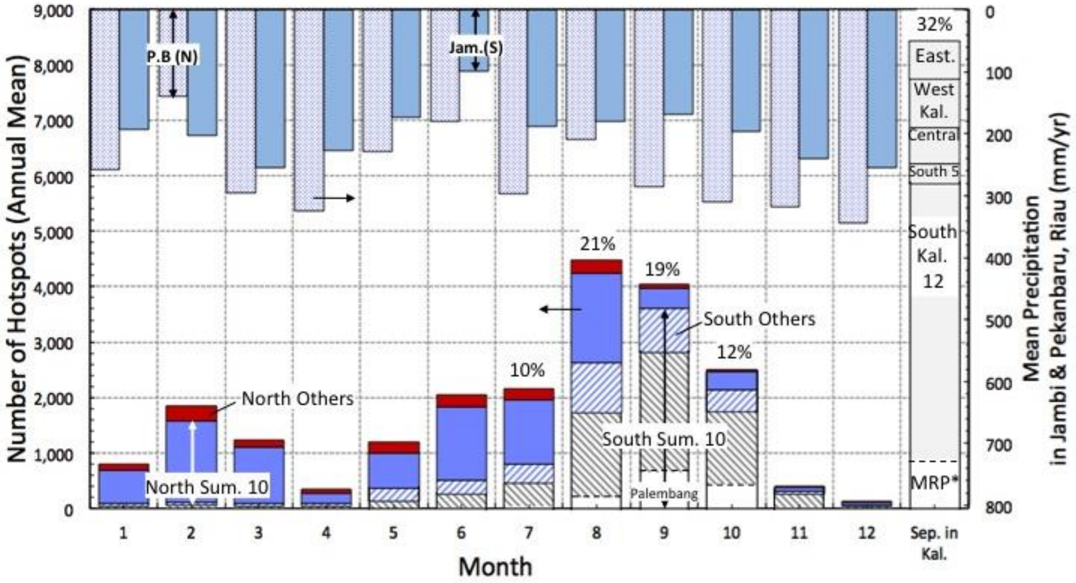

Figure 11. Fire periods in Sumatera, and monthly mean precipitations in Jambi and Pekan Baru (Riau)

Figure 11 shows times of highest fire incidence of Sumatera is not as clear as in Kalimantan in Figure 8. In Sumatera the highest number of fires in August is not much higher than in other months, the contribution of fires in August is only 21% of the whole year, which is smaller than the 32% in September (the month with most fires) in Kalimantan. In addition, north Sumatera showed different period with the highest fire incidence, it is however not as distinct as the high incidence period in south Sumatera. In North Sumatera there are two fire periods, one is in February and March, and another is from June to August. The presence of two periods with many fires could explain why 2005 is the year with the second largest number of fires (Figure 9) and why the month with the most fires is August in Sumatera (Figure 10). In south Sumatera, there were most fires in the three months: August, September, and October, similar to Kalimantan (Figure 8). The above different fire occurrence patterns in north and south Sumatera can be explained with differences in the precipitation patterns in the two areas.

Two different precipitation types for north and south Sumatera were shown using inversed Y-axis and two bar graphs in Figure 11. Two climate zones with two different precipitation patterns in Sumatera were already analyzed by Aldrian & Susanto, 2003. Monthly mean precipitation trend in Figure 11 showed Pekan Baru (Riau) had low precipitation of three months or February, June, and August. Fires in north Sumatera tended to occur mainly in these months. On the other hand, Jambi (south Sumatera) showed only one lowest precipitation month in June but fires could become active from August to October. This fire trend was similar to south Kalimantan in Figure 8. Because south of Sumatera and south of Kalimantan are belong to the same climate zone. Fire activities from August to October in south of Sumatera in Figure 11 were weaker than that of south Kalimantan in Figure 8. This difference may be mainly due to difference in monthly precipitation amount or about 200mm in south Sumatera and about 100 mm in Kalimantan.

Conclusions

The present fire situation, fire prone areas, and the trends in fire incidence for all of Indonesia, for Kalimantan and Sumatera were analyzed using MODIS hotspot data from 2002 to 2011 with 1x1 degree cell. The conclusions can be summarized into the following three parts:

Firstly, the present fire situation and fire prone areas as follows:

1. There were eleven cells where the number of hotspots exceeds 1,000 hotspots/(yr cell) among the approximately 500 cells covering all of Indonesia. These most fire prone areas were found in three regions: south Kalimantan, and south and north Sumatera. (see Figure 3)
2. The cell with the highest fire incidence (H-1, MRP*) was found in the Mega Rice Project (MRP) area in south Kalimantan. This one cell had both the maximum and the highest mean number of hotspots in the recent ten years, 5,382 hotspots in 2006 and 2,223 hotspots/year respectively. The maximum hotspot density was 0.438 hotspots/(km^2yr). (see Figure 1, 3, 6)
3. The three cells with the highest fire incidence (H-1, H-2, H-3) covered most of the MRP area. (see Figure 6) The total number of hotspots of these three cells was 5,174 hotspots/yr.
4. The cell with the fourth highest fire incidence (H-4) was in the Palembang area in south Sumatera. The number of hotspots was 1,387 hotspots/yr. (see Figure 3, 9)
5. In Sumatera, the five cells with the highest fire incidence (H-6, H-7, H-9, H-10, and H-11) were in north Sumatera. (see Figure 3, 9) The total number of hotspots of the five cells was 5,744 hotspots/yr.
6. Other areas where the fire incidences exceed 500 hotspots/(yr cell) were found in Sumba, Timor, west and east Kalimantan, and central Sulawesi. (see Figure 3, 6)

Secondly, the trends in the annual fire incidence as follow:

7. The annual mean number of hotspots in the whole of Indonesia was 57,800 with 78% of these fires occurring in Kalimantan (41%) and Sumatera (37%). (see Figure 4)
8. In the year with the most fires, in 2006, the total number of hotspots was about twice (115,000) the annual mean (57,800). In 2006, the contribution of Kalimantan (47%) and Sumatera (37%) was 84%. (see Figure 4)
9. For all of Kalimantan, the annual mean number of hotspots was 23,250 for the ten years. About 61% were recorded in south Kalimantan (South Kalimantan 12 and South 5). In 2006, the year with the most fires, the total number of hotspots was about 2.3 times larger (about 54,000 hotspots/yr) than the annual mean, with the contribution of south Kalimantan 71%. (see Figure 6, 7)
10. In Sumatera, the annual mean number of hotspots was 21,200, nearly equal for south and north, 51% vs. 49%. The year with the most recorded fires in Sumatera was also 2006, with 41,900 hotspots (about twice the annual mean); 72% of fires in 2006 occurred in south Sumatera. (see Figure 9, 10)
11. For north Sumatera, the year with the most fires was 2005 (second highest incidence for all of Sumatera). In 2005, the total number of hotspots here reached 31,500 (84.6%). (see Figure 9, 10)

Thirdly, the trends in fire incidence by month as follows:

12. For all of Indonesia the three months of August, September, and October had the clearly highest incidences, with about 70% of fires (39,743) occurring in these three months. The percentages of the average annual number of fires (57,800) in August, September, and October were 24% (13,890), 25% (14,589), and 19% (11,264) respectively. (see Figure 5)
13. Kalimantan and Sumatera also had high incidences of fires in August, September, and October with 87%, 80%, and 66% of total number of fires in each month, respectively. (see Figure 5)
14. Kalimantan also had the most fires in August, September, and October. The fire peak for central and south Kalimantan was September and for west Kalimantan was August. (see Figure 8)
15. In Sumatera, the most intense fire period by month was not easily defined. South Sumatera had the most fires in the three months of August, September, and October while north of Sumatera had two periods with high fire numbers, one in February and March, and the other in June, July, and August. (see Figure 11)

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JICA COOPERATION IN FORESTRY SECTOR AND A NEW PROJECT ON REDD+ (IJ-REDD+) IN INDONESIA

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Introduction

The area of tropical forests in Indonesia is the third largest in the world providing rich biodiversity and ecosystem services. JICA (Japan International Cooperation Agency) has a long history of cooperation in Indonesia in the field of forest management and biodiversity conservation. Through that cooperation, capacity building and technology transfer were pursued utilizing Japanese cutting edge technologies such as satellite image analysis and silvicultural technology.

Recently, forests and peat land in tropical regions draw global attention as one of major sources of GHG emission. Reducing emission from deforestation and forest degradation (REDD+) has emerged as a potential mechanism for tackling this issue and Indonesia is recognized as one of the leading countries for establishing REDD+. JICA's cooperation past and on-going is considered to contribute establishing mechanism of REDD+ in various aspects from central level to field level, from policy issues to technological issues including MRV or safeguards related to community involvement and biodiversity.

Currently, in response to the proposal made by Government of Indonesia on "Indonesia-Japan Project for Development of REDD+ Implementation Mechanism (IJ-REDD+)", JICA is working together with Ministry of Forestry in Indonesia for formulation of this new cooperation project for REDD+ with the purpose of developing provincial REDD+ implementation mechanism, aiming to integrate it into national REDD+ mechanism.

JICA Forestry Cooperation in Indonesia

JICA's technical cooperation projects in forestry sector in Indonesia started in 1970s. Since then, more than 20 projects have been conducted, including on-going projects, in collaboration with Ministry of Forestry and other organizations. The issues tackled by these projects have been changing depend on the technological, economic and social requirements of the age. In 1977, the first project started with a target of transferring mountain logging technology and the main issue of the cooperation in this age is forest resource utilization. From 1980s to 1990s, JICA cooperation shifted to forest resource development such as plantation or tree improvement technology.

Since 1990s, environmental aspect such as rehabilitation of forests, conservation of biodiversity has drawn attention as a center issue. Three priority areas of JICA cooperation up to now, i.e., forest fire prevention, mangrove rehabilitation and conservation, collaborative management of national parks, were first taken up as projects in 1990s.

Approach of JICA cooperation is comprehensive, not only in terms of range of issues to be tackled, but also in terms of the scope of the projects. It varies from national level to local and field level, from policy level to technical level. Some characteristics of JICA cooperation can be also pointed out as (1) utilizing the Japanese cutting technology such as satellite remote sensing, (2) addressing local people for better livelihood, and (3) involvement of multi stakeholders including private sectors, universities and NGOs. The Table 1 shows the recent JICA projects in forestry sector and their comprehensive approach towards sustainable management of forest and conservation of biodiversity.

Table 1. On-going and recent JICA projects in the forestry sector in Indonesia

JICA-JST Carbon Project ***JICA-JST Project on Wild Fire and Carbon Management in Peat-Forest (2009-2014)*** BSN, UNPAR, LAPAN, LIPI, FORDA, BPPT Tropical peat land in Central Kalimantan is a significant carbon reservoir. However, deforestation in this area has decreased ground water level and increased carbon emissions by biological decomposition and fires in peat land. This project aims to establish an integrated carbon management system for the peat land to mitigate global warming by reducing carbon emissions from Central Kalimantan.
Satellite Project ***Project for the Support on Forest Resources Management through Leveraging Satellite Image Information (2008-2011)*** Directorate General of Forestry Planning/MoF The Satellite Project aimed to develop forest resource monitoring technology by using PALSAR, a micro wave sensor loaded on satellite named Daichi. It was seeking the possibility of adapting the technology for carbon measurement which is necessary for the implementation of REDD+.
MECS Project ***Project on Mangrove Ecosystems Conservation and Sustainable Use in the ASEAN Region (2011-2014)*** Directorate General of Watershed Management Development and Social Forestry (BPDAS-PS)/MoF The MECS Project aims to develop a co-operating mechanism to share good practices and lessons learned ("Shared-Learning"), regarding the mangrove ecosystems conservation and sustainable use in the ASEAN region. Benefits that humans receive from mangroves are enomous. This region has the biggest portion of mangrove cover in the world. However, it is rapidly disappearing.
FCP ***Program for Community Development of Fire Control in Peat Land Areas (2010-2015)*** Directorate General of Forest Protection and Nature Conservation (PHKA)/MoF FCP aims to improve the capacity of fire prevention in peat land areas through capacity building of community fire control groups, enhancement of collaboration among institutions concerned in West Kalimantan and Riau Provinces, and institutionalizing fire brigades of MoF.
Restoration Project ***Project on Capacity Building for Restoration of Ecosystems in Conservation Areas (2010-2015)*** Directorate General of Forest Protection and Nature Conservation (PHKA)/MoF The Restoration Project aims to develop restoration and conservation technologies considering the biodiversity on degraded lands in five national parks by using the outputs of past JICA assistance along with the aspects of policy, techniques and finance.
CFET Project ***Project on Strategy for Strengthening Biodiversity Conservation through Appropriate National Park Management and Human Resource Development (2009-2012)*** Forestry Extension and Human Resource Development Agency (BP2SDM)/MoF The CFET Project aims to develop the capacities of MoF officials on collaborative national park management developed by the Gunung Halimun Salak National Park management project to extend it throughout Indonesia.
SDL Project ***Project for Facilitating Development of the Wood Industry in Small Diameter Logs (SDL) Processing (2012-2013)*** Directorate General of Forest Business Development (BUK)/MoF The SDL Project is to establish a local model of integrated community- based small diameter logs processing through better marketing, improving processing technology and capacity building of stake holders, aiming to contribute to the income generation of rural people and sustainable forest management.
FFORTRA Project ***Project for Facilitating the Implementation of National Forestry Strategic Plan (2009-2012)*** Center for International Cooperation (KLN)/MoF The FFORTRA Project supports the implementation of 5 year forestry strategic plan with particular focus on REDD+ through assisting mainstreaming REDD+, capacity building for policy planning and monitoring, partners` coordination and analyzing policy agendas related to REDD+ such as social forestry, along with coordination of Japanese assistance.

REDD+ and JICA Cooperation

Recently, forests and peat land in tropical regions draw global attention as one of major sources of GHG emission. In Indonesia, among total GHG emission, around 60% is estimated to come from forest and land use sector including peat land in 2005 (2nd National Communication). This is allegedly due to the deforestation and degradation of forests and peat land caused by conversion to the oil palm plantation, forest and peat fire, etc.

REDD+ (reducing emission from deforestation and degradation of forests) has emerged as a prospective scheme to address these issues in the international level through negotiations in UNFCC. Indonesia is one of leading countries who tries to develop REDD+ mechanism.

Measures and policies taken for REDD+ are mostly common with those taken for sustainable management of forests. Thus, outcomes of past and on-going JICA cooperation could also contribute to development of REDD+ in Indonesia (Figure 1).

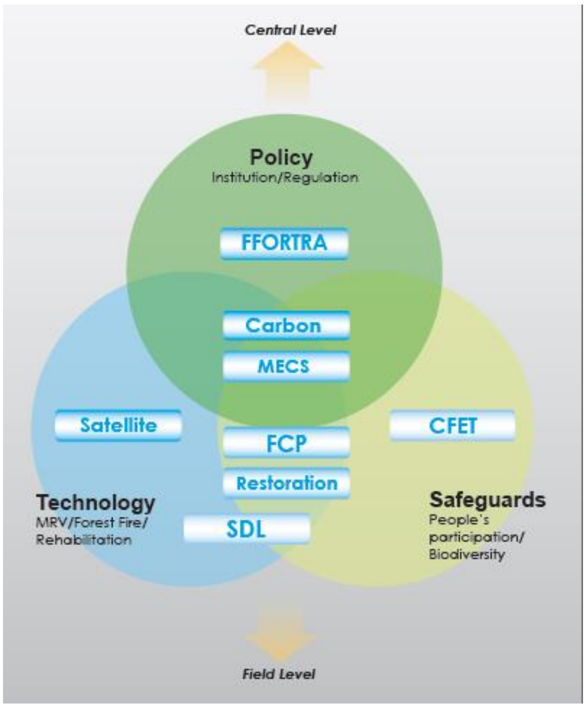

Figure 1. Contribution of JICA projects to the development of REDD+

Plan of JICA`s new project on REDD+ (IJ-REDD+ Project)

JICA recognizes the conservation of the natural environment, including climate change issues, as one of the highest priorities of international cooperation. Moreover, Japanese Government is beginning to commit more strongly to the climate change issues in bilateral relation with Indonesia. In November 2011, the both governments released the document of bilateral cooperation on climate change issues, which stated further implementation of REDD+ cooperation as well as initiation of discussion on bilateral offset credit mechanism.

In line with the above situation, Government of Indonesia proposed Government of Japan a new project "Indonesia Japan Project for Development of REDD+ Implementation Mechanism (IJ-REDD+)". JICA FFORTRA project facilitated designing of IJ-REDD+ project activities through dispatching short-term expert and others. IJ-REDD+ is currently under consultation between Ministry of Forestry and JICA toward implementation.

Figure 2 shows the vision of IJ-REDD+ project. Sustainable forest management and forest conservation are achieved through collaborative management of forests with local communities, while communities receive benefits in the form of social and environmental services. In order to attain this, financial mechanism through carbon credit (REDD+) is expected to be introduced. Incentive could be also derived from economic evaluation of biodiversity and environmental services (PES).

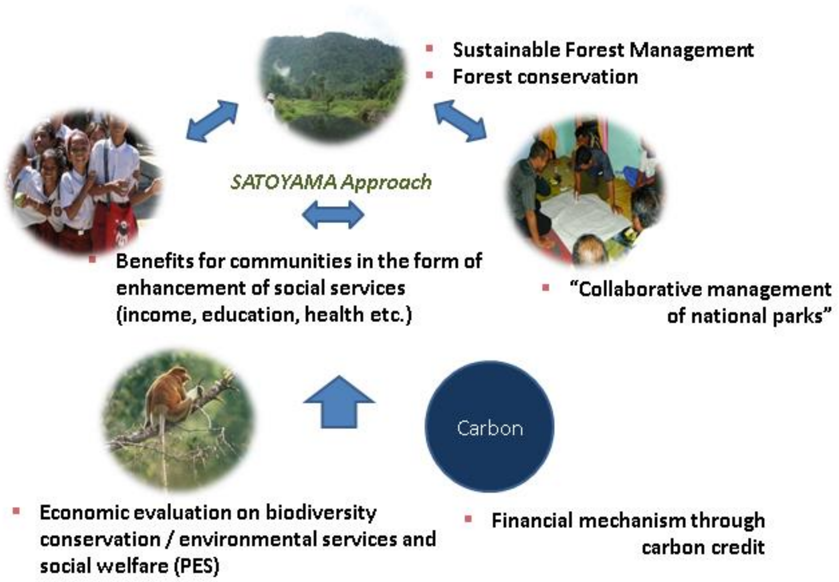

Figure 2. Vision of IJ-REDD+ Project

According to the draft project design, target provinces of IJ-REDD+ will be West Kalimantan and Central Kalimantan. In West Kalimantan, target areas are coastal peat land areas and project activities will be to develop sub-national REDD+ framework focusing in MRV and REL, to develop national park REDD+ model at Gunung Palung NP as a pilot site, and to develop REDD+ model in other areas such as production forests. In Central Kalimantan, the activities will be mostly in provincial level for strengthening REDD+ institutional arrangement focusing on MRV. The findings in these provinces through project activities are expected to be referred to in the development of national level REDD+ mechanism (Figure 3).

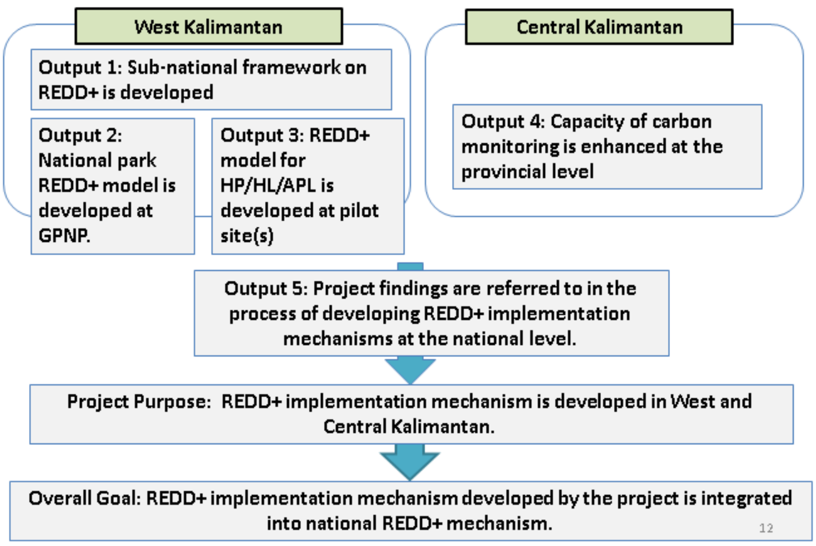

Figure 3. IJ-REDD+ Implementation Image

Conclusion

REDD+ is considered as a prospective mechanism to enhance sustainable management of forests and peat land while improving livelihood of local community and protecting biodiversity by channeling funds from developed countries. The IJ-REDD+ is expected to contribute development of REDD+ mechanism in Indonesia in collaboration with Ministry of Forestry and other related stakeholders by integrating lessons learned from past and on-going JICA cooperation in the forestry sector.

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PILOTING A VILLAGE-BASED FIRE PREVENTION PROGRAM (PHKA/MOF-JICA) AT PEAT LAND AREA IN WEST KALIMANTAN TO RESPOND DECENTRALIZATION

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"Program of Community Development in Fires Control in Peatland Area (FCP) (PHKA/MoF-JICA) initiated piloting a comprehensive extension program for fire prevention in village level ("Village-based Fire Prevention [VFP]) in West Kalimantan Province. This paper introduces the background and concept of VFP and its progress.

***Keywords*:** community-based fire prevention, peatland, land burning behaviour, decentralization

Introduction

Forest and land fire prevention especially in peat land is indispensable for climate change mitigation in Indonesia. Fires from peatland have become one of major sources of carbon emissions (World Bank, DFID & PEACE, 2007).

There are two approaches to prevent fires. The classic (or business as usual) approach is "Preparedness (to Outbreak)" that derived from disaster management to prepare so as to react quickly to and minimize damages when fires outbreak. While "Preventive (to Outbreak)" is in order to reduce causes of fire outbreaks by optimizing drivers for fire causes especially human-related matters. In preventive to fire outbreak, such social factors as "Erosion of Local knowledge", "Erosion of Social Cohesiveness and Customary Laws" were inferred one of most influential drivers affecting the fire sources through community attitude (Indonesian State Ministry for Environment & UNDP, 1998). But it is difficult to find an effective way and good practice model to control such drivers for fire causes developed in Indonesia.

The classic approach to fire prevention has been largely unsuccessful by the lack of resources necessary to operate state-controlled fire monitoring systems (FAO 2001). Indonesia seems to be needed to build an innovative fire prevention system to break through the weakness of centralized fires control system because Indonesia has been developing decentralization since 1999.

The Indonesian Ministry of Forestry (MoF) and Japan International Cooperation Agency (JICA) initiated a pilot of a comprehensive extension program for fire prevention in village level ("Village-based Fire Prevention [VFP]") under the "Program of Community Development in Fires Control in Peatland Area (FCP)". The VFP is based on the field experiences and lessons learned from the past technical cooperation between MoF and JICA and taking into consideration development of decentralization in Indonesia. The First Project Year selected one targeted village in each targeted district to launch piloting VFP. The Second and Third Year selected 3 and 6 villages respectively in West Kalimantan Province.

This paper deals with the background and concept of VFP and its progress for further analysis to find an innovative ways effective to preventive to fire outbreak in the following years.

Methods

Background of VFP

Hotspot distribution (NOAA 18, MoF) in the whole West Kalimantan Province during 10 years (2001-2010) (Indonesian MoF & JICA, 2011) shows the most prominent fire prone sites are in “Other than State Forest” and “Production Forests” in State Forest by land status. Post-fire land covers distribute evenly except in Mangrove Forests. Land covers that density increased in 2006-2010 than 2001-2005 are “Estate Crop Land”, “Dry Land Crop with Woodlands”. Those trends inferred land conversion or misuse of fires for farming has something to do with one of drivers for fire outbreaks. More effective method of preventive to fire outbreaks caused by land burning for farming is needed according to localized situations.

As a result of decentralization, the responsibility of fire prevention in all lands and forests except of Conservation Forests belongs to District Government in Indonesia. The VFP prioritizes to approach to “Village” as a unit of fire prevention assurance by bottom-up planning of tailor-made fire prevention actions according to diverse drivers and localized situations, because village is the smallest unit of local autonomy under district.

Concept of VFP implementation mechanism

The VFP can be said an interaction program between district and village as shown in *Figure 1*. In district level, an inter-sector networking like working group to support Institutional Arrangement for Fire Controls by involving community empowerment agencies like Extension Office, land-based sector agencies like Agriculture Office, and also planning agencies like Bappeda. This networking aims at planning and doing collaborative actions, at supporting the targeted villages and at examining necessary policy and administrative measures, finally at proposing a district fire prevention program.

To bridge district and village level, Village Facilitators’ Team (VFT) may be organized as a networking of the important stakeholders who live in or work for the targeted villages, mainly from district administration and Conservation Forest Fire Brigade (Manggala Agni) of MoF, community empowerment agencies, village administration and some village groups. The VFT accompanies the targeted villages to stimulate community potential for planning and doing fire prevention and to bring information on reality of ground as well as community needs and initiatives to district as a motivator in cooperated actions with district.

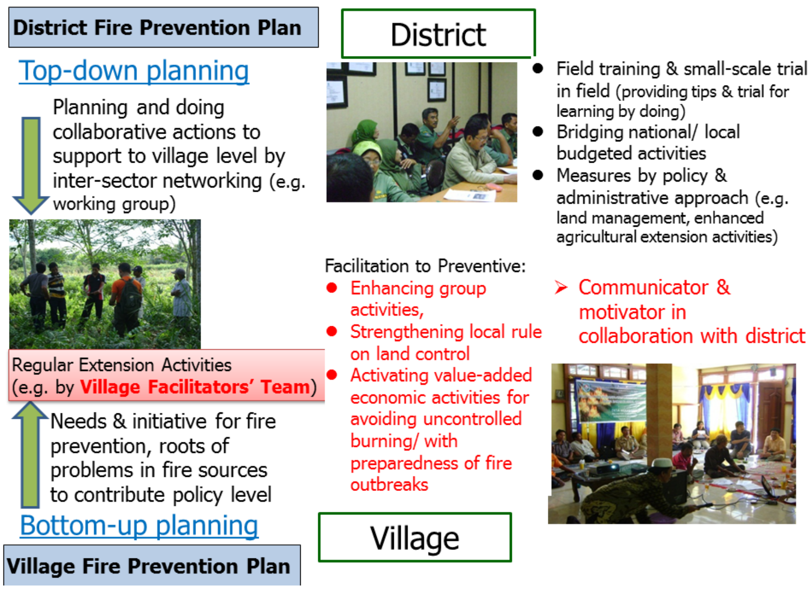


Figure 1. VFP implementation mechanism by district and village

Concept of VFP toward preventive to fire outbreaks

The VFT does not focus on handling fires (Preparedness to Fire Outbreaks) such as preparing fire-fighting equipment and do awareness building to fire prevention such as campaigning directly, but focus on enhancing social control and developing capacity of sustainable land management. The VFT facilitates village to plan written rules or programs, or sketch on rules or programs by combining or integrating the important 3 approaches as village fire prevention plan: "Village Land Control", "Activating Village People Groups"and "Diversifying Village Economic Activities (like intercropping, home industry and aquaculture) to develop capacities for intensifying land use and land productivities and enhancing land suitability as shown in Figure 2.

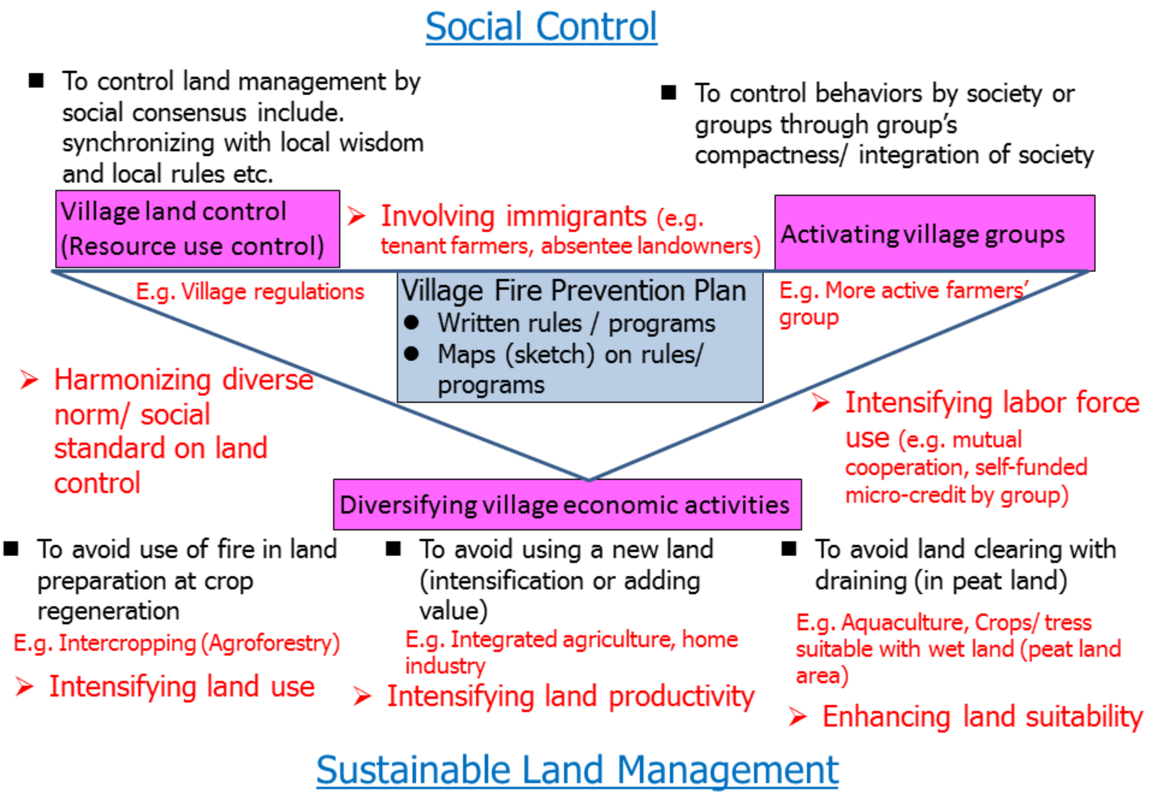


Figure 2. Planning and doing preventive to fire outbreaks in village-level under the VFP

The integration of those approaches is expected to support environmental-benign village development and then integrate fire prevention in village development so as for villagers to feel able to do land management without burning without feeling sacrificing themselves. Another integration is to strenghen social control as watching and social sanction to actors related land burning including immigrants as absenttee land owners by local society and collective actions to land management, through clarifying rules of village and enhancing compactness of village people groups with utilizing also local wisdom and custom so as to increase effectiveness and sustainability of land management without burning.

Results and Discussion

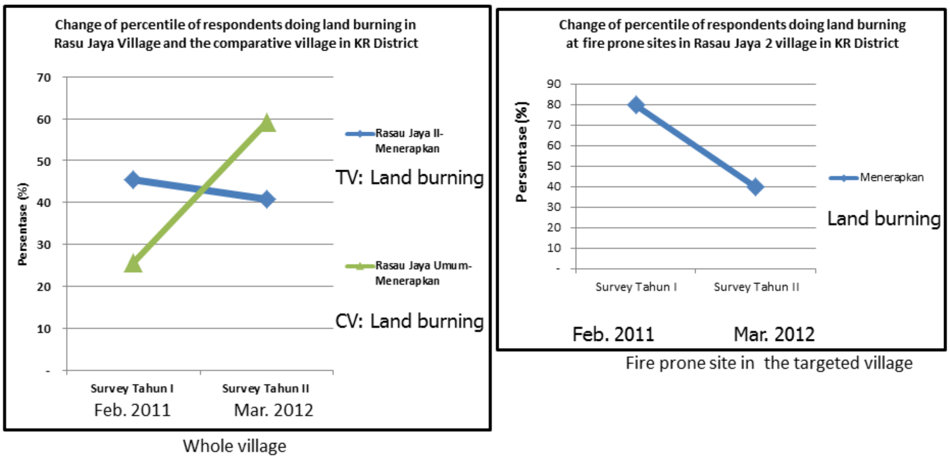
Progress of VFP in West Kalimantan Province

The progress of selected targeted villages by July 2012 in West Kalimantan Province is shown in Table 1.

Table 1. Selected Targeted Villages in West Kalimantan Province

Targeted Village	Starting Village Facilitation	Actual Action Days (as of Jul. 2012)	Major progress output
Kubu Raya District (Targeted haze-free zone around airport)			
Rasau Jaya 2	Jun. 2011	99	**Village regulation**
Mekar Sari	Apr. 2012	39	Sketch of fire prone hamlets
Teluk Bakung	Mar. 2012	40	Sketch of lands of farmers' groups
Rasau Jaya Umum	Around Feb. 2013	-	-
Pungur Kecil	Ditto	-	-
Kuala Dua	Ditto	-	-
Sungai Raya Dalam	Ditto	-	-
Bengkayang District (Coastal area)			
Sungai Pangkalan 2	Apr. 2011	88	Village maps (land stakeholders) and Farmers' group's work program
Sungai Jaga A	Mar. 2012	25	Activating home garden
Karimunting	Around Jan. 2013	-	-
Sungai Duri	Ditto	-	-

One of the targeted villages selected in the 1st Year (Rasau Jaya 2 Village) succeeded in concluding a village regulation covering fire prevention. The change of percentile of respondents doing land burning in whole village and only in fire prone site in Rasau Jaya 2 Village is shown in Figure 3.



		Change of actors of land burning
TV	Targeted village	- 4 %
CV	Comparative village	+ 33%
	Comprehensive impact	-37%

Figure 3. Change of Percentile of Respondents Doing Land Burning in Rasau Jaya 2 Village and it's comparative village

These graphics show that the village fire prevention plan influences reducing land burning actors by 4% of whole population in village and by 40% of land stakeholders at the fire prone sites in the village. Comparing the comparative village, it can also be estimated that the comprehensive impact to reduce actors of land burning by 37%. This result implicates that clarifying local norm using village regulation enhances social control to transform to refrain from land burning.

Factors influential to transform to without land burning

In order to seek factors effective to preventive to fire outbreak, the regression analysis of 21 variables on community profiles and variables on land burning behaviors (probability, frequency and land size for burning) was tried using ther results of socio-economic surveys for baseline and monitoring in cooperation with the local third party ("Socio-economic Surveys"). Table 2 shows 5 variables significant and influential to land burning behaviors found in the regression analysis by the Socio-economic Surveys conducted in the 2nd Year.

Table 2. Variables significant and influential to burning behaviors

Dependent variables [a]	**Adjusted R^2** [b]	**Independent Variable** [c]	**Coefficient value**	**Remarks**
Y_1:Burning behavior (Probability)	0.707	D_3 (Demographic Status: Indigenous/ immigrant)	-2.046	Social cohesiveness
		X_1 (Area of Land)	3.123	Land control
		D_4 (Local Wisdom: preparedness to fire outbreaks)	-2.330	Land control
Y_2:Frequency of burning (in 10 years period)	0.416	X_5 (Attendance in Agriculture Extension)	-0.442	Land economy
		D_3 (Demographic Status: Indigenous/ immigrant)	-0.322	Social cohesiveness
		D_6 (Costmary Sanction)	-2.437	Land control
Y_3 : Burned area (Area burned in once burning)	0.333	X_1 (Area of Land)	0.094	Land control
		X_5 (Attendance in Agriculture Extension)	-0.103	Land economy
		D_3 (Demographic Status: Indigenous/ immigrant)	-0.252	Social cohesiveness

Notes: a) Y_1 : Binary Logit; Y_2 and Y_3: OLS
b) n= 645 respondents (10 villages: both targeted villages and comparative villages in Bengkayang and Kubu Raya Districts)
c) Coefficient (absolute value) > 0.1 approximately

Those variables are "Area of Land", "Local Wisdom" and "Costmary Sanction" relating land control, "Demographic Status or Social Heterogeneity" relating activating village groups, and "Attendance in Agriculture Extension" relating village economy.

The positive coefficient in "Area of Land" implicates that the larger-scale land holding or land use will tend to affect to do land burning and increase area of land burning, while the negative coefficient in "Local Wisdom" and "Costmary Sanction" implicates that social control derived from such local norm as local wisdom and customary sanction will tend to affect to refrain from and reduce frequency of land burning. The negative coefficient in "Demographic Status" implicates that the influences from immigrants will tend to affect to do and to increase frequency and area of land burning.

The valuables relating to income and poverty among the 21 valuables in the above-shown analysis resulted in significant but little influential to land burning behaviors. The approaches for income generation or livelihood improvement are not expected to be effective to fire prevention. This result implicates integration of social and economic approaches focusing on land control, community integration and intensifying sustainable land-use economic activities will give us a breakthrough to more effective fire prevention.

Conclusions

The VFP have a potential to develop more effective fire preventive method than preparedness method even in peat land area by reducing land burning.

Acknowledgement

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USE OF PEAT SOILS AS A SUSTAINABLE AGRICULTURAL LAND

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Peat soils have a great potential to be developed as agricultural land when implemented at selected locations and with proper management. References of extensive peatlands in Indonesia vary depending on the time and methodological approach, for example by Polak (1952), it was around 18.35 million ha and by ICALRRD (2011), it was about 14.91 million ha. One important issue in clearing peatland for agricultural expansion is subsidence which is reflecting the presence of soil compaction and greenhouse gas emissions. Therefore, the use of peatland for sustainable agriculture land should consider the issue. Indonesian Agency for Agricultural Research and Development, Universities, and other institutions have produced many peatland management technologies to increase agricultural production and reduce greenhouse gas emissions. These technologies included water management, landscaping and plants arrangement, as well as amelioration and fertilization. Water management with stop-log (pintu tabat) and terraced stop-log could maintain groundwater level, thereby reduced oxidation of peat material and reduced GHGs emission as well as improved crop yields. Farming systems base on a thickness of the peatland and type of flood arrangement as well as selection of plants that are adaptive and have high economic value have been proven to be beneficial to farmers in peatlands. Amelioration and fertilization with pugam A, pugam T, rice husk ash, animal manure, tankos, and mineral soil materials effectively reduced CO2 and CH4 emissions as well as increased crop yields in peatlands.

Keywords: *agricultural land, peat soils, sustainable*

Introduction

Peatland is a potential ecosystem for agricultural development in outside of Java which is distributed in three major islands, namely, Sumatera, Borneo, and Papua. According to Polak (1952), peatland area in Indonesia was around 18.35 million ha, while Soepraptohardjo and Driessen (1976) stated that it was initially estimated at around 17 million hectares. Nugroho et al. (1992) suggested that swampland in Indonesia about 33.4 million hectares, consisting of 20.10 million hectares of tidal swampland and 13.30 million hectares of non-tidal swampland (back swampland). Tidal swampland consists of 6.7 million hectares of acid sulfate soil, 11 million hectares of peatland, 0.4 million hectares of saline land, and the remaining land is still potential for agriculture. Peatlands are generally found in coastal areas or in eastern and western coast of Sumatera, western, southern, and slightly in eastern part of Borneo, and in southern coast of Papua. Furthermore Indonesian Center for Agricultural Land Resources Research and Development (ICALRRD) (2011) stated that based on calculation of spatial updating maps of peat, using research data until 2011, the total area of peatland in the three major islands (Sumatera, Borneo, and Papua) was 14.9 million hectares.

Soil Survey Staff (1986) reported that peat contains organic matter ranged between 21-65% and are generally in wetlands, in both tidal swampland and non-tidal swampland. From most of the material, its original form is clearly seen, which is derived from timber and leaves. Only a small portion which is not clearly seen its original form. At around sediment of peat, it is frequently found fluviatil deposits of mineral soil carried by water river (Furukawa and Sabiham, 1985). Therefore, the peat deposit on the bottom layer which is scattered around the river, its materials are often in a state of peat mixed with mineral soil.

Opening and exploitation of peat has been started since 1920. In 1969-1994, the government through the Ministry of Public Workers cleared tidal swamplands massively, including peatlands of Borneo and Sumatera islands. About 500 thousand hectares of the lands opened and reclaimed for agricultural development in supporting resettlement program. In 1995, government has opened 1.4 million hectares of swampland known as the Lowland Development Project (PLG) in Central Kalimantan. The project was stopped, however, because of negative impacts on environment and socio-economic communities. Approximately 200-300 thousand hectares of the PLG land was potential for agricultural development.

Peat soils have specific properties that are different with non-peat soil (mineral soil). Not all peatland can be used for agricultural crops, such as at dome part of peat should not be opened because it will cause harmful environmental impacts (subsidence and greenhouse gas emissions). Only at selected sites, agricultural activities can be done. Peatlands which are suitable for farming have requirements such as (1) thickness of peat < 100cm, (2) sapric-hemic maturity, (3) thickness of peat about 20cm at top layer since the peat mix with mineral soil, (4) mineral soil material contain organic matter < 25% after reclamation or drainage, and (5) water level < 70cm. Research results showed that productivity of rice in peat decreases with increasing soil thickness up to 100 cm (Noor and Supriyo, 1991; Noor, 2001). Peatlands with thickness > 100cm have a very low level of mineralization as well as low level of soil fertility. Rice yield cultivated on thick peat soil continuously declined over time, so it was frequently abandoned. To maintain its productivity, appropriate and sustainable soil, water and plant managements are needed. This paper discus some perspectives about peatland potency and management for sustainable farming.

Peatland Potency and Development

According to the latest information from ICALRRD (2011), Indonesian peatlands were about 14.9 million hectares spread across three major islands of Sumatera, Borneo, and Papua (Table 1). Largest peatland in Sumatera scattered Riau, South Sumatera and Jambi Provinces respectively. Being the second largest peatland area was found on Borneo Island with the widest distribution in Central Kalimantan, West Kalimantan, East Kalimantan and South Kalimantan Provinces respectively. Furthermore Papua Island has the third largest peatland area that spread across Papua and West Papua Provinces (Table 2).

Peatlands have multifunctional aspect, namely as: (1) development zone which is an area for agricultural, plantation, animal husbandry including fisheries productions, (2) buffer zone which is an area for conservation and limited agricultural activities, and (3) conservation zone which is an area for biodiversity and landscapes conservation including peat conservation. Peatlands that are very deep (> 3 meters) and contain specific environment such as orang utan habitat as well as black water are included into this zone.

Table 1. Peatland area in Sumatera, Kalimantan, and Papua Islands

Island	Peat deep (cm)				Area (ha)
	50-100	101-200	201-400	> 400	
Sumatera	1.767.303	1.707.827	1.242.959	1.718.560	6.436.649
Kalimantan	1.048.611	1.389.813	1.072.769	1.266.811	4.778.004
Papua	2.425523	817.651	447.747	0	3.690.921
Total area (ha)	5.241.438	3.915.291	2.763.475	2.985.371	14.905.574

Table 2. Peatland area in Sumatera, Kalimantan, and Papua Provinces

Province	Peat depth (cm)				Total area (ha)
	50-100	101-200	201-400	> 400	
NAD	144.272	71.430	0	0	215.704
North Sumatera	209.335	36.472	0	15.427	261.234
West Sumatera	11.454	24.370	14.533	50.329	100.687
Riau	509.209	908.553	838.538	1.611.114	3.867.413
Riau Islands	103	8.083	0	0	8.186
Jambi	91.816	142.716	345.811	40.746	621.089
Bengkulu	3.856	802	2.451	944	8.052
South Sumatera	705.357	515.400	41.627	0	1.262.385
Bangka Belitung Islands	42.586	0	0	0	42.568
Lampung	49.331	0	0	0	49.331
West Kalimantan	421.697	818.460	192.988	246.989	1.680.135
Central Kalimantan	572.372	508.648	632.989	945.225	2.659.234
South Kalimantan	10.185	21.124	74.962	0	106.271
East Kalimantan	44.357	41.582	171.830	74.597	332.365
Papua	1.506.913	817.651	319.874	0	2.644.438
West Papua	918.610	0	127.873	0	1.046.483

Opening and exploitation of peatland was originally inspired by indigenous people who opened and planted with food crops (rice, sago, maize, sweet potatoes, etc.) and plantation crops (rubber, coconut, cocoa, etc.). The government, then, opened the peatlands massively for developing food crops as well as supporting resettlement program in 1969-1994 in order to increase particularly rice production. The research results showed that the productivity of peatlands is very diverse because it is influenced by biophysical properties and environment aspect of the land as well as technology of land management including agro input (seeds, ameliorant materials, fertilizers, agricultural mechanization, etc.). The productivity of rice in the peatlands is especially not only affected by the thickness and maturity of peat, but also crop nutrient management, particularly after reclamation.

Table 3. Potential rice yields at several peat thicknesses

Peat thickness (cm)	Grain Yield (t/ha)	Peat thickness (cm)	Grain Yield (t/ha)
0 – 10	1.6 - 2.4	0 – 30	no data
10 – 30	2.4 - 3.2	30 – 60	4.0 – 5.5
30 – 60	3.2 - 4.4	60 – 90	3.2 - 4.2
60 – 100	0.8 - 1.6	90 – 10	2.3-3.0

Sources: Supriyo *in* Noor et al. (2001)

The development of peatland for agricultural was spread among other in South Sumatera, Jambi, Riau, West Sumatera, West Kalimantan, South Kalimantan and Central Kalimantan Provinces (Table 4). Ahead challenges in the development of peatlands for agriculture is environmental and climate change issues. Peat is expressed as a source of greenhouse gas emissions so that their use is restricted. The government agreed reduction of GHG emissions until 2020 by 26% independently and 41% with international support where 9.5 to 13% of the emission is from peatlands. Another challenge in the development of food crops on peat in current situation is land conversion from paddy rice lands into oil palm plantations with quite rapid acceleration. Oil palm development on peatland in the last ten years was very quickly and estimated around 20% (> 200 thousand hectares in 1990) of oil palm plantations on peatland (Indonesian Agency for Agricultural Research and Development (IAARD), 2010;

Noor, 2010). Peatland conversion to oil palm fields requires drainage process, so that water table goes down and cause subsidence and greenhouse gas emissions.

Efforts to minimize negative impact of climate change phenomena, especially in the development of agricultural technology in reducing GHG emissions requires some policies, among others, are: (1) improving an understanding of farmers and other interested stakeholders in anticipation of climate change, (2) improving an ability of agriculture sector to adapt on climate change, (3) assembling and applying appropriate technologies to mitigate greenhouse gas emissions, and (4) improving the performance of research and development of climate change adaptation and mitigation (IAARD, 2010).

Table 4. Transmigration settlements unit in Sumatera and Kalimantan peatlands

No.	Province	Location	Comodity
1.	South Sumatera	Karang Agung, Delta Upang, Air Saleh, Air Sugihan, Air Telang, Pulau Rimau	Crop
2.	J a m b i	Sungai Bahar, Rantau Rasau, Lagan Hulu	Plantation and crop
3.	R i a u	Pulau Burung, Gunung Kaleman, Delta Reteh, Sungai Siak	Plantation
4.	West Sumatera	Lunang	Crop
5.	South Kalimantan	Tamban, Sakalagun	Crop
6.	West Kalimantan	Rasau Jaya, Padang Tikar, Teluk Batang, Sei Bulan	Crop
7.	Central Kalimantan	Pangkoh (Pandih Batu, Kanamit, Kantan, Talio, Maliku, Basarang, Sebangau), Seruyan, Lamunti (PLG Blok A)	Crop and plantation

According to road map of IAARD (2010), program and research activities needed to anticipate, mitigate and adapt to climate change within 5 (five) years, was among others: (1) a comprehensive analysis of vulnerability and impact of changes climate on agricultural sector, (2) development of information networks, communication systems, and climate advocacy, modules, maps and guides (cropping calendar, flood and drought anticipation, etc.), (3) Research and development of crop varieties which are adaptive to extreme climate change (drought, rising temperatures, salinity, floods, etc.), (4) Research and technological development of mitigation/reduction of GHG emissions and adaptation technologies, such as soil, fertilizer, water, plants and animals managements, (5) Research and development as well as comprehensive assessment on impact of peat utilization, (6) Identification and mapping of potential and little risk of peat, as well as the development of adaptive technology (eco-friendly) and conservation of peatland, (7) Research and development of institutions to support ability to adapt on climate change and mitigate greenhouse gas emissions, and (8) Analysis of policies for adaptation and mitigation of climate change.

The results of studies conducted by several research institutions of universities, IAARD, and other international research institutions showed that peatland could be developed for agricultural since with using proper and correct management. Proper and correct peatland management could increase not only agricultural production, but also reduce environmental impact, such as subsidence and greenhouse gas emissions. In summary, these technologies include: (1) water management, (2) land and crops arrangement, and (3) amelioration and fertilization. These three aspects are discussed below.

Water Management

Water management at micro level or at farm level are differentiated into flood type and cultivated commodities. At A and B flood type, water management with one-way system (one flow system) showed better rice yield than those with two-way system (two-flow system). We have to be aware, however, that soil leaching by small and large flooding did not only discard toxic elements but also removed essential nutrients. While changes in soil chemical properties showed that one way-system was better than two-way system. Application of water management of one-way system in acid sulfate soil has been shown to increase soil productivity.

Rice yield in acid sulfate soil with B food type, Tatas Unit, Central Kalimantan with using one way-system water management increased about 60% in dry season and 120-150% in wet season compared to two-way system (Noor and Saragih, 1997). Harsono (2010) also reported that the one way-system water management at tidal swamplands of UPT Delta Telang I, Delta Saleh, Banyuasin Regency and Delta Sugihan Kanan, OKI Regency, South Sumatera could increase soil pH from 4.33 to 5.59 and rice yield from 2.39 to 5.59 t grain/ha. The closer canal space the higher amount of washed ions. Study on water management in the future should be combined with land management in order to reduce essential nutrients loss but still effectively discard toxic substances (Alihamsyah et al., 2001).

Figure 1. Some models floodgates (flapgate and stoplog / dignity) swamp area in South Sumatera and Central Kalimantan (Doc EdyHarsono and M. Noor)

In type C and D settings overflowing water is directed at water conservation system with dignity (BALITTRA, 2003). In some areas flood type B / C can be developed one way system, combined with a system of dignity (SISTAK). Dignity multilevel system allows for setting a more diverse cropping pattern thus provide development opportunities and vegetable crops. Dignity system implemented by way of a functioning secondary channels collector channel. In this channel be mounted door dignity stoplog to regulate water level in the plot of land so that the height of the door can be adjusted as required. At the moment there is rain, the doors are left open to remove toxic elements from the plot of land, but after 4 to 6 weeks later the door dignity are functioning according to his need. System dignity combined with other technical culture can also support the development of rice-paddy cropping pattern, grain-crops and crops-crops as long as accompanied by the appropriate water management at the tertiary level and the plot of land. The experimental results of the water system with the dignity conserving rain water for paddy crop varieties IR66 rainy season rice-grain pattern in tidal surge of type C can increase rice yields from 3.31 tons / ha to 4.53 t/ha (Sarwani et al., 1997).

Organization of Land and Plant

Landscaping and plants is one of the critical success factors of agricultural development in tidal lands (both mineral soil and peat) in conjunction with the optimization of resource utilization and conservation of land (AdhiWidjaya and Alihamsyah, 1998). Tidal lands can be styled as rice paddies, fields and surjan adapted to the type of flood water and land typologies and utilization purposes (Table 5). Generally seen that land type A for always terluapi flood water should be laid out as a field, while the land type B outbursts can be styled as rice or surjan. Soil type overflow B / C and C because the tide terluapi but shallow groundwater can be styled as rainfed or surjan gradual and moor, while the land laid out as a type of overflow D or rainfed rice fields and gardens. Landscaping surjan in farming systems in wetlands play an important role because it has several advantages, among others: (1) intensistas land use increases, (2) a variety of agricultural production can be generated, (3) the risk of crop failure can be reduced, and (4) increased production and income stability. One example of landscaping and plants in West Kalimantan peatland for vegetable crops is shown in Figure 2.

Table 5. Reference plants in landscaping and agricultural development in wetlands

Land typology	Flood type			
	A	B	C	D
Potential soil	Sawah	Sawah/surjan	Sawah/surjan/upland	Sawah/upland/plantation
Acid sulphate soil	-	Sawah/surjan	Sawah/surjan/upland	Sawah/upland/plantation
Mineral+peat soil	-	Sawah/surjan	Sawah/upland	Sawah/upland/plantation
Shallow peat soil	-	Sawah	Upland/plantation	Upland/plantation
Medium peat soil	-	Conservation	Upland/plantation	Plantation
Deep peat soil	-	Conservation	Upland/plantation	Plantation
Saline soil	Sawah/fish farm	Sawah/fish farm	-	-

Source: Widjaya-Adhi (1995) and Alihamsyah et al. (2000)

Land preparation is generally done farmers slash and burn system. System of land preparation for paddy crop is highly dependent on the type of rice and aquaculture systems (Noor, 2010). In peatland type B outbursts do penyawahan by planting rice while the overflow type C according to upland rice, except during the rainy season can be planted paddy (Noor, 2001; 2007).

Figure 2. Structuring West Kalimantan peatland to plant vegetables that have been done intensively

In South Kalimantan in preparing land use tool known as System Banjar trowel trowel-Puntal-paving. Land preparation using tractor has a lot to do farmers in peat land, particularly peat and peat lands shallow, but for tractor use peat was often collapsed due to constrained land capacity is very low. According Chairunas et al (2001) on peat land preparation can be done by: (1) slashing grass/shrub performed using a machete, blow results gathered in one place, and then set on fire, and (2) Create a channel with kemalir width 30cm, depth 20cm and the distance between the channel and the channel ranges from 6-10m circumference.

The results of a cost benefit analysis citrus farming on peatland in West Sulawesi financially viable because the value of B / C> 1 (1.18 to 1.50). Positive NPV (US$ 11,037,121 - Rp. 17,682,333), and IRR is greater than the prevailing interest rate (from 48.01 to 49.24%). Compared with the interest rates the Bank's current (9% /yr), the citrus farming is profitable enough to interest rate of 18% due to the lower interest rate it will be more profitable farming.

Table 6. Cost benefit analysis of citrus farms at six villages of West Sulawesi in 2009

Investment criteria	Benefit cost analysis		
	DF 12%	DF 15%	DF 18%
B/C	1.50	1.30	1.18
NPV (Rp)	17.682.333	13.961.142	11.037.121
IRR (%)	49.24	48.48	48.01

Sources: RinaYanti, 2010

According to citrus growers farming on peatland easier to implement than the dry land, because land is more fertile peat, rare weeds and unnecessary holes in for planting. This situation will save the use of fertilizer and labor are the main limiting factor in farming.

Amelioration and Fertilizing

Giving ameliorant materials and fertilizing can be done to overcome the problems of soil acidity and low nutrient availability in the peat soil. Materials used can be ameliorant the offerings ash, river mud, soil minerals, steel slag, manure and lime as presented in Table 5. The use of materials ameliorant are interchangeable, for example, if given the lime, then the amount of the provision can be reduced to ashes.

Peat CEC value is high, but nevertheless the power pegangnya low exchangeable cation that fertilization should be done several times with low doses that are not easily leached nutrients. High CEC value actually due to the dominance of H+ ions is high, the other cations are generally low. Nutrients need to be added can be in the form of fertilizer that N, P, K, Ca, Mg and several micro nutrients, especially Cu, Zn and Mo. Based on the results Noor et al., (2006), contains micro elements Cu and Zn in peat Kanamit Village, District Maliku, Round Knife district, Central Kalimantan each is 4.95 ppm and 11.85 ppm and a relatively very low. Giving Cu more effectively absorbed through the leaves due to the strong nature of the peat and the lack of cars in the plant.

Table 7. Recommended dose ameliorant material at peatlands

Ameliorant	Dose (t/ha/year)	Benefit
Lime	1 – 2	Increasing soil basis and pH
Animal manure	5 – 10	Enriching macro and micro nutrients
Steel sludge	2 – 5	Decreasing toxicity of organic acids, increasing P fertilizer efficiency
Mineral soil	10 – 20	Decreasing toxicity of organic acid, increasing macro and micro nutrients
Ash	10 – 20	Increasing soil basis and pH
River sludge	10 – 20	Decreasing toxicity of organic acid, increasing soil basis as well as macro and micro nutrients

Sources: Agus and Subiksa (2008)

The results Noor et al (2009) on rice cultivation in peatlands showed that the land has undergone pemasaman (soil pH <4.5) is required lime at least 0.5 t/ha/season, while P and K nutrient status if given the low haranya fertilizer P and K respectively 100 kg/ha. Mineral soils containing high Fe may decrease the activity of phenolic acids. Phenolic acids is one of the organic acids produced from the anaerobic biodegradation of lignin compounds in high concentrations are toxic to plants.

Hartatik and Ardi (2006) reported a dose of mineral soil berpirit as much as 20% of the weight of the peat soil increases yield of rice but when the mixture was increased to 40% causes a decrease in grain yield due to the increased weight of the vacuum. Mixing berpirit mineral soil should be aware because it can have a negative impact on plant growth due to increasing Al-dd, H-dd and SO42-. Water management for rice with a dignity that serves to maintain the water at a rate of 5-10 cm from ground level and opened periodically to provide rice growth better than dignity is maintained during March-December (Supriyo et al., 2007; 2008). Water regulation by menabat tertiary canal at a height 110 cm inundation combined with giving ameliorant and fertilizer equivalent (5000 + 1000 Lime PPK cage + 50 N + 60 P2O5 + 50 K2O) kg / ha can improve water quality characterized by increased pH of the water and DHL water in the vegetative phase, increasing plant growth (number of productive tillers and plant height and fix some chemical properties of peat soils (soil pH increased from 4.16 to 4.56, the status of N, P and K-TSD-tot land) and lowering soil acidity exchanged (H- and Al-dddd) compared with control (water control with dignity since December to April, and dignity to the tertiary canal opened free until harvest).

In the face of climate change, provision of materials ameliorant to reduce GHG emissions from peatlands to limit some degree, depending on the type of peat, peat maturity and thickness. For example, fiber-seratan turf or grass (sphagnum) or peat ombrotropik have CH4 emission rate lower than forest peat timber. Sphagnum peat CH4 emissions at between 2.0 to 2.5 mg CH4 m-2.hour-1, while in the woods peat between 8.0 ± 1.1 and 9.6 ± 3.0 mg CH4 m-2. hour-1. The results Ariani et al (2008) showed that administration of dolomite (CaMgCO3) can lower total CH4 emissions by about 35% compared with steel slag or zeolites can only decrease total emissions respectively 29% and 6.6%. Giving dolomite, steel slag and zeolite, resulting in CH4 emissions respectively 493.5 ± 41.09; 537, 2 ± 16.88, and 695.5 ± 115.03 lower than without amelioration with 758.9 ± CH4 emissions 41.12 (Table 8).

Table 8. CH_4 emissions and rice grain yield with using ameliorant materials at peatlands

Ameliorant	CH_4 emission (kg ha^{-1})	CH_4 emission g C m^{-2}	Rice yield (t ha^{-1})
Without ameliorant	758.9 ± 41.12 a	75.9 ± 4.1	5.2 ± 1.15 a
Dolomite (5 t.ha^{-1})	493.5 ± 41.09 c	49.3 ± 4.1	5.2 ± 1.34 a
Zeolite (5 t.ha^{-1})	695.5 ± 115.03 ab	69.5 ± 11.5	5.0 ± 0.76 a
Steel sludge (5 t.ha^{-1})	537. 2 ± 16.88 b	53.7 ± 1.7	6.0 ± 0.89 a

Sources: Ariani et al. (2008)

The percentage reduction in CH4 emissions by giving ameliorant shown in Table 7. The use of materials ameliorant showed high CH4 emission reduction (40-57%) compared to treatment without ameliorant. Contained the highest decline in the use of rice husk ash followed by a pile. While the ability ameliorant materials to reduce CO2 emissions by approximately (5-30%). The highest decrease in the provision pile (34%), followed by administration of mineral soil (23%). According Nursyamsi et al (2011), the results in the first season showed that amelioration can reduce CO2 emissions (28-45%) and the highest reduction in the use of rice husk ash and pile.

Tabel 9. Global Warming Potensial (GWP) and reduction of GHG emission at use of ameliorant materials

Treatment	Total emission (t/ha/yr)		GWP (t CO2-e/ha/yr)	Emission reduction each gas (%)		GHG emission reduction (%)
	CH_4	CO_2		CH_4	CO_2	
Control	0.085	31.6	33.8	*bs*	*bs*	*bs*
Ash	0.037	30.0	30.9	-56.7	-5.1	8.4
Animal manure	0.041	21.2	22.2	-51.4	-32.9	34.1
Pugam A	0.051	24.6	25.8	-40.0	-22.3	23.5
Pugam T	0.046	25.1	26.3	-45.6	-20.5	22.1
Mineral soil	0.044	24.3	25.4	-48.9	-23.0	24.7

bs: baseline

Calculation of Global Warming Potential (GWP) showed that the use of pile on the second season can reduce GHG emissions from the highest other ameliorant. Husk ash, can reduce CH4 emissions peak, but its role in reducing CO2 emissions low. While the pile looks consistently derive both CH4 and CO2 emissions.

Future Peatland Use

Future utilization of peatlands should apply some basic key management such as: (1) supporting the legality peatland management, (2) based on spatial units peat hydrological system as a functional area of peatland ecosystems, (3) water management on peatlands, (4) development approaches based on the characteristics of mineralized material below the peat layer, (5) increased stability and decreased toxic properties of peat materials, and (6) the selection of plants according to the characteristics of the land.

Indonesia Presidential Decree No. 32 of 1990 on the management of protected areas, clearly states that the criteria for protected areas are peat as peat soil with a thickness of 3.0 m or more located in the upper river and marsh. Actually in establishing protected areas for peatland is not only determined by the thickness of the peat alone. Mineral soil material under the turf is also a concern. Although peat thin (<3.0 m) but if the peat layer beneath quartz sand, then this area should be protected. While peat deposit contained in the mineral soil of young and old can be recommended for agriculture crops, horticulture, and plantation, but must be done carefully and not at the center of the peat dome.

Peat can serve as reservoirs, water storage, and then distribute it to areas that are around. Therefore, every stretch of peat can be used as a functional area of peat ecosystems that serve as flood control, drought prevention, and as a buffer to the intrusion of sea water. Additionally drainage system must be designed carefully by considering the characteristics of peatland ecosystem.

Closing

Opening rice swamp land by the government were initially inspired by the success of local communities in developing rice plants. Approximately 3.0 million acres of tidal wetlands have been opened by the community organizations and 1.8 million hectares reclaimed by the government in the period 1970-1990. Then there are 1.4 million acres open to the PLG teleh Million Hectare Central Kalimantan, of which about 200-300 thousand hectares suitable for agriculture food. Of the total wetlands that have been opened about 500 thousand hectares are peatlands that can serve as the development of food crops and horticulture.

Development of farming on peat lands face many problems such as the water and land penglolaan aspects: (1) the height of inundation or groundwater levels are difficult to control, (2) pyrite layers beneath shallow peat layer, (3) and a thick layer of peat is raw, (4) intrusion of sea water, (5) the lack of supporting infrastructure or limited support, and (6) socio-economic conditions and investment of farmers on the land is limited. In dealing with the issue of climate change research activities in peatland necessary due to the limited level of information.

Development of the swamp requires a strong commitment both central and local government, including farmers. One key to success is the coaching, because most of our farmers are still generally low education, limited capital, limited orientation and comprehensive knowledge is limited, including marketing and pricing are controlled by external parties (vendors or large employers in both the means of production and production). Agriculture had long lost passion for today's youth so that agriculture is not an option as the business, especially in peatlands which includes troubled land. Therefore, the support of all parties, especially the government as an engine of development is needed to make agriculture can provide welfare and benefit of life assurance.

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WATER MANAGEMENT AND MRV METHODOLOGY FOR COASTAL RICE FARMING PEATLAND IN INDONESIA

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There is an international need to reduce CO_2 emissions from degraded tropical peatlands and to establish MRV (measureble, reportable and verifiable) methodology for their mitigation projects. To develop land for growing rice, coastal peatland of the Berbak Delta in Jambi, Indonesia was deforested,and canals and water gates were built to supply water to paddy fieldsin the 1970s and 1980s. These have since been insufficiently maintained, allowing the peatland to dry and decompose due to the decline of the water table and leading in turn to the generation of CO_2 and fall in rice production. This study presents aMRV methodologydeveloped to evaluate the CO_2 emission reductions in tropical peatland mitigation projects. The methodology combinesfield measurements, satellite data, and hydrological model calculationin a practical manner. The methodology was applied to a pilot projectarea of the Berbak Delta, where water level was raised and rice was grown during the dry season in 2012, and it was verified with the measured data. CO2 emission reduction estimated with the methodology is 414,000 tCO2/y of the 20,000 ha Brbak Delta, and there is a potential of 6 million tCO2/y reduction when applied nationwide.

***Keywords*:** MRV, methodology, peatland, rice farming, CO_2 emission reduction, water management, Indonesia.

Introduction

Tropical peatland covers approximately 250,000km^2 of land in Southeast Asia including Indonesia, and around 68.0 billion tons of carbon is estimated stored (Page et al., 2011). Over 80% of this is situated in Indonesia, and it is estimated that approximately 0.8 billion tons of CO_2 per year is being emitted as a result of peat fires and peat decomposition (DNPI, 2010). This is comparable to the amount of CO_2 emitted in Japan and accounts for around 5% of world CO_2 emissions. Peat decompostion as well as peat fires occur mainly during the dry season due to the decline of groundwater levels in peatland caused by deforestation and associated drainage, and are especially severe in El Niño years (such as 1997, 2002 and 2006). To mitigate these phenomena, water levels in peatland need to be restored to rewet the peat, and corresponding MRV (Mesurable, Reportable and Verifiable) methodology to quantify the effects of such action is necessary to be developed.

Study area is a rice farming coastal lowland in Berbak Delta region of Jambi province in Indonesia. Much of the area has peat soil, with a remaining thickness around 1m on average after decades of drainage and surface subsidence. The area was deforested in the 1970s and water channels and gates were built in the 1980s for growing rice by transimmigrants. Water level management has since been not well maintained, allowing drop of average water levels and causing CO_2 emissionsdue to aerobic peat decomposition. To curb this, peat oxidation needs to be reduced by restoring water levels through water management. This paper reports the results of water management pilot study conducted in the site and development of an MRV methodology using the site monitoring data, satellite data, and hydrological modeling.

Methods

1) Conditions of the study site

The Berbak Delta between Berbak and Batang Hari rivers on the east coast of Jambi was developed prior to the Mega Rice Project in Central Kalimantan by the Indonesian government, which madecanals and water gates in the area for rice farming by transimmigrants from Java (Figure 1). These canals and water gates have not been well maintained, and gates are often left open for drainage purpose and even bypasses have been built in some locations. As a result, water level control in the paddy fields does not function, and rice production is available only in the wet season most cases, resulting in low yearly yield of 1-2 tons/ha and not paying attention to peat oxidation.

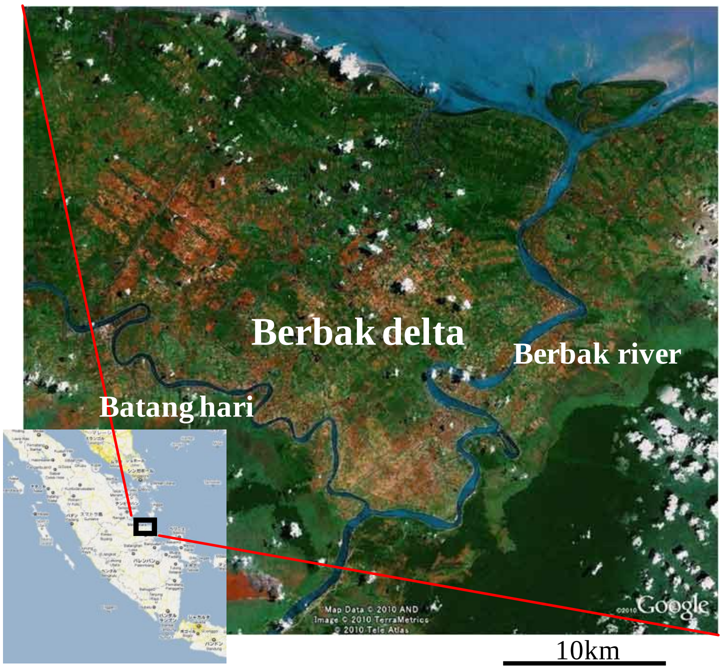

Figure 1. Study site (Tanjung Jabung Timur, Jambi, Sumatera)

2) Reduction of CO2 emission from peatland by water level control

Rewetting dried peatland by restoring water levels inhibits aerobic decomposition of peat and reduces the amount of CO_2 generated. As Figure 2 illustrates, this can be achieved by damming canals with gates to restore the water level in the paddy on peat layer. The associated CO_2 emission reduction can be calculated from the difference before and after restoring water levels withan emission factor for peat decomposition.

$$RE_y = \sum A_i \text{x } RWL_{i,y} \text{x } EF_{PEAT} \quad (1)$$

$$PE_y = \sum A_i \text{ x } PWL_{i,\,y} \text{ x } EF_{PEAT} \quad (2)$$

$$ER_y = RE_y - PE_y \quad (3)$$

where *RE* is CO_2 emission in reference scenario (tCO_2/y),*PE* is CO_2 emission in project implementation (tCO_2/y),*ER* is CO_2 emission reduction (tCO_2/y), *A* is an area where hydrological and peat conditions may be regarded as the same (ha), *PWL* is the annual mean water level during the project where water level be controlled to rise (m), *RWL* is the reference annual mean water level in reference scenario (m), and EF_{PEAT} is the emission factor of peat decomposition (tCO_2/ha/y/m), subscripts of *i* and *y* indicate area number and a year, respectively. Reference scenario in this study is set as BaU (Business as Ususal), that is groundwater level will not be managed if there is no project activity.

The above equations 1 and 2 correlating water level and peat decomposition were derived based on empirical evidence as shown in Figure 3 (Figure adapted from Hooijer et al., 2012), where dashed lines represent studies using only gas flux measurements (Jauhiainen et al., 2012; Hirano et al., 2012); the other lines represent subsidence studies (except Hooijer et al. 2006, 2010, which applied a combination). NEE number from Hirano et al (2012) is a minimum estimate for net (heterotrophic) emissions resulting from peat oxidation, as a correction for net carbon uptake by growing biomass in these regenerating degraded areas is required.

Despite these results having been obtained under a variety of conditions, CO_2 emissions stay within a comparatively narrow range of approximately 20 tCO_2/ha/y, indicating that knowledge of the relationship between water level and CO_2 emissions from tropical peatland has reached apracticallevel for use in CO_2 emission assessment of a project.

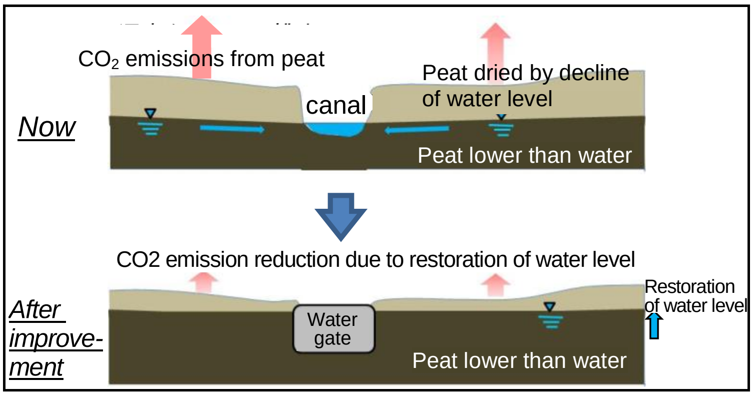

Figure 2. Reduction of CO_2 emissions by water level control in peat layer

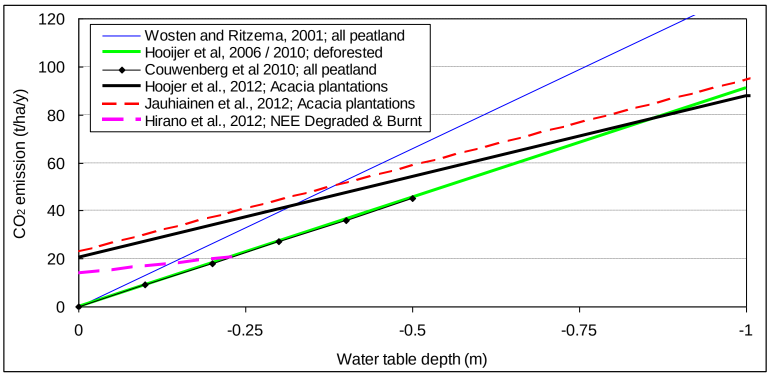

Figure 3. Relationship between water level and CO_2 emissions

3) MRV methodology

The total CO_2 reduction at the site can be determined by calculating the reduction of each area where water level and peat condition may be regarded as the same, and then summing the results. This is performed through the following stepsin general (see Figure 4).

I. Groundwater level (GWL), subsidence rate, peat thickness, and topography shall be monitored at representative points in each area of the project site,

II. Satellite data of topography, vegetation, and weather shall be obtained for the same period of time corresponding to the above site data,

III. *RWL*, annual average reference groundwater level of each area, shall be determined using the hydrologic model with input of the satellite climate data. The model calculation result shall be verified with GWL data monitored in the selected points of the project site in prior to the project implementation,

IV. *PWL*, annual average groundwater level of each area during project activity, shall be determined using a hydrologic model including effect of water control in the project with input of the satellite climate data (rainfall, air-temperature), and checked with the site monitored GWL. The calculation shall be verified for its accuracy with the site monitored GWL at selected areas with route mean square error less than 10 cm,

V. CO_2 emission in the project *PE* and in the reference scenario *RE* can be calculated by multiplying with emission factor EF_{PEAT} of peat decomposition with *PWL* and *RWL*, respectively. The difference between *PE* and *RE* gives the reduction on the site as a whole. (in Figure 4, the above two equations 1 and 2 are made into one equation), and

VI. As reference scenario is BaU and rice production is planned to be double or more in Indonesia according to national policy plan, effect of methane and N_2O emission due to the increase of groundwater table is not accounted as far as the rice production is less than the planned amount. If the production exceeds the plan, CH_4 and N_2O shall be calculated according to IPCC guideline.

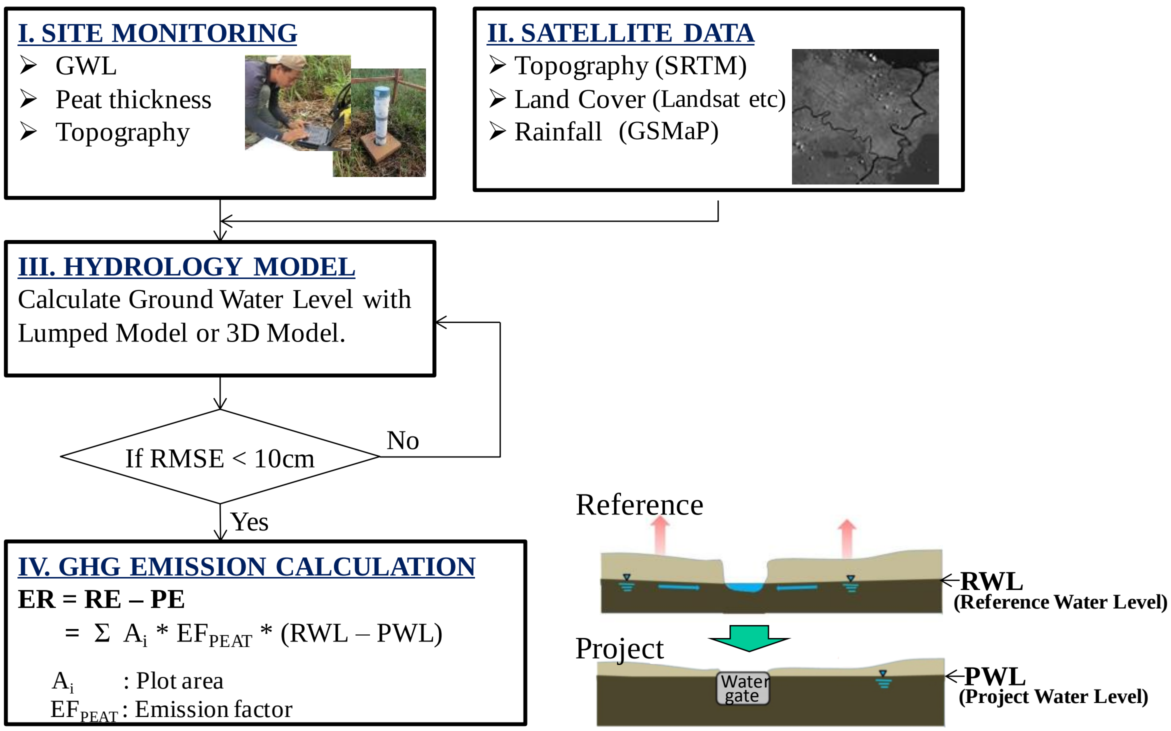

Figure 4. MRV methodology for CO_2 emission reduction by water management in peatland

Results

1) Groundwater level simulation for the entire site scale

Water level fluctuation in the project area can be calculated with alumped model by solving the water balance equation as shown in Equation 4, if the peat layer at the site is distributed approximately uniformly and the hydraulic gradient of groundwater is sufficiently small.

$$P_r - E_T - R = \frac{A \cdot \phi \cdot \Delta GWL}{\Delta t} \qquad (4)$$

where P_r: precipitation[LT^{-1}], E_T: evapotranspiration[LT^{-1}], R: inflow or outflow, ϕ: effective porosity[-], GWL: average groundwater level[L], A: project area [L^2],andΔt: time step.

Using satellite data of Pr and E_T, reference water level *RWL* and project water level *PWL* are calculated by adjusting *R*in each case to minimizeerror, which is the difference between the calculated groundwater levels and average groundwater levelsmeasured at multiple points. Figure 5 shows a comparison of the calculated groundwater level fluctuationfor 20,000ha area withaverage of water levels measured once every two weeks at 72 points across the entire site. The root mean square error (RMSE) between the calculated values and the measured ones is 10 cm, which indicates that groundwater levels on this 20,000 ha scale can be simulated by using the simple lumped model.

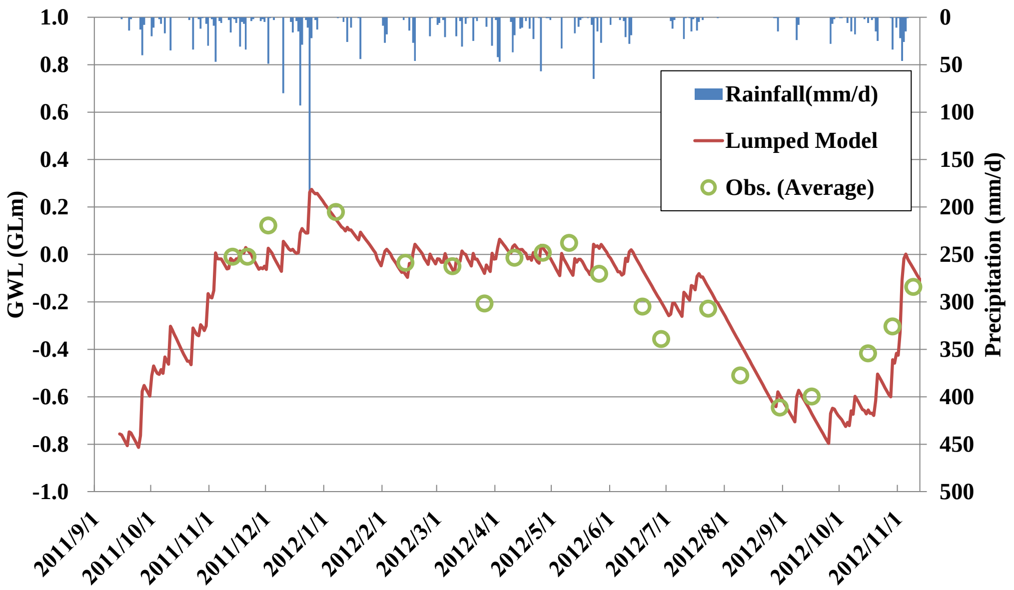

Figure 5. Groundwater level calculation atthe large site scale compared with measurement

2) Groundwater level in pilot project area with water control

The lumped model was then applied to a smaller scale of a12 ha pilot project area (Plot A), where water gate installation and its control was conducted to raise the water level during the dry season in 2012. Figure 6 shows groundwater levels measured in Plot A (*PWL*) varying in the range from 0.0m to -0.5m as well as ones in surrounding area (*RWL*) ranging from 0.0m to -1.2m. The groundwater level fluctuation can be simulated with the lumped model by adjusting the inflow/outflow parameter *R*to be -0.5 mm/day (red line) for the minimum water level drop case, 1.2 mm/day for the maximum case (blue line), and 0.4 mm/day for the average (green line).This result of the pilot study indicates that the water level rise of about 0.4m during the dry season can be made with water gates control, and that effect can be simulated with the adjustment of parameter *R* by the lumped model. Considering the physical meaning of *R*, in case *R* is negative that corresponds to water supply to the area with river water and hoding the water in the area, resulting in water level rise. When *R* has a positive value, meaning that water is discharged to the rivers lowering groundwater level in the area.

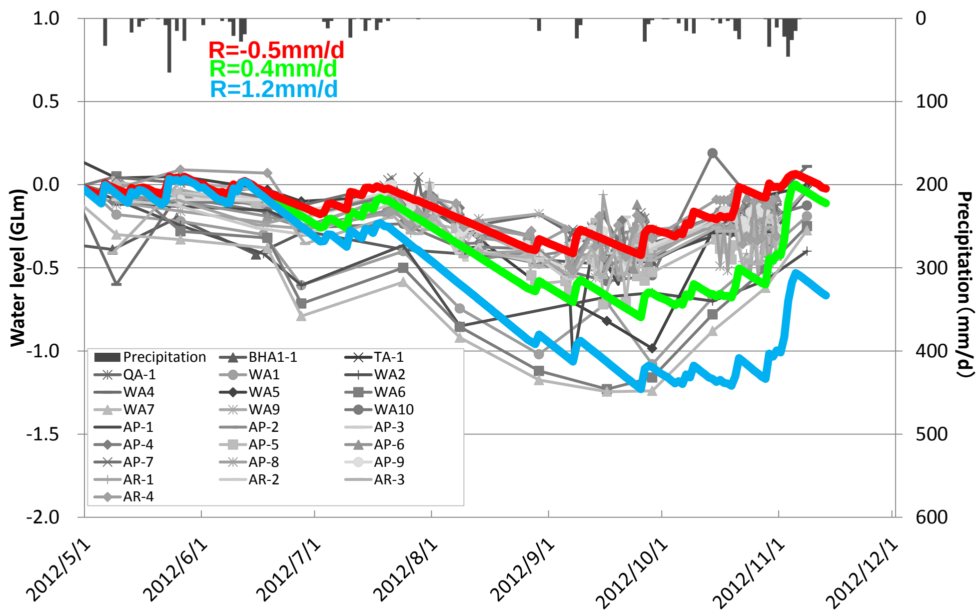

Figure 6. Effect of inflo/outflow on groundwater level simulation

Based on the above analysis, the *RWL* was calculated with effective porosity ϕ=0.15, inflow/outflow *R*=5 mm/day during the water level being above ground and *R*=0.1 mm/day during water level being below ground level as shown in Figure 7.RMSEbetween calculation and average measured water levels is 11 cm. On the otherhand, *PWL* in the pilot project area with water level control was simulated with ϕ=0.15, *R*=5 mm/day during the water level being above ground, and *R*=0.5 mm/day during water level being below ground level as shown in Figure 8, where RMSE is 8cm showing enough accuracy of the model calculation, and annual mean water level can be determined from the calculation.

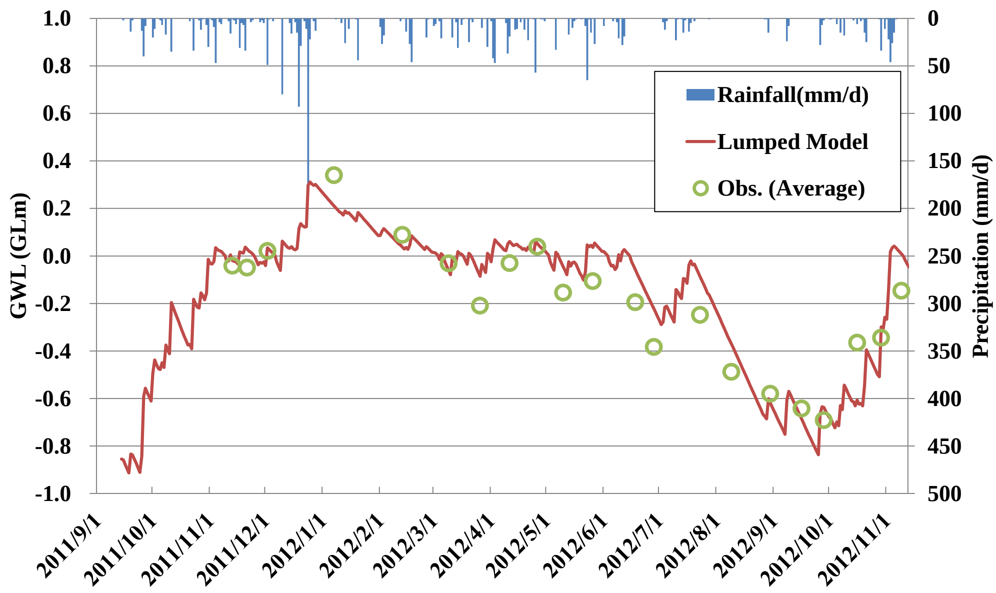

Figure 7. Comparison of simulated and measured reference groundwater levels

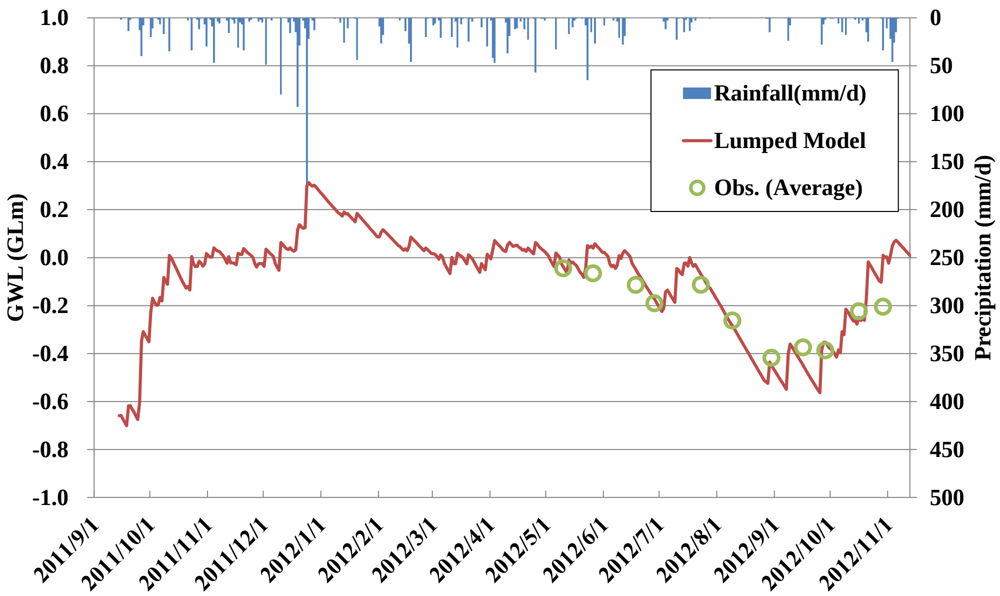

Figure 8. Comparison of simulated and measured groundwater levels in pilot project area

3) CO_2 emission reduction estimation

When the project be implemented, annual average water levels under two scenarios (the reference scenario and the project scenario) shall be calculated as above, and the CO_2 emission reduction shall be determined using the two water levels by Equations(1) - (3). If water levels wereraised by an average of 30 cm over the 20,000 ha site and assuming the emission factor to be 69 tCO_2/ha/y/m, it is estimated that CO_2 emission reductions are414,000 tons per year. When the same approach be applied nationwide, where some 260,000 ha of rice farming coastal peatland is estimated to exist, there is a potential of approximately 6 million tons of CO_2 reduction per year.

Conclusions

As peatland extends over vast areas of inaccessible terrain, it can be unfeasible to input the human and financial resources necessary to conduct detailed measurements with a high degree of temporal and spatial frequency. This report therefore describes in outline of the MRV methodology, which can be applicable to peatland mitigation projects and resulting CO_2 emission reductions evaluation,developed based on the field measurements including the pilot project to raisegroundwater levels over a period of one year and several months. Details of the methodology including calculation sheet are available at the website of the Global Environment Centre Foundation (GEC) http://gec.jp/main.nsf/en/Activities-Climate_Change_Mitigation-FS2012jcmfs05.

The pilot study showed that rice production during the dry season becomes possible as well as CO_2 emission reductions by raising groundwater levels through water management, thereby demonstrating the sustainability of the project as seen in Figure 9.

Figure 9. Rice growth during the dry season in the pilot project area (right hand side of the newly made tertiary canal and gate)

Acknowledgement

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INTERNATIONAL MOVEMENT OF CARBON CREDIT

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Market-Based Mechanism and Climate Change Policy Approach

The market based approach is one of the effective approaches for environmental issue and considered more effective than "command and control" approach. The Rio Declaration (UNCED, 1992) principle 16 stated "National authorities should endeavor to promote the internalization of environmental costs and use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution and so on". This principle means to say, the market-based approach was recommended as one of effective approach for environmental issue.

In Japan, the Basic Environment Act article 22 stated regarding importance of economic instrument for environmental protection approach. The Kyoto mechanisms of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) are considered as typical international market-based approach, so called "flexibility mechanisms". The Kyoto mechanisms includes Emissions Trading (ET, Article 17), Joint Implementation (JI, Article 6) and Clean Development Mechanism (CDM, Article 17), those three mechanisms shall be supplemental to domestic action.

Market for trading carbon (Carbon dioxide) is called as carbon market and can be categorized in two, as Compliance market and Voluntary market.(1) Credits of compliance market are used compliance purpose for emission reduction target, and followings are compliance market in the world. As international market, Kyoto protocol Emission Trading is implementing among Annex I countries. As regional market, EU-ETS is promoting among EU countries. As domestic market, New Zealand ET, Australian ET and US domestic market scheme such as Regional Greenhouse Gas Initiative (RGGI). Tokyo metropolitan government ET scheme is also considered as compliance market.

Voluntary markets are expanding worldwide, as international market, Verified Carbon Standard (VSC) is well known. In Japan, Japan Verified Emission Reduction scheme (J-VER) was established in 2008. Due to problem of second commitment period of Kyoto Protocol and uncertainty of the future framework from 2020, demand of carbon credit, especially in compliance market, has been decreased and market price was fallen down sharply because of big gap of demand and supply of carbon credit. This serious problem has been proved problem of capability of market-based approach for climate change policy such as ET of Kyoto Protocol and EUETS.

COP17 Agreement on Market-Based Mechanism

Despite of this problem, market-based approach will playing important role for climate change policy. At COP17, "new market mechanisms" was agreed for the target at 2020 and the next framework from 2020, and also agreed that appropriate market-based approach could be developed by the COP for REDD-plus. Two different types of "new market mechanisms" were agreed at COP17 and carbon credit expected to be used for target 2020 and new frame work from 2020.[2]

Following four paragraph (para) of COP17 Draft decision [-/CP.17] are considered important from the view point of market - based mechanism, and details as follows.

- Parties may, individually or jointly, develop and implement such approach in accordance with their national circumstance. (Preface of Chapter E)
- Various approach must meet standard that deliver real, permanent, additional and verified mitigation outcomes (para79)
- A new market based mechanism, operating under the guidance and authority of the COP to promote mitigation action------, may assist developed countries to meet part of their mitigation target or commitments under UNFCCC. (para83)

Also defined regarding REDD-plus market-based mechanism as follows

- Consider that, in the light of the experience gained from current and future demonstration activity, appropriate market-based approach could be developed by the COP to support result-based action by developing country Parties---(para66)

Japanese Policy on Climate Change and Market-Based Mechanism

a) Japanese policy and legal countermeasures on climate change

The climate change policy is promoting under “The Law for Promotion of countermeasures to Global Warming” (1998, revised 2002, 2005, 2006 and 2008). The main object of this law is for achievement of “Kyoto Target” of the first commitment period of Kyoto Protocol. Japan has submitted to UNFCCC on Jan. 2010 25% emission reduction in 2020. However this target is currently reviewed due to the Great East Japan Earthquake and nuclear disaster.

For achievement new target in 2020, “the Bill for the Basic Act on Global Warming Countermeasures” (Bill) was decided by the Cabinet in 2010, however this Bill is under reconsideration and not approved by the Diet. This bill including domestic emission trading scheme (ETS) is one of the key policy measure. Japan will continue to make emission reduction efforts beyond 2012, although Japan will not participate in the second commitment period of Kyoto Protocol

b) Current market-based credit system in Japan

In Japan, two market-based credit systems are promoting namely “the J-VER system” and “Japan’s domestic CDM system” since 2008.

(1) Outline of J-VER system
Japan-Verified Emission Reduction (J-VER) are managed under the ministry of Environment (MOE) as carbon-offset system in Japan. Initiatives by MOE are described in Table 1.

Table 1. Initiatives by MOE for J-VER

• Guidelines for Carbon-offset in Japan: published in Feb.2008 as general guidance • The carbon-offset J-VER guideline : published in Nov.2008 • The forest J-VER guideline :published in Mar.2009 • The prefectural J-VER program” scheme was started Feb, 2010 • The bilateral carbon-offset type” was started June, 2010

The J-VER guideline is considered as implementation rules and is stipulated highly transparent and reliable monitoring, reporting and verification (MRV) rules and framework.

J-VER scheme and flow of procedure is shown in Figure 1.

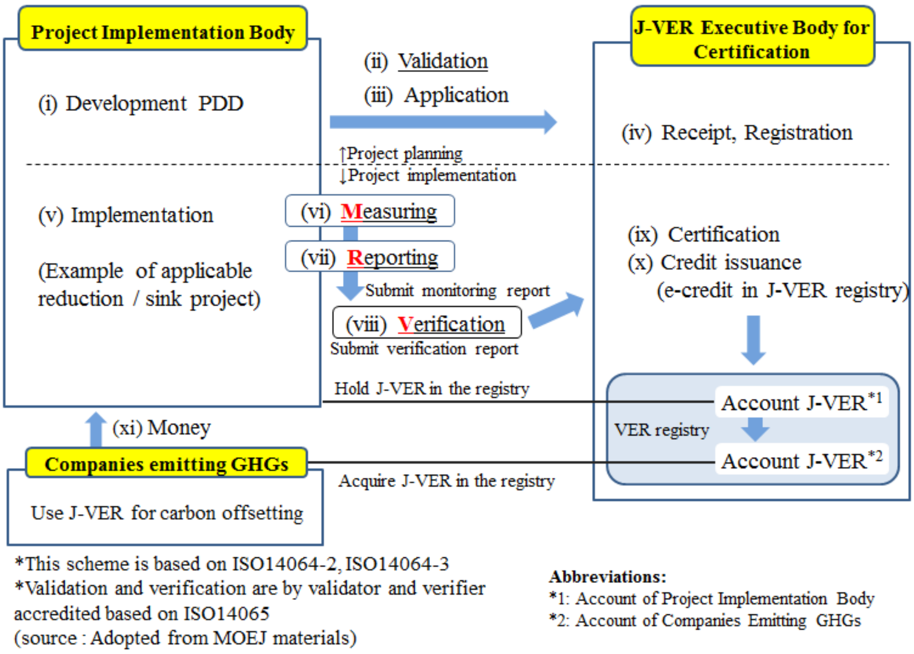


Figure 1. J-VER scheme and procedure

The credit under J-VER system includes credits of carbon sink by forest projects and emission reduction credits by energy projects. As of April 2012, 201 J-VER projects have been registered and certified 155 projects about 300,000 CO2 tons. Forest projects are held 55% of J-VER registered 201 projects and 94% of certified CO2 volumes. This figure shows that forest projects are one of important characteristic of J-VER.

(2) Outline of Japan’s domestic CDM system

The domestic CDM system is managed mainly by Ministry of Economy Trade and Industry (METI) in together with MOE and the Ministry Agriculture, Forestry and Fisheries (MAFF).

Outline of this system is follows;

- Large companies and small and medium scale enterprises (SMEs) conduct joint projects or GHG reduction.
- Targets of this system are energy saving projects, civilian activities for emission reduction. Forestry projects (sink projects) are excluded, but forest biomass energy projects are included.
- Large companies provide necessary capital in exchange for domestic credits which utilized to achieve voluntary action plan goal by industries federation for the Kyoto protocol, CSR and offsets.

The domestic CDM system scheme and flow is shown in Figure 2.

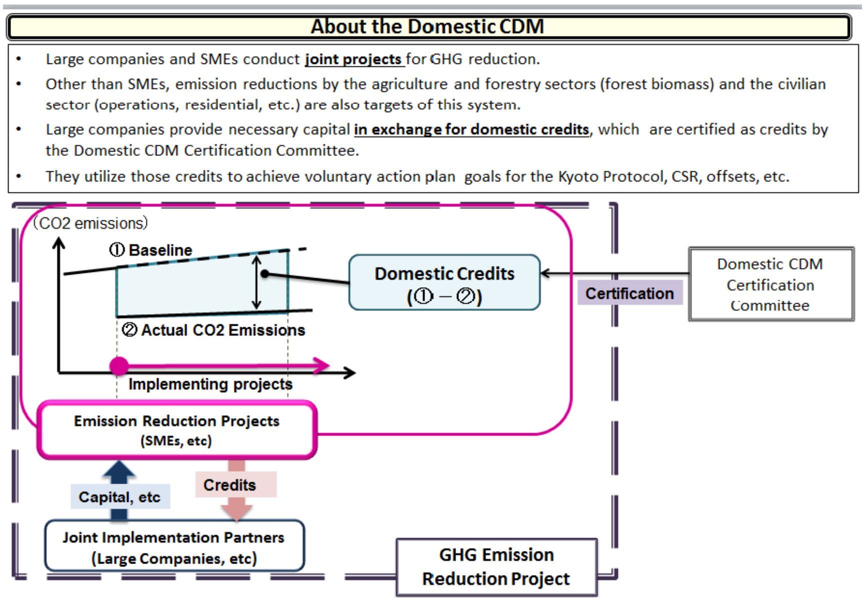


Figure 2. The domestic CDM scheme and procedure

As of April 2012, 1037 projects were approved and 795 projects 450,000 CO_2 tons were certified.

(3) Outline of the New Credit System

As described above, Two market-based credit system are existing and there is confusion of existing two systems, "The study group on the state of the new credit system" was established on April 2012 by MOE, METI and MAFF and conclusion as follows;

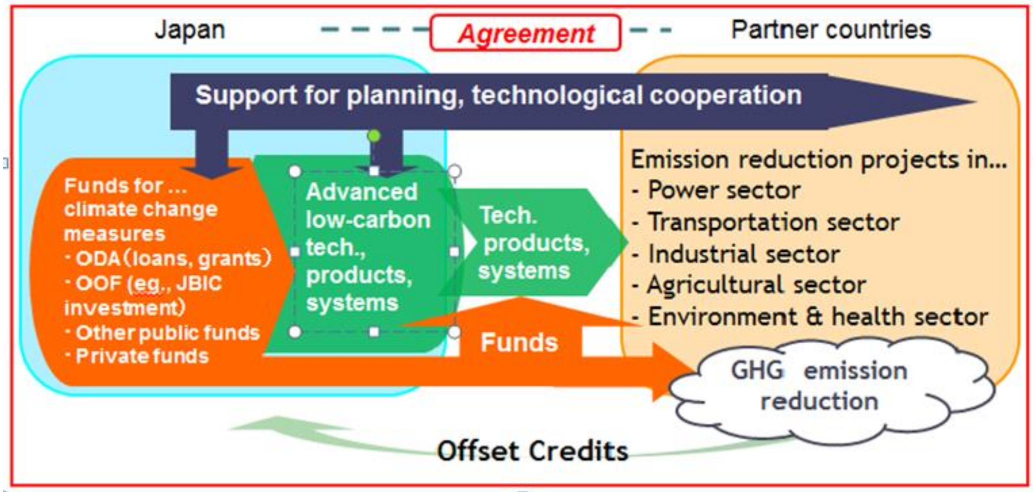
- Integration of the J-VER system and the domestic CDM system. To avoid confusion coexist two systems and to enhance the credit system.
- The new system should be established based on four concept below;
  - Adopt the merit of the two current systems
  - Viable environment but also convenient, applicable a broad range of cases
  - Support regional effort towards reduction of GHGs and local revitalization
  - Highly evaluated internationally and used as a reference by international effort to establish similar systems

The New Credit System will launch on April 2013, outline as follows;

- Type of projects is emission reduction projects and forest projects such as J-VER forest projects.
- Methodology and additionality are defined by "Positive list", same as J-VER scheme.
- MRV based on ISO14064-2, 14064-3 and ISO14065
- Purpose to use credit are CSR, carbon-offset, voluntary emission reduction target of big company, promotion of sales, etc.
- The prefectural program which similar to scheme of the J-VER System will be established.
- Scheme might be based on J-VER scheme which described in Figure 1.

(4) "The Bilateral offset Credit Mechanism (BOCM)"

The aim of BOCM is establishment "win -win" relations between developed and developing counties through promotion of technology transfer and emission credits. Japanese government will make agreement with partner countries for promotion of BOCM. BOCM projects include emission reduction projects such as power section, transportation sector, industrial sector, agriculture sector, etc. Also include REDD-plus projects. Outline of BOCM shows in Figure 3.



Sources: MOEJ

Figure 3. Outline of The Bilateral Offset Credit Mechanism (BOCM**)**

In order to promote BOCM, Japanese government (MOE and METI) finance to private sector for BOCM feasibility study (F/S) and F/S in fiscal year 2012 are follows;

- MOEJ
  25 projects were selected from 15 countries,
  Indonesia 3 projects (one project REDD-plus)
- METI-J
  As first stage 36 project were selected from 15 countries,
  Indonesia 11 projects
  As second stage 18 project were selected

Conclusion

1) Necessity of improvement market-based mechanism
   As the conclusion, following four points are considered essential of improvement market-based mechanism.
   - Market-based mechanism is playing important role of countermeasure on climate change, however current serious problem of CER, EU-ETS shows certain limit of capability of market-based mechanism
   - Credit price should be cover mitigation cost and transaction cost
   - Establishment of the Governance of market-based mechanism for REDD-plus is necessary
   - The positive incentive" of REDD-plus should be evaluated not only carbon value but also environmental, social value of forest

2) Socio-Economic and Environmental Value of Carbon Sequestration by Forrest and Peatland (4).
   REDD-plus is expected to have the potential to create a new scheme of evaluation in

relation to tropical forest and climate change. As shows in Figure 4, the value of carbon sequestration by forest should be evaluated in together with social, environmental value. Income from the credit should be contributed for mitigation of climate change, protection of forest, increase income of peoples, and sustainable rural development. This concept shows in Figure 4.

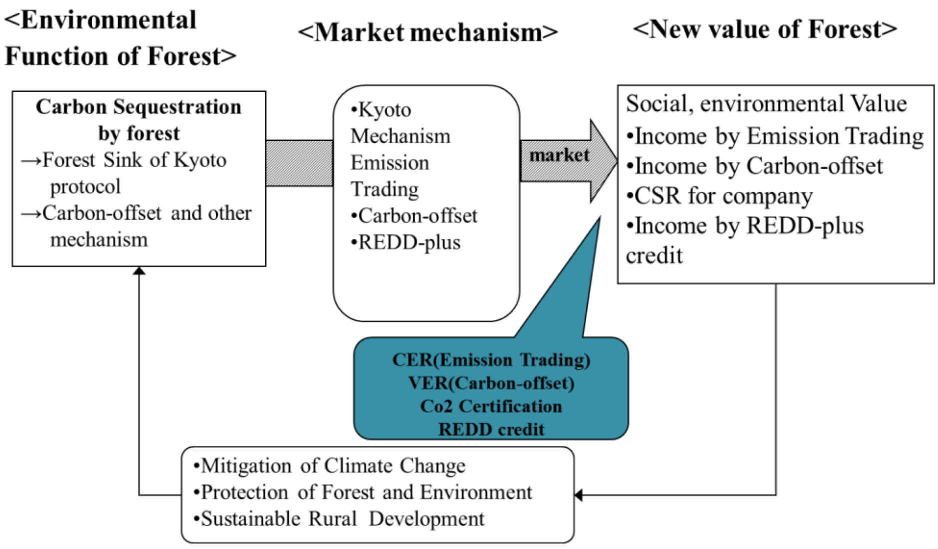


Figure 4. Socio-Economic and Environmental Value of Carbon Sequestration by Forest and Peatland

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REDD+ READINESS IN MYANMAR

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Introduction

Union of Myanmar, a tropical country in Continental South East Asia, Lies between latitudes 9° 30’ to 28° 31’ North and longitudes 92° 10’ to 101° 10’ East. The total land area of the country is 676,577km^2 (67.7 million hectares). It has an annual rainfall of less than 1,000 mm to more than 5,000mm. The average temperature is 32 to 38°C during the summer season and 10 to 25°C in cold season. The country’s population has reached to 58.38 million and over 70% of the country’s total population is rural and dependent on forest resources for basic needs such as food, fodder, fuel, and shelter. Myanmar is an agriculture-based nation. Consequently, greater emphasis is placed on the sustainable development of agriculture. Net sown area of agriculture has increased nearly double as a result of national land reclamation program along with the development of irrigation facilities. Agricultural expansion has taken place mostly in non-forested areas.

Mainly four categories of land use can be found in our country. Forest area is 47.01% of total land area (about 31.8 mil. ha), other wooded land is 29.73% (about 20.1mil.ha), other land use is 20.50% (about 13.9 mil. ha), and inland water body is 2.81% (about 1.9 mil. ha). Forest areas can be classified as mainly seven major types such as mangrove forests (4%), tropical evergreen forests (16%), mixed deciduous forests (37%), indaing (Dipterocarps) forests (5%), dry forests (10%), hill and temperate evergreen forests (25%), and scrub lands (3%).

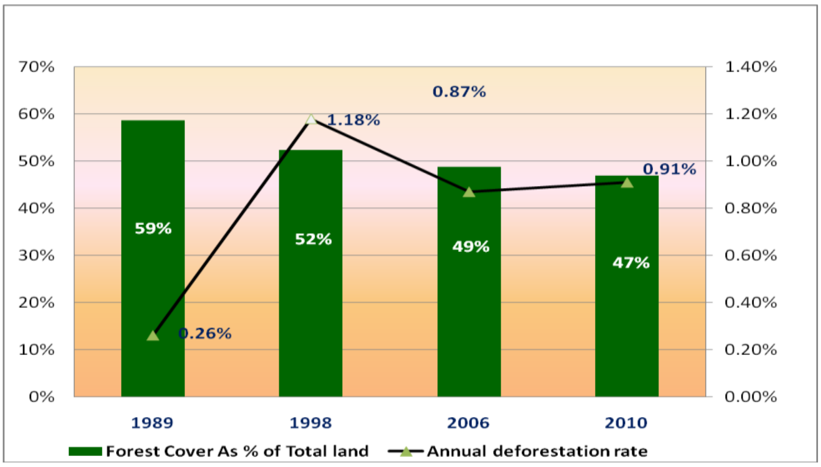
About 11,800 plant species are recorded to date, 1,071 are endemic. There are 1,347 species of big trees, 741 species of small trees, 1,696 species of shrubs, 96 species of bamboos, 36 species of rattan and 841 species of orchids so far recorded. Out of the 2,088 tree species, 85 have been recognized and accepted as producing multiple-used timber of premium quality. Bamboo grows abundantly throughout the country either mixed with tree species or in pure stands.

The distribution of the forests within the country is highly variable. Forest cover in the northern part of the country with sparse population is fairly undisturbed and dense. But in thickly populated areas, the forest cover is very low and the Central Dry Zone is practically devoid of high forests. Increasing population pressure, fuel-wood demand and industrial wood processing are the key factors in reducing the extent of forested land and thereby accelerating forest degradation.

Deforestation rate in Myanmar

During the period from 1975 to 1989, the forest cover had decreased at the rate of 0.64 percent or 220,000 ha annually. Due to the potential threats such as shifting cultivation, agriculture expansion, rural poverty, fuel wood collection, illicit logging, commercial logging, the forest cover had decreased from 59% to 47% of the total land area during the period from 1989 to 2010. The highest deforestation rate is occurred in the period of 1989 to 1998 which is about 1.18% annually.

Figure 1. Deforestation rate in Myanmar



1990-2010, annual loss = 372,250 ha (FAO-FRA, 2010)

Institutional capacity

Four institutions under the Ministry of Environmental Conservation and Forestry are undertaking their specific duties and responsibilities mainly related to environmental conservation and forest management.

1) Planning and Statistics Department
2) Forest Department
3) Myanmar Timber Enterprise
4) Dry Zone Greening Department

Enabling Condition for REDD+

Forest policy and legislation

Myanmar has been streamlining its national forest programmes since the early 1990s and many reforms have been made to reflect the national as well as regional and international concerns in the forest sector. Policy, legislative and institutional arrangements have been revised and updated in accordance with the Agenda 21. In order to achieve broader national goal and objectives, forest policy has identified six imperatives, namely, *protection*, *sustainability*, *basic needs*, *efficiency*, *participation* and *public awareness* that must be given the highest priority.

The major instruments currently used for managing the forest in Myanmar are as follows:

- Forest law, 1992
- Protection of wildlife and wild plants and conservation of natural areas law, 1994
- Forest rules, 1995
- Community forestry instructions, 1995
- National forestry action plan, 1995
- Myanmar Agenda 21, 1997
- Criteria and indicators for sustainable forest management, 1999
- National code of forest harvesting practices in Myanmar, 2000
- National forest master plan, 2001
- Protection of wildlife and wild plants and conservation of natural areas rules, 1994
- Environmental conservation law, 2012

Superseding the Burma Forest Act 1902, the new Forest Law was enacted in 1992, with adequate provisions for increased private sector involvement, community participation, biodiversity conservation, and increased forest resources security.

The former Forest Rules, prescribed in 1902 were replaced by the new Forest Rules in 1995. In order to facilitate implementation of the 1992 Forest Law, the new rules also place emphasis on increased formation and protection of reserved forests and protected public forests, sharing of forest management responsibility with the local communities, establishment of fast growing plantations on degraded forest lands to conserve soil, water and biodiversity and harvesting of timber and other forest products in an environmentally sound manner.

The Wildlife Protection Act (1936) was replaced by the new law in 1994. Under the new law, the modern concept of biodiversity conservation was introduced and the need for extended formulation of the protected areas system was also highlighted.

Community Forestry Instruction (CFI) was issued by the Forest Department in 1995 and marked a significant development in the aspects of partnership, participation and decentralization in managing the forests in Myanmar. The instruction grants the local communities trees and forest land tenure rights for an initial 30-year period, which is extendable. The Forest Department provides technical assistance and plays the leadership role in the exercise of community forestry.

Planning under policy stipulation

The 1995 Forest Policy aims at initiating development planning for the forestry sector to achieve sustainable development in resource production, processing and marketing, biodiversity conservation and restoration of ecological balance. In conformity with these policy stipulations necessary policy actions are formulation and implementation of long-term and immediate or short-term plans to realize the goal of SFM.

Myanmar forestry action program (MFAP) was also formulated and adopted in 1995 as a follow-up action to the tropical forest action plan. Eight main issue areas, which were obviously an extension of policy imperatives, were identified in the MFAP. They are sustainability, basic needs, protection, efficiency, institutions, policy and legislation, forestry extension and research.

In 1998, National Forestry Master Plan (NFMP) for a 30-year period from 2001-02 to 2030-31 was initiated by Forest Department as a follow-up action for MFAP as well as a national forest program exercise. The plan covers all main issue areas adopted by the MFAP. Establishment of forest plantation, community forestry development, bio-energy, non-wood forest products, human resource development, and forestry extension are the major components of the plan.

In 1996, Forest Department launched a special operation to update and reformulate the old working plans in line with modern forestry concepts. The new forest management plans place emphasis not only on timber production but also on NWFPs, biodiversity conservation and socio-economic well-being of local people. This forest management plans formulated for 64 districts which covering the whole country and adopted for action.

Natural forest management

Natural forests in Myanmar are being managed under a selection-cum-regeneration system known as Myanmar Selection System (MSS). Under MSS, only mature trees are selected and harvested. Harvesting of trees is regulated based on annual growth and controlled by girth limits prescribed species-wise. Teak and other hardwoods from the natural forests are harvested within the prescribed annual allowable cut (AAC) which is a tool to ensure harvest of timber-yield on sustained basis. The AAC for teak and other hardwoods are revised periodically, in accordance with the existing stock.

Reforestation program

Generally, more than 30,000 ha of forest plantations had annually been established since from 1980 due to rapid deforestation. Forest Department (FD) establishes four types of forest plantations, namely commercial plantation, village supply plantation, industrial plantation and watershed plantation. At the end of 2010, a total of 838,642 ha of forest plantations have already been established by FD throughout the country.

With the development of market-oriented economy, the government has been encouraging involvement of private sector in plantation forestry to support economic development of the country and environmental conservation. Establishing forest plantation by private entrepreneurs/companies/local people has been started since 2006-2007. At the end of 2010, about 49809 ha of teak plantations and 16220 ha of other hardwood plantations have already been established by private sector.

Establishment of community forests

It is the importance of participation of the local people in both planning and implementing activities in forestry sector so as to ensure that all parties would share responsibilities and benefits. Nowadays, many countries in tropical Asia including Myanmar, have actively engaged in the practice of community forestry, hoping to help to restore the productivity of degraded forest lands and to promote the welfare of the local people. It is a major breakthrough in forestry sector in order to keep pace with the changing socio-economic and environmental concerns.

Forest Department has been promoting community forestry in Myanmar since CFI has been issued. At present, community involvement in forest conservation and utilization gradually become accelerated and the total area of community forests has reached up to 42,147 hectare at the end of 2010.

Afforestation in dry zone area

Desert-like formation has been a threatening environmental issue facing the dry zone of the central Myanmar. Land and forest degradations are the major issues in the region. The Dry Zone Greening Department (DZGD) was therefore formed in 1997 with special tasks to restore environment, prevent desertification and mitigate climate change in the dry zone of the central Myanmar. Establishment of forest plantations, protection and conservation of remnant natural forests, promotion of wood-fuel substitution, and development of water resources have been implemented as major tasks in this region.

The extent of the closed forest in the dry zone is now 1.72 million ha constituting only 19.7 percent of the total land area of the region. The integrated plan has envisaged making up the balance by conserving and improving degraded forests and by artificially regenerating suitable sites. Therefore, approximately 730,000 ha of the degraded forests will be conserved and upgraded by natural means, while 323,750 ha will be planted during the plan period of 30 years. In addition, about 500,000 ha of the natural and planted forests will be converted to community forests by the end of the plan.

Bago Yoma greening program

Bago Yoma is the name of the mountain ranges running north to south which is situated in the central part of lower Myanmar. It includes 31 townships in 8 districts of 4 regions. At the previous, this region was endowed with vast forest resources. The forested area of Bago Yoma in 1856 was about 8.5 million hectares. However, the present forested area has decreased to 5.1 million hectares due to the population pressure and utilizing the forest products recklessly. It has been increasingly apparent that forests have been degraded at an alarming rate. Therefore, the rehabilitation program is being carried out through the planting of teak and locally adaptable species so that this region will become green and contribute to local, regional, and national developments in social and economic perspectives. The program is started from 2004 and the rehabilitation activities such as conservation and protection of natural forest, enrichment planting, natural regeneration, establishment of forest plantation, establishment of community forest, development of water resources, forestry extension service for local community, encouragement of fuel wood substitution have been carrying out in this region.

Development of C&Is towards SFM

Identification of C&Is for SFM at national and forest management unit level (FMU) was initiated by Forest Department in 1996 based on ITTO's Criteria. Myanmar C&Is for SFM was revised in line with the latest ITTO’s C&Is with the cooperation of the Forest Department (FD), Myanmar Timber Enterprise (MTE) and the Timber Certification Committee (Myanmar). There are 7 criteria and 50 indicators at the FMU level for the sustainable management of the forest resources, including environmental performance assessment. The FD has been testing and assessing the adequacy and applicability of C&Is at FMU level for further improvement.

National Code for forest harvesting

The mission of Code has been identified as the protection, conservation, management and utilization of forest resources of Myanmar for sustainable development, taking into account of social, economic and environmental values of forests in an integral manner. It is the guidelines for forest harvesting agencies in all types of production forests and for conservation and management of protected areas. The Code covers in details for pre-harvest, harvest and post-harvest planning, engineering works concerning road construction and maintenance.

Establishment of protected areas (PAS)

Although biodiversity habitats have been diminishing throughout the country, Myanmar has a potential for establishing the protected area system before forest areas lose their ability to provide adequate ecosystem services. Targeting to increase PAS coverage up to 10% at the end of year 2030, the Ministry of Environmental Conservation and Forestry has notified 34 protected areas covering about 3.93% of the total land area and designated 9 protected areas covering about 3.38% of total land area.

Current situation of REDD+ readiness

Preparation activities

The Government of Myanmar signed UNFCCC on 11 June 1992 and ratified the convention on 25 November 1994 and also ratified Kyoto Protocol in 2003 as a non-Annex I party. DNA of Myanmar was established in 2006 in order to provide information and to implement CDM activities. DNA has 22 members from 15 ministries, led by Ministry of Environmental Conservation and Forestry. Forest Department organized a core unit and it has been preparing the A/R CDM PDD as well as REDD activities such as awareness raising about REDD+ and capacity building through workshops, trainings and publication. To develop the guide lines, strategies, and procedures, REDD+ readiness preparation projects and programs have been implementing in the country. Furthermore, Myanmar became a partner country of UN-REDD Program.

Organizing of training and workshop

First national workshop on REDD in Myanmar was held on April 7, 2010 and Second national workshop on disaster risk reduction and REDD was held on December 20-21, 2010, at Forest Department, Nay Pyi Taw, jointly organized by the FD and UNDP. Regional workshop on REDD-plus (10-11 May, 2011) and capacity building training on REDD-plus (12-13 May, 2011) were organized with the cooperation of Korea Forest Service. Personnel from ASEAN Member States, UN-REDD program, UNDP, UN-HABITAT, FAO, JICA, KOICA, WCS, Government Ministries, NGOs and private companies participated to this regional workshop.

Implementation of projects and programs

(a) Capacity building for developing REDD-Plus activities in the context of sustainable forest management project (ITTO project - 3 years)

Expected output 1: Development of REDD-plus national strategy
Activities: Collecting all available information on REDD-plus initiatives and implementing extension activities through media, publications, poster, pamphlet, cartoons, public educational talks;
Building institutional capacity for REDD-plus national strategy through workshops, trainings, seminars, and lessons learnt;
Formulation of REDD-plus national strategy through organizing series of stakeholders' consultations meetings and establishing coordination mechanism;
Publication and dissemination of REDD-plus national strategy;

Expected output 2: Institutional setting for capacity building on REDD+ strengthened
Activities: Preparation of scheme and integrated plan to build capacity on REDD-plus through consultation meetings among stakeholders;
Strengthening coordination mechanism among relevant stakeholders;
Organizing series of trainings, workshops and seminars as well as practice REDD-plus activities to increase well-trained persons in REDD-plus activities including MRV of carbon stock;
Building capacity for free, prior and informed consent (FPIC) through trainings and practicing in the project site;

Expected output 3: Capacity to conduct MRV of carbon stock built
Activities: Preparing standard operational guidelines for MRV of carbon stock and forest resource inventory in the project site;
Establishing demonstration site and practicing REDD-plus activities;
Conducting forest cover assessment, forest resource inventory and measuring carbon stocks for baseline data on carbon stocks of project site;
Setting reference level of carbon emission of the project site;

(b) Mitigation of climate change impacts through restoration of degraded forests and REDD-plus activities project (cooperation with Korea Forest Service - 1 year)

This project is being implemented in yoma unclass forest, yedashe township, Bago region. The objectives of the project are; to initiate pilot activities for restoration of degraded forests and conservation of ecosystem in order to mitigate climate change impacts and support sustainable forest management, to measure baseline carbon stocks and set reference scenario of carbon emissions through a reliable MRV system focusing on REDD+ readiness, and to strengthen capacity and enhance awareness of FD staffs and relevant stakeholders in REDD+ readiness and ecosystem conservation. The main project activities are;

1) Conservation of natural forest, establishment of arboretum, and establishment of community woodlot for the enhancement of forest carbon stock,
2) Organizing the technical trainings, workshop, seminars, public talks, publication, study tour and consultation meetings for capacity building and awareness raising on REDD+,
3) Forest inventory and forest cover change assessment for MRV & baseline carbon stock,
4) Distributing horticultural fruit trees and social welfare for Income generation and rural development,
5) Preparation of technical reports (deforestation analysis, baseline carbon, species composition, stand structure), translation REDD+ documents for development of REDD+ Readiness,

(c) Program for Myanmar REDD-plus readiness preparation especially for MRV and stakeholders engagement. (Technical cooperation with Asia air co. ltd., Japan)
(d) Development of roadmap and strategies for REDD-plus (UN-REDD program)

National REDD+ strategies (draft)

Strategy 1 - Tackling deforestation and forest degradation
Major tasks - Analyze major drivers of deforestation and forest degradation, develop more effective conservation and management of Permanent Forest Estate (PFE), develop more effective management of planted forests and enhance forest carbon stock, stabilization of shifting cultivation, integrate forestry with rural development program;

Strategy 2- Enabling policies
Major tasks - Establish institutional mechanism, clarify and ensure legal carbon and land tenure right, establish quantifiable national forestry emissions reduction targets, develop long-term policy on payment for Ecosystem Service (PES), ensure REDD-plus social and environmental safeguard;

Strategy 3- Strengthening forest governance
Major tasks - Establish National REDD+ Committee/REDD National Working Group, integrate/mainstream REDD+ into sectoral plans, establish equitable benefit distribution system, develop technical and institutional guidance to implement REDD+, strengthen law enforcement and anti-corruption scheme;

Strategy 4- Set reference level emission (REL) at the national level
Major tasks - Measurement of baseline carbon stock at the national level (sub-national level) with appropriate MRV tools, establishment of MRV system at national level (sub-national level), implementation of pilot project for MRV and REL;

Strategy 5- Strengthen institution, building capacity and raising awareness about REDD+
Major tasks - Development of infrastructures for REDD+, establishment of multi-stakeholders coordination mechanism, building capacity of all relevant stakeholders, implementing Free, Prior Informed Consent, promote REDD+ through information, education and communication (IEC), enhancing learning exchange, sustaining government and non-government cooperation;

Strategy 6- Ensure sustainable financing for REDD+
Major tasks - Implementing multilateral and bi-lateral approaches for sustaining financing (diverse long-term funding mechanism), seeking immediate donor funding for

REDD+ readiness, pursuing equitable and reasonable benefit sharing among stakeholders;

REDD-plus roadmap (draft)

No.	National REDD+ Roadmap	Time Frame								
		1st Year		2nd Year		3rd Year		4th Year		5th Year
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	
1	Phase I									
2	Phase II									
3	Phase III									

Collection of information will be in phase I. Management of the REDD+ readiness process, stakeholder engagement, implementation framework, REDD+ strategy setting, reference scenario, and national monitoring system will be carried out in phase II, and implementation of REDD+ in Phase III.

Conclusions

Reducing emissions from deforestation and forest degradation, and enhancing forest carbon stocks in developing countries (REDD and REDD+) started as a global initiative. Maintaining existing forests, reducing deforestation and eliminating forest degradation are important elements of a future climate change scenario that integrates the role of forests and forestry.

Myanmar is one of the tropical countries possessed high forest cover that contribute to the mitigating climate change and has many enabling conditions for the implementation REDD-plus. Most of REDD as well as REDD+ activities are in line with the Myanmar forest policy and forest management system which focuses on sustainable production of timber with the least adverse effects on the forests. Community forestry is also practiced with people's participation in order to secure livelihood of the rural communities and to support the SFM. Protected area systems are also established across the country to not only to conserve biodiversity but also environmental stability.

But there are many things still needed to do preparation for the Readiness of REDD-plus. Myanmar has been trying our best with our capacity. International cooperation and development aids are needed for capacity building, demonstration activities, policy reforms and strengthening governance.

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DISTRIBUTION OF VEGETATION SPECIES ANALYSIS IN A HYPERSPECTRAL IMAGE IN TROPICAL PEAT SWAMP FOREST, CENTRAL KALIMANTAN

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HyMap is one from several the hyperspectral sensors which has a narrow and specific spectral, analytical interpretation expected to be generated more accurately, especially for high diversity of land cover location. Study site is a part of the Mega Rice project area and covered by peat swamp forests (PSF), located in the Equator region. In previous study was conducted comparison between Landsat 5 TM image and HyMap. Result of training data from HyMap image demonstrates reflectance value is inversely proportional to the level of vegetation health, on the spectral range of 0.76-1.35 μm or so-called Near Infrared (NIR), before comparing the both of image data should be converted into the same units, reflectance unit. For this lack at study sites that chose classification unsupervised without using training data as a basis for classification (Lillesand et al., 2007). Compare two approaches in unsupervised classification; K-means approach is more effective than ISODATA.

Keywords: hyperspectral sensor, classification, vegetation diversity, tropical peatland

Introduction

Vegetation in peatlands

Tropical peat swamp forest has various functions and social environments in natural conditions. This area is home for thousands of plants and animal's species (biodiversity), and plays an important role in global climate change, etc. Scale damage in the peat swamp area is large and has changed its function, and still continues. However, now, the role of peatlands has an impact on climate change, as storage of large amounts of carbon (especially CO2).

On the disturbed forest, these changes lead to extreme fire susceptibility and dried peat soil is highly flammable and difficult to detect because fire movement was under the soil surface. At first, fire only relatively is small. However, when the El Niño caused significant drought in Indonesia; large fires continued to occur.

Figure 1. Degraded peatland in block C of the former Mega Rice project area, Peat swamp forest has been replaced by fern-dominated vegetation

Mostly, the environmental damage is caused by human activities. Damage can be seen through reducing of forest area and changing functions of forest, such as Mega Rice project.

The peat-swamp forests were characterized by poor nutritional conditions. This is a unique and important ecosystem, but they are fragile and sensitive for development. Some previous studies in this location such as Brady (1997), Shepherd et al. (1997), Stoneman (1997), and Page et al. (1999), in general reported the presence of relationship between vegetation type and peat-depth, and sequence of vegetation type from the river to the inland.

Slowing the rate of degradation is the most important programs to be pursued. One was to improve the condition of ecosystems, including vegetation that grew around the canals, so it is necessary to make mapping vegetation growing in peat doom areas between the canals (Edi, 2010b).

From the previous studies at Central Kalimantan known, the vegetation is characterized by peat-swamp forest, with condition in general was flooded and with the peat layer depth varied from 2 to 10 m or more. The daily temperature varied from 25^{o} up to 33^{o}C, with high in humidity (up to 90%) (Edi Mirmanto, 2010).

Hyperspectral sensor

Hyperspectral sensors use reflections from hundreds of bands in the visible and infrared range of the electromagnetic spectrum. Light reflects off materials, produces a specific signature wave unique related to that material. If the signature is in a database of known materials, then a single pixel can provide enough information to identify a substance.

Near-infrared and shortwave infrared bands are the best at distinguishing between natural terrain and man-made objects. For an environmental purpose, could use them to spot spikes in emissions and vegetation monitor.

A hyperspectral image is one in which the reflectance from each pixel is measured, contiguous wavelength intervals. Such an image provides detailed spectral signatures for every pixel. These signatures often provide enough information to identify and quantify the material existing within the pixels. A user can, for instance, employ a hyperspectral image to locate and quantify different types of materials or minerals that might be present within an area of interest or even within a single pixel.

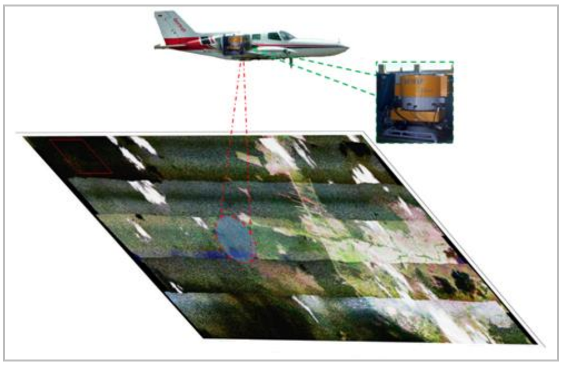

Figure 2. HYMAP instrument mounted on a PK-DCJ aircraft

Materials

Field data

The study site has been chosen in a part Katingan District, Central Kalimantan (Fig. 2). Size of study site is around 320 km^2 (20 x 16 km) between 1° 47' 38.46'' - 1° 56' 44.67'' S and 113° 27'18.72''-113° 38' 19.17'' E. Katingan District has peat-swamp forest area, and geographically located in the equator region.

Figure 3. Location of study area

Methods

Classification Method

The spectral calibration procedures are used to determine the band wavelengths and bandwidths. Additionally, the procedures can be used to verify that the sensor has met specification with regard to out of band leakage that could have been caused by problems such as scattered light or multi-order diffraction (T. Cocks et al., 1998).

Classification in this context can be defined as a process of grouping pixels into classes defined by the variables that are used or so-called segmentation. In generally this classification is displayed with color coding and symbols. This classification is based on the variation of class for each pixel. In the process, pixels that are similar will be grouped in one cluster, in a multivariate data it is assumed that the data is derived from a homogeneous population. However, in the fact these data come from diverse population. Formed clusters sometimes contain a gap. DN value of each band is determined randomly by computer. Then continue conducted the iteration and grouping of pixels based on the similarity of the DN.

However, in one class, there are differences that called variant of class. Image texture is a pattern of pixel brightness in a single group. The classification is divided into two, namely supervised and unsupervised classification.

Results

Before decide the training data (sample areas), have to obtain the best image or true images. There should be conducted simulation between combinations of bands based on Red-Green-Blue (RGB). Determination of spectral in the spectrum is continuous colors with no clear boundaries between one color, approximation of wavelength in spectral colors, as below (Thomas J. Bruno and Svoronos, 2006). And training data organized and grouped into several classes of groups.

Digital Number Value (DN) of Hyper

Table 2. Hyper DN value mean based on second sample areas

WaveLenght WL (µm)

DN_mean		0.456	0.47	0.486	0.5	0.516		2.475	2.49
Cl_ID	Cl_name	band 01	band 02	band 03	band 04	band 05		band 123	band 124
11	High_forest	45.1888	42.8182	50.4135	69.0445	96.5508		374.91	2172.69
12	Mod_forest	41.6048	41.6996	53.2222	67.2634	112.8373		362.93	2205.19
13	Low_forest n other	90.2352	89.0438	113.6245	137.1538	238.1800		289.82	2211.55
2	Bare	148.2746	148.2036	176.8679	193.6091	246.7852		490.10	2363.58
3	Road	600.6951	597.4035	641.4588	657.6098	712.8933		1050.37	2739.70

DN to Reflectance

Table 3. Reflectance of Hyper based on second sample areas

WaveLenght WL (µm) Geo correction number 10.000

DN_mean		0.456	0.47	0.486	0.5	0.516		2.475	2.49
Cl_ID	Cl_name	band 01	band 02	band 03	band 04	band 05		band 123	band 124
11	High_forest	0.00452	0.00428	0.00504	0.00690	0.00966		0.0375	0.2173
12	Mod_forest	0.00416	0.00417	0.00532	0.00673	0.01128		0.0363	0.2205
13	Low_forest n other	0.00902	0.00890	0.01136	0.01372	0.02382		0.0290	0.2212
2	Bare	0.01483	0.01482	0.01769	0.01936	0.02468		0.0490	0.2364
3	Road	0.06007	0.05974	0.06415	0.06576	0.07129		0.1050	0.2740

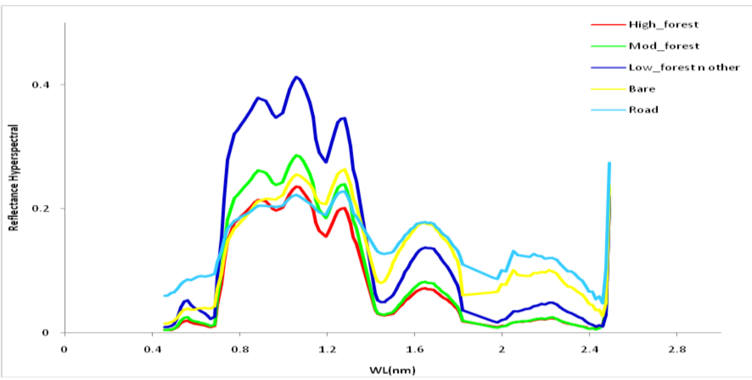

Figure 4. Graph of Hyper reflectance value based on sample areas

As we know, unsupervised classifiers do not utilize training data as the basis for classification. The group of classifiers involves algorithms that examine the unknown pixels in an image, and the aggregate into a number of classes based on the image value. The result classes from this classification are spectral classes (Lillesand et al., 2007).

After conducted several of exercise analysts in this study location, decide unsupervised classification by K-means approach is more effective than ISODATA. It can be evaluated from the number of classes derived in the final stage of classification. Initial criterion is 100 classes and 10 iterations using the same location. The numbers of classes on the K-means have fewer than ISODATA. The results of classification are checked again from 72 classes with the true image and result image is as follows.

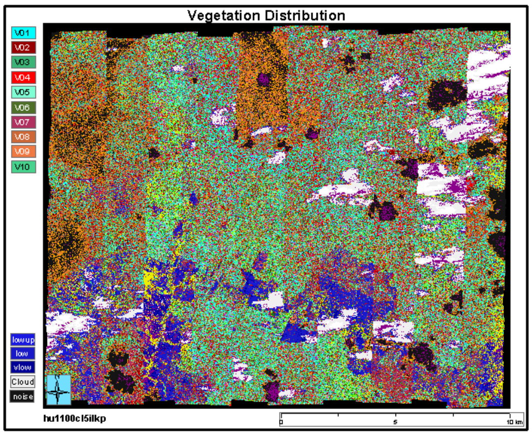

Figure 5. Vegetation distribution map by unsupervised classification K-Means

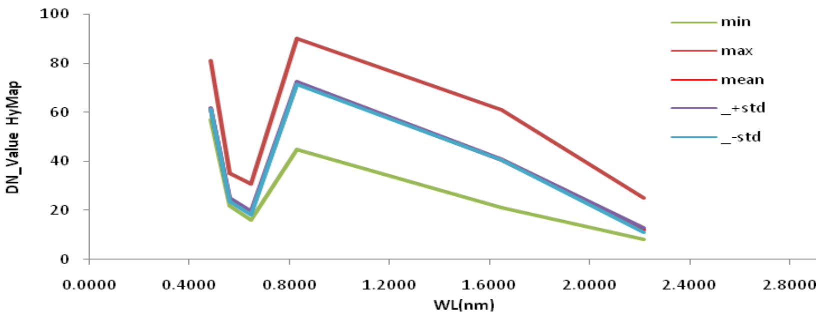

Figure 6. Graph of HyMap DN values mean based on high forest sample

Discussion

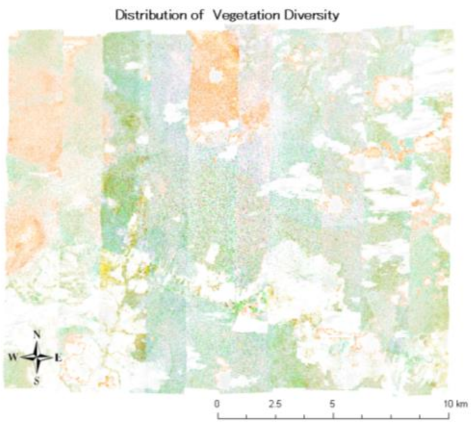

Figure 5. Vegetation distributions mapping on high forest location by unsupervised classification K-Means

For this study, K-means approach is better than ISODATA approach for vegetation map, based on the number of classes in data classification of previous researches in Central Kalimantan.

Acknowledgments

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THE DYNAMIC OF ABOVEGROUND CARBON STOCK IN PEAT SWAMP FOREST

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Many studies on aboveground living biomass and carbon stock in tropical forests have been carried out, either measured directly based on destructive sampling in experimental plots or estimated based on forest inventory data. However, most of these studies focused on the estimation of forest biomass and carbon stock at one occasion. Forest biomass and carbon stock may be dynamic and changes occur continuously throughout time due to loss of biomass during deforestation and forest degradation as well as accumulation of biomass during re-growth of forests. This study aimed to estimate the dynamic of aboveground carbon stock in peat swamp forest using forest inventory data from permanent sample plots established in Jambi, Indonesia. Inventory data collected from sixteen Permanent Sample Plots (100 m x 100 m each) which have been selectively logged and measured annually for 5 years were used to estimate the dynamic of aboveground carbon stock of the peat swamp forest. All woody plants of at least 10 cm dbh were identified for species and measured for both dbh and total tree height. The dead and newly recruited trees were recorded at each measurement time. Overall, the aboveground carbon stock of all species in the plots increased although in several plots showed loss of biomass due to mortality. The increase of carbon stock may be attributed to the high rate of recruitment and growth of some species. The mean annual increment of carbon stock was 3.27 Mg C ha^{-1} yr^{-1}. There was a significant logarithmic relationship between the aboveground carbon stock and its annual increment. This relationship could be applied to estimate the carbon stock change of the peat swamp forest in the study site.

Keywords**:** biomass, carbon stock, stand structure, dynamic, peatland.

Introduction

Knowledge of the aboveground biomass is useful in determining the amount of carbon stored through photosynthesis in the forest stands. Many studies on aboveground living biomass and carbon stock in tropical forests have been carried out, either measured directly based on destructive sampling in experimental plots (e.g. Ludang and Jaya 2007, Miyamoto *et al*. 2007) or estimated based on forest inventory data (e.g. Brown and Lugo 1984, Brown *et al*. 1989). However, most of these studies focused on the estimation of forest biomass and carbon stock at one occasion. Forest biomass and carbon stock may be dynamic and changes occur continuously throughout time due to loss of biomass during deforestation and forest degradation as well as accumulation of biomass during re-growth of forest.

Understanding the dynamics of tropical forest biomass and carbon stock is essential in order to know how the forest will grow and respond to natural conditions or occasional disturbances. The estimates of the forest biomass and carbon stock dynamics are also important in predicting the potential impacts of both climate change and land use change on forest ecosystem, as well as essential component for national carbon accounting (Eamus et al., 2000; Comley and McGuiness, 2005; Soares and Schaeffer-Novelli, 2005). To monitor the dynamic of forest biomass and carbon stock, successive measurement of permanent sample plots at certain time intervals and over a long period of time are needed. This study aimed to estimate the dynamic of aboveground carbon stock in peat swamp forest using forest inventory data collected from permanent sample plots in Jambi, Indonesia.

Methods

Inventory data collected from sixteen Permanent Sample Plots (PSPs) (100 m x 100 m each) established at a forest concession area in Jambi, Indonesia (103°55'- 104°00' E and 1°36' - 1°35' S, *Figure 1*) were used to estimate the dynamics of aboveground carbon stock of the peat swamp forest. All plots were established in 1994 and first measured in January 1995 and then re-measured annually in 1996, 1997, 1998, 1999, and 2000. The plots have been selectively logged with a minimum diameter cutting limit of 40 cm in 1992/1993.

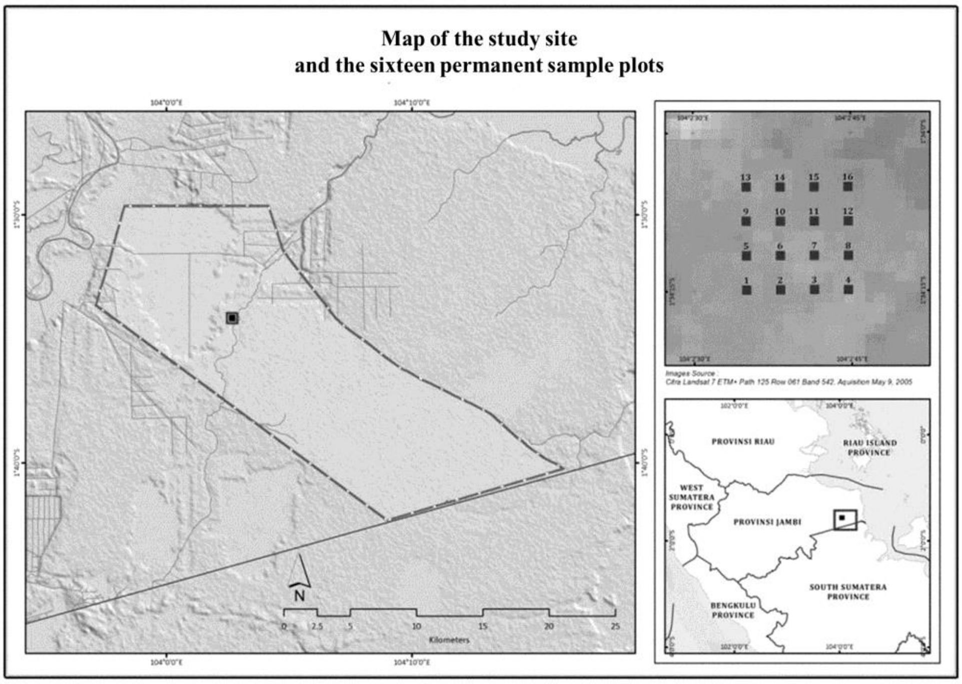

Figure 1. Map of the study site

In each measurement plot, all woody plants of at least 10 cm dbh (diameter at breast height) were identified for species and measured for both dbh and total tree height. The dead and newly recruited (ingrowth) trees were recorded at each re-measurement time. Stand density (number of trees), basal area, and aboveground biomass were calculated at each measurement time. The aboveground biomass (AGB) of each tree in the plot was estimated using an allometric model ($AGB = 0.206\ dbh^{2.451}$, $R_{-sq} = 0.96$) developed for logged-over peat swamp forest in South Sumatra which was considered to have similar characteristics with this present study site in terms of forest type, topography, climate, soil type, and dominant species in the forests. Carbon stocks were then estimated by multiplying the aboveground biomass by a factor (carbon fraction) of 0.5 (IPCC 2003).

Results and Discussion

Stand structure

We found 80 tree species, 55 genera and 30 families in all plots with the range of wood density varied from 0.39 to 1.04 kg m^{-3}. The average basal area and the number of surviving trees at each measurement time over 5 year period are presented in *Figure 2*. In general, the average number of surviving trees in the study site increased by 11.6% from 610 trees per ha in 1995 to above 680 trees per ha in 2000 although there was a slight decrease in 1997 due to higher mortality rate. The average basal area also tended to increase over 5 year period; although its increase was not as high as the increase in the number of surviving trees per ha, which was only 2.6% from 23 m^2 ha^{-1} to 23.6 m^2 ha^{-1}. The average annual diameter increments of trees in the plots were 0.33-0.47 cm. These values were slightly higher than the diameter increments found in logged-over peat swamp forest in Riau, Sumatra (Krisnawati and Wahjono, 1997). Of these trees, only 2-3 trees were found to have diameter larger than 100 cm at the time of measurement.

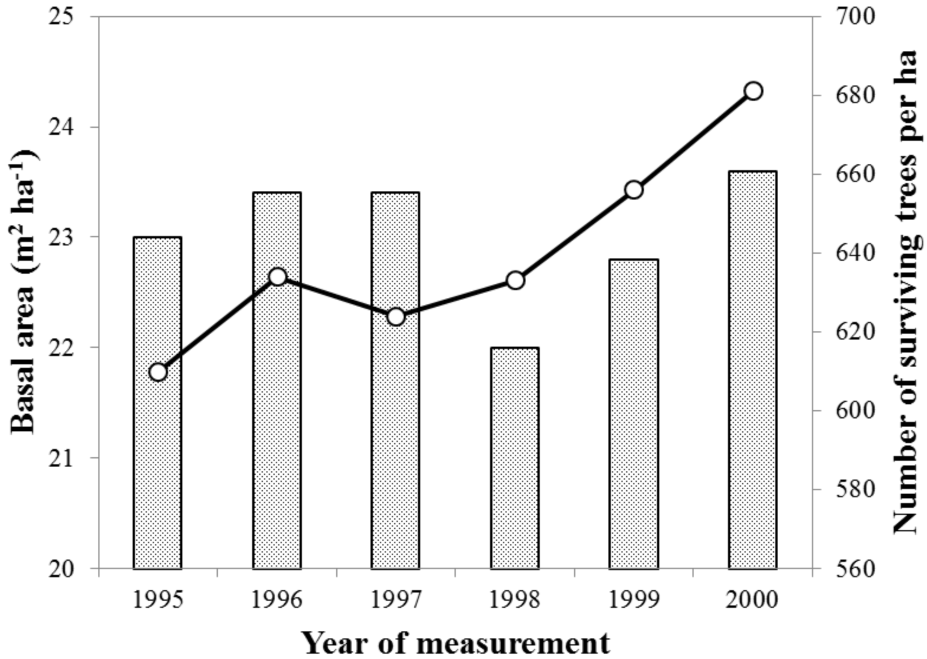

Figure 2. The average basal area and the number of surviving trees over 5 year period

Aboveground carbon stock estimates

The estimates of aboveground carbon stocks of the sixteen PSPs at each measurement time over 5 year period are presented in *Figure 3*. The estimates of aboveground carbon stocks of the sixteen PSPs vary from 79.58 to 235.72 Mg C ha^{-1} (average = 140.87 Mg C ha^{-1}) in 1995 and from 92.88 to 261.40 Mg C ha^{-1} (average = 152.98 Mg C ha^{-1}) in 2000. Overall, the aboveground carbon stock of all species in the plots increased from the initial value.

These average aboveground carbon stock estimates were relatively lower with those measured directly for mature tropical forests in Asia (175 Mg C ha^{-1}; n = 4) and for all mature tropical forests of the world (150 Mg C ha^{-1}; n = 25) (Brown and Lugo, 1982). However, Clark *et al*. (2001) stated that direct measurement of biomass based on a few small plots could potentially result in overestimates due to plot biases (plots may not represent the population of interest or have a small sample size, and the influence of large trees).

The lower aboveground carbon stock recorded in the present study may be because the forests included in the inventory of this study have been previously logged 2–7 years ago, in which some bigger commercial trees (dbh $\geq$ 40 cm) were harvested. Brown *et al.* (1991) showed that tropical forests in Asia that appeared to have experienced little human disturbance had aboveground carbon stock of more than 175-200 Mg C ha^{-1}, compared with 92-135 Mg C ha^{-1} for forests that were exposed to human disturbance.

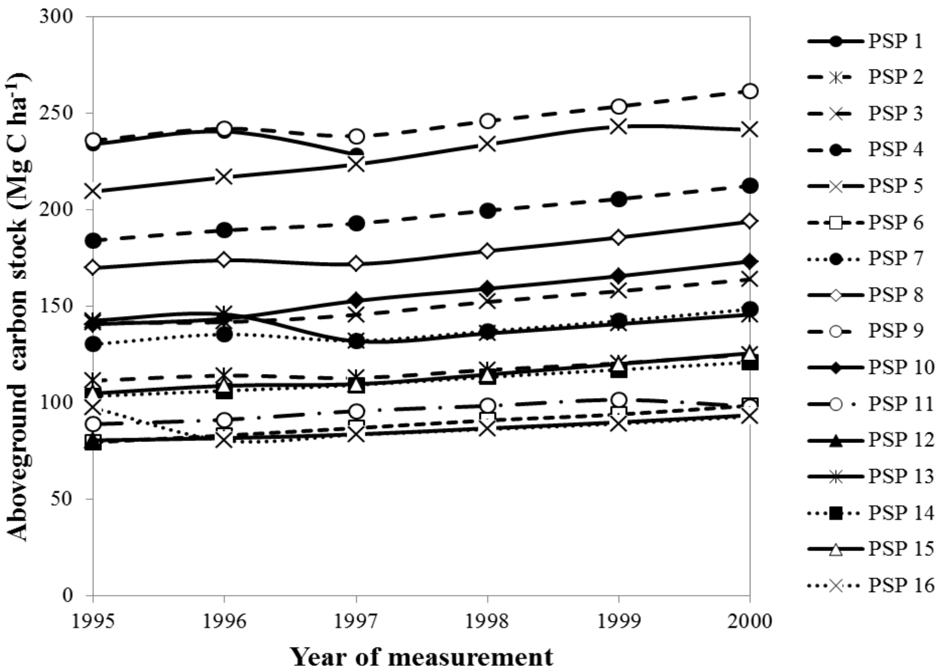

Figure 3. Aboveground carbon stock estimates of the PSPs over 5 year period

Carbon stock changes

The changes of aboveground carbon stock for 5 years from the sixteen PSPs are presented in *Table 1*. The positive value means there was an addition in aboveground carbon stock which may be attributed to the high rate of recruitment and growth of some species. The negative value means there was a reduction in aboveground carbon stock due to loss of biomass as a result of mortality. Overall, the average aboveground carbon stock increment between two successive measurements was 3.27 Mg C ha^{-1} yr^{-1}.

Table 1. The changes of aboveground carbon stock of the sixteen PSPs over 5 year period

PSP	Carbon stock change (Mg C ha^{-1} yr^{-1})					
	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	1995-2000
1	6.55	-11.89				-2.67
2	2.67	-1.22	4.18	3.38	4.64	2.73
3	0.23	3.79	6.67	5.54	6.12	4.47
4	5.21	3.55	6.74	5.94	6.83	5.65
5	7.38	6.68	10.31	9.18	-1.62	6.39
6	3.50	3.82	3.96	3.09	4.58	3.79
7	5.10	-3.24	4.87	5.33	6.08	3.63
8	4.04	-2.06	6.80	7.02	8.21	4.80
9	6.18	-3.82	7.71	7.61	7.99	5.14
10	2.91	9.17	6.30	6.48	7.64	6.50
11	2.28	4.47	2.67	3.11	-3.38	1.83
12	1.14	1.95	3.16	3.12	3.67	2.61
13	3.22	-13.91	4.02	4.88	4.86	0.61
14	2.75	2.98	4.13	3.81	3.84	3.50
15	3.97	0.82	5.00	5.45	5.58	4.16
16	-16.88	3.00	2.81	2.87	3.73	-0.89
Average	**2.52**	**0.26**	**5.29**	**5.12**	**4.58**	**3.27**

The estimates of aboveground carbon stock increment were considerably lower than those reported for undisturbed forest in East Kalimantan which found an average aboveground carbon stock increment of 3.85 Mg C ha^{-1} yr^{-1} (Krisnawati *et al*., 2011).

Relationships between carbon stock and its increment

The relationships between the aboveground carbon stocks and its annual aboveground carbon stock increment obtained from the sixteen PSPs are presented in *Figure 4*. There was a significant logarithmic relationship (P < 0.01) between the aboveground carbon stock and its annual increment. The determination coefficient of the logarithmic relationship was relatively high (R^2 = 0.805). Such a significant logarithmic relationship was also found by Clark *et al*. (2001) who analyzed published data from 17 old growth tropical forests (R^2 = 0.53).

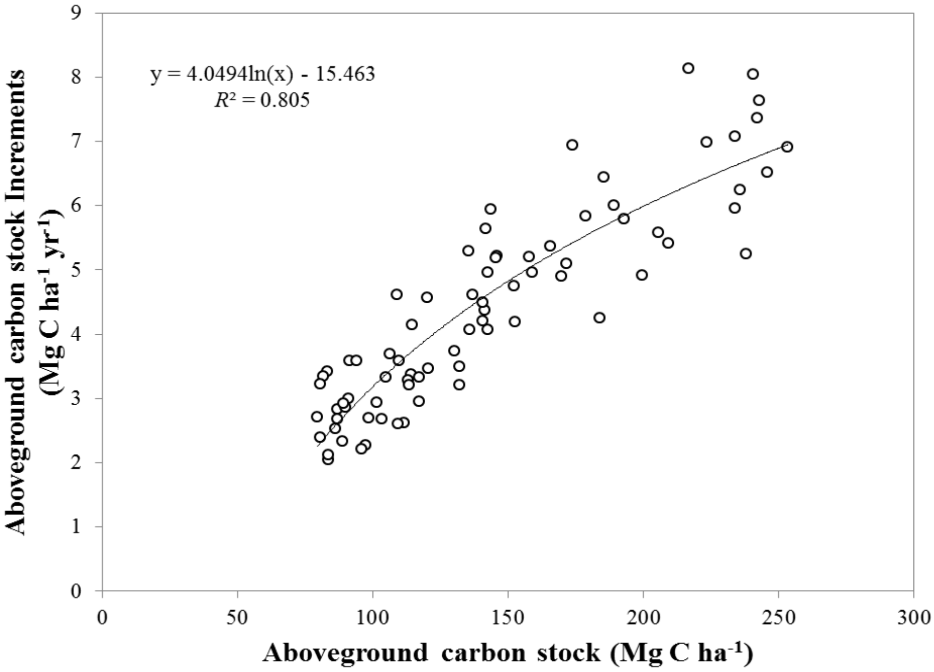

Figure 4. The relationship between annual aboveground carbon stock increment and aboveground carbon stock

Conclusions

Aboveground carbon stock in peat swamp forest is dynamic. The mean annual increment is about 3.27 Mg C ha^{-1} yr^{-1}. The relationship (model) between aboveground carbon stock and its increment could be used to estimate carbon stock change in the study site by calculating the product of the aboveground carbon stock increment per ha and forest area.

Acknowledgement

Data used in the study were collected from the forest concession area of PT Putraduta Indah Wood Industries. Funding from the Research and Development Center for Conservation and Rehabilitation (formerly Research and Development Center for Forest and Nature Conservation) during monitoring the plots is gratefully acknowledged.

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GEOTECHNICAL PROPERTIES OF SOFT SOILS IN KALAMPANGAN CANAL

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This paper presents geotechnical properties of the shallow soil layers which consist of peat and sand in the Kalampangan canal, central Kalimantan, Indonesia. The authors discussed the management of peatland groundwater based on the construction of a series of weirs in the Kalampangan Canal in the other paper. Thus geotechnical investigation was conducted, undisturbed samples were collected and laboratory soil tests on peat and sand collected from the Canal area were carried out.

Keywords**:** geotechnical property, peat, sand, Kalampangan Canal

Introduction

Carbon dioxide emissions from tropical peatland in Indonesia are associated with the lowering of ground water levels caused by development in the region. The main factors behind such emissions are the break-up of peat due to land dehydration and loss of peat due to fires. Accordingly, groundwater management is a crucial consideration in the conservation of tropical peatland and the formulation of carbon management guidelines. The authors discussed the management of peatland groundwater based on the construction of a series of weirs in the Kalampangan Canal located in Indonesia’s Central Kalimantan region (Ochi et al., 2012).

Information on the geotechnical properties in this region is necessary for weir construction. However no previous studies have sought to elucidate these properties. To clarify the situation, undisturbed samples need to be collected. This also applies to the measurement of carbon levels in peat.

Against such a background, geotechnical investigation was conducted, undisturbed samples were collected and laboratory soil tests on peat and sand collected from the Kalampangan Canal area were carried out. This paper describes the method of collecting undisturbed peat and the geotechnical properties of soft soils in the region.

Investigation site and method

Geotechnical investigation was conducted in July 2012 near Weir 11 on the Kalampangan Canal. Figure 1 shows the results of cross-sectional surveying for the channel. The width of the canal at the water surface was approximately 16 m and the maximum water depth was approximately 0.85 m. The canal has channels to discharge water from surrounding ground on the outer sides of weir embankments on both sides of the canal.

In-situ tests were carried out from the crown of a weir embankment on the right bank. The ground consisted of a 2-m-thick layer of excavated sandy peat, the original 1-m-thick peat layer directly below it, and sand below that (Figure 1). At the Tarunajaya and Taka sites, however, clay was present under the peat layer.

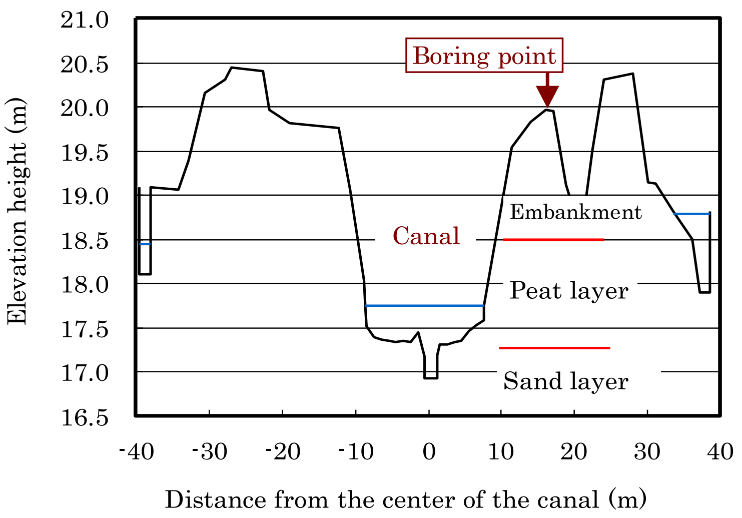

Figure 1. Cross section at the site

A thin-walled tube sampler with fixed piston in accordance with the Japanese Geotechnical Society's standard (Figure 2) was used to collect undisturbed samples from peat layers (JGS method: JGS, 2004) and standard penetration test (SPT) was performed for the sand layer (Fugre 3). In-situ permeability tests were also conducted.

Further samples were collected from the peat surface layer using a simple tube with fixed piston, and unconfined compression test and consolidation test were carried out in a laboratory.

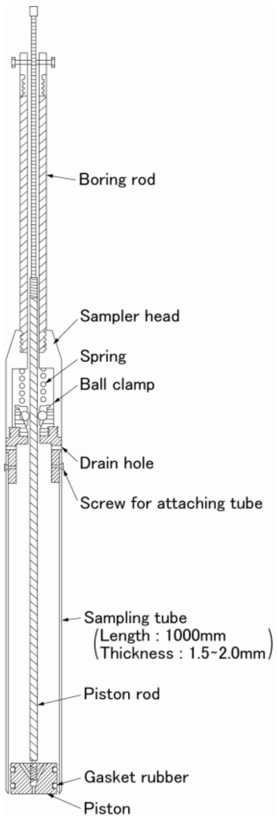

Figure 2. Thin-walled tube sampler with fixed piston used (JGS method)

Figure 3. Works of the standard penetration test (SPT)

Results and discussion

Undisturbed peat sampling method

In March 2011, undisturbed samples were collected using a machine owned by the Indonesian Institute of Sciences (LIPI method) at Weirs 3 and 4 of the Kalampangan Canal and at the Taka site.

Table 1 shows the sampling rate *R*, which is defined as follows:

$$R\ (\%) = (L_c / D_d) \times 100$$

where, L_c is the length of the collected sample (cm) and D_d is the depth of drilling (cm). It is judged that higher sampling rates are favorable.

As the JGS method produced higher sampling rates (over 90%) than the LIPI method (37 – 80%), it can be considered to have higher applicability to woody peat. The sampling tube used in the LIPI method is thicker and it is made of vinyl chloride. The peat sampled is also considered to have been compressed because the tube penetrated the ground slowly, leading to low sampling rates. In contrast, the tube used in the JGS method was thinner (wall thickness: 1.5 – 2.0 mm) with a leading-edge angle of 6 degrees, and penetration was comparatively fast. These things are considered to explain the relative effectiveness of the JGS method for woody peat.

Table 1. Result of sampling rate for peat

Sampling method	Rate of sampling R (%)
LIPI method	37 to 80
JGS method	90 and more

Geotechnical properties of foundation ground

Accurate information on foundation ground variables such as strength, compressibility and permeability is important in designing weirs. This section describes the properties of peat and sand, which form the foundation ground of the study's investigation areas.

The peat test results shown in Table 2 indicate that the unconfined compressive strength of peat was 3.2 kN/m^2, and distinct shearing was observed (Figure 4). With peat in Japan's Hokkaido region, the chance of observing shear during unconfined compression test is small. This discrepancy between the two types is presumed to stem from differences in the peat formation process. The *e*-log*P* relationship obtained from consolidation test is shown in Figure 3. It can be inferred that consolidation settlement occurs when in-situ effective stress caused by weirs in addition to the in-situ effective overburden pressure exceeds peat's compressive yield stress of 25.3 kN/m^2. The compression amount here is dependent on a compression index of 3.0. In weir design, foundation ground permeability is seen as the most important parameter. The coefficient of permeability determined from in-situ permeability test was 2.7×10^{-4} – 3.1×10^{-6} cm/s, and its value fell with greater depth. This level of permeability is similar to those of silty soil and clay.

Table 2. Summary of test results for peat

Properties	Value
specific gravity	1.607 to 1.949
wet density (g/cm^3)	0.96 to 1.16
dry density (g/cm^3)	0.13 to 0.38
natural water content (%)	202 to 673
in-situ void ratio	3.7 to 7.5
ignition loss (%)	35 to 96
unconfined compression strength (kN/m^2)	3.2
coefficient of permeability (cm/s)	2.7×10^{-4} to 3.1×10^{-6}

Figure 4. Specimen after unconfined compressive strength test

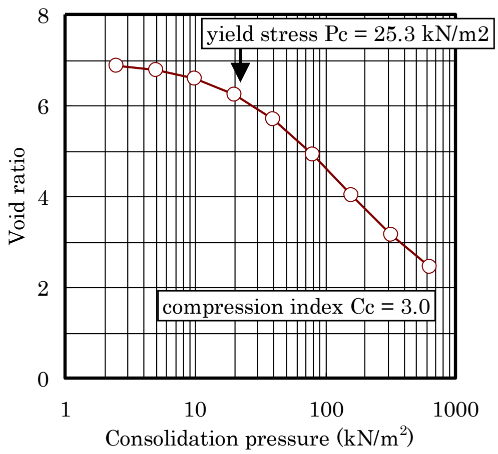

Figure 5. *e* – log *P* curve for peat

Physical index correlations provide useful pointers for determining the properties of peat. As a typical example, the relationship between saturated water content and dry density is shown in Figure 4; a clear correlation exists between the two. The solid line in the figure highlights the relationship calculated using ignition loss as an index, and closely matches the measured values. As dry density can be determined from basic experiments such as ignition loss test, it is a useful index for calculating ground carbon content.

Below the peat layer was a layer of white sand (Photo 3), which originates from granite (Hu et al., 2012). Table 3 shows N values obtained from SPT and physical index obtained from laboratory tests, while Figure 8 shows the distribution curve of grain size.

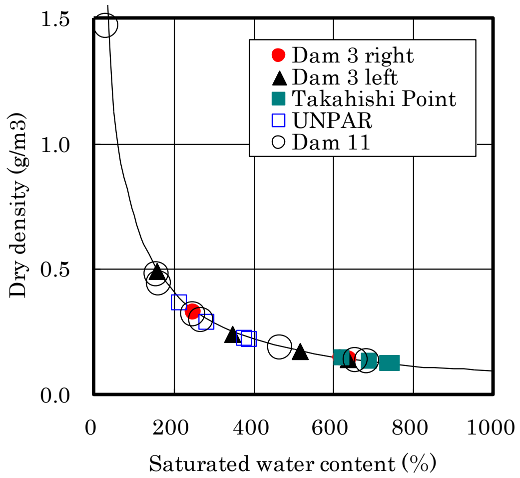

Figure 6. Relationship between saturated water content and dry density for peat

Figure 7. Sand collected by SPT sampler

Table 3. Summary of test results for sand

Properties	Value
specific gravity	2.536 to 2.675
natural water content (%)	18.9 to 21.3
N values obtained from SPT	15 to 17

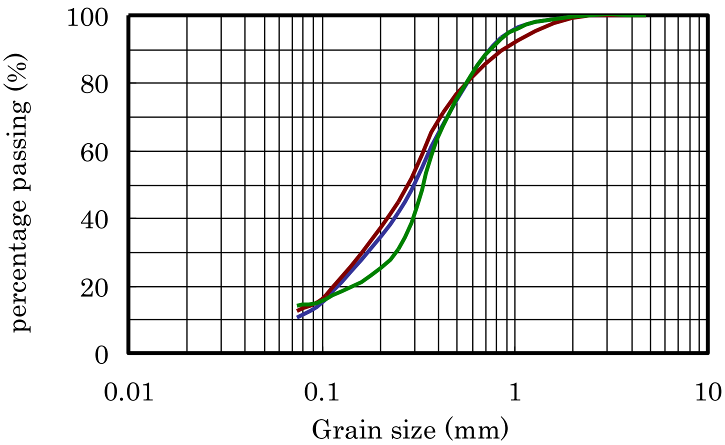

Figure 8. Grain size distribution for sand

Conclusions

At the Kalampangan Canal in Indonesia's central Kalimantan region, geotechnical investigation was performed and undisturbed peat/disturbed sand samples were collected for laboratory soil test. The results can be summarized as follows:

1. The JGS method produced higher sampling rates (over 90%) than the LIPI method (37 – 80%), indicating its higher applicability to woody peat.
2. In weir design, the most important parameter is the coefficient of permeability for peat, which was found to be $2.7 \times 10^{-4} – 3.1 \times 10^{-6}$ cm/s. This was similar to the corresponding coefficients for silty soil and clay.
3. A clear correlation between saturated water content and dry density is known to exist. Correlations between physical indices provide useful information for determining the characteristics of peat.
4. The mechanical characteristics of sand accumulated underneath peat were clarified.

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A CANONICAL VARIATE ANALYSIS METHODE TO CLASSIFY FOREST AND NON FOREST USING LANDSAT IMAGE FOR CENTRAL KALIMANTAN PROVINCE IN 2000-2008

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The information of forest and non forest for Central Kalimantan Province in year 2000-2008 derived using Landsat 5 and 7 images. This research is conducted by Indonesia's National Carbon Accounting System (INCAS) project in order to support a mechanism scheme plan of decreasing emission from Reducing Emissions from Deforestation and Forest Degradation/REDD. The INCAS activities in LAPAN are inventoring Landsat data, scene selection, orthorectification, radiometric correction, cloud masking, mosaicing wall to wall per year, and classification. This paper is only discussed of classification of forest and non forest. The criterion of forest in this term is a trees, having canopy cover more than 20%, and 2 meter tall. The data are Landsat 5 and 7 in year 2000 and 2008. The secondary data are Ikonos, Quickbird, geology, and ground truth data. The stages of process are decided training sample, forest base probability, forest matching, and stratification zones. The methodology to make forest base probability is using canonical variate analysis (CVA) to derive the indices and threshold. The result are forest extend and changes per year.

Keywords: INCAS, Landsat, Canonical Variate Analysis, Central Kalimantan Province

Introduction

Indonesia as a developed country taking apart in action to overcome global issue on climate change by develop and arrange national system to support mechanism of decreasing emission from Reducing Emissions from Deforestation and Forest Degradation/REDD. Indonesia's National Carbon Accounting System (INCAS) is being established as part of this action. INCAS is a collaborating project between Indonesia and Australia. This project aims to support design and implementation of robust forest monitoring in Indonesia by adopting the system that successfully implemented in Australia.

The INCAS activities in LAPAN are collecting Landsat 5 and 7 images from 1998 to 2012, scene selection with maximum cloud cover 25%, geometric correction, terrain correction, cloud and shadow masking, mosaicing and digital classification for mapping forest and its changes. Forest change that has been monitored is only caused by land conversion from human activities, not by the nature disturbance, ex. flood, and landslide.

The location of this research is focusing in Central Kalimantan Province, which has 15.399.229Ha of wide spread area that counted base on Bakosurtanal region border. Forest in Central Kalimantan Province has many types. There are a widespread area of peat swamp forest, coastal forest, forest in Meratus hills and lowland forest. Central Kalimantan Province is also one of province in Indonesia that already finish mapped for forest monitoring.

Methodology

This paper is only discussed on digital classification of forest and its changes in year 2000 and 2008. The stages of classification are making forest base probability in year 2008, making stratification zone and making forest probability in year 2000. The Landsat images in year 2008 is decided to be the images for forest base probability, because it has nearly close to current year and the high resolution images that provided to make a training sample become more accurate, mostly acquired in year 2008. This image in year 2008 would be a base for making forest probability compare to other years.

a. Data

The images are mosaic Landsat 5 and 7, multispectral and multitemporal in year 2000 and 2008 with spatial resolution with cubicconvulation resampling into 25meter. The secondary data also needed to increase the accuracy in taking a training sampel of forest and non forest. They are Quickbird and Ikonos images in 2008-2009, geology data and ground truth data.

b. Software

All the processing data done using C++ in Windows Dos. They are *train_extract.exe, incas_cv_analysis_sig_v2.exe, plotcvmeans.R, plotbndmeans_v2.R, incas_enter_contrast.exe, incas_index_smooth.exe, incas_enter_index_threshold.exe, image2prob_forest.exe,* and *incas_mosaic_prb1.exe.* Ermapper 7.1 also needed to display Landsat images on taking training sample and software R to make a plotting.

c. Canonical Variate Analysis (CVA) Methode

To produce forest base probability for Landsat 7 mosaic images in 2008 done by taking training sample, choosing indices and threshold that created from canonical variate analysis (CVA) method. This indices and threshold would applied within all the location, but if any location did not match, it mean that it would need a new indices and threshold. The area that has a suitable indices and threshold then we drew as one zone stratification and so on for others zone.

The indices derived by The Canonical variate Analysis method. This method gives the best separation between forest and non forest. The indices come from linear combination from band within the images with the maximum separation. This depend on the accuracy of training sample that been chosen. Canonical vector depict maximum direction of separation and canonical root gives a value of those separation. Generally, canonical vector and canonical root could give best separation but sometimes it is need to be modified by focusing the separation of training sample. This can be done by simplify and smoothing it to obtain maximum contras value. The indices for certain area could contain two or three indices, usually it takes two indices but for ex. In coastal region needs three indices two detect the mangrove and wet land.

d. Work Flow

Work flow of this research is described in figure 1.

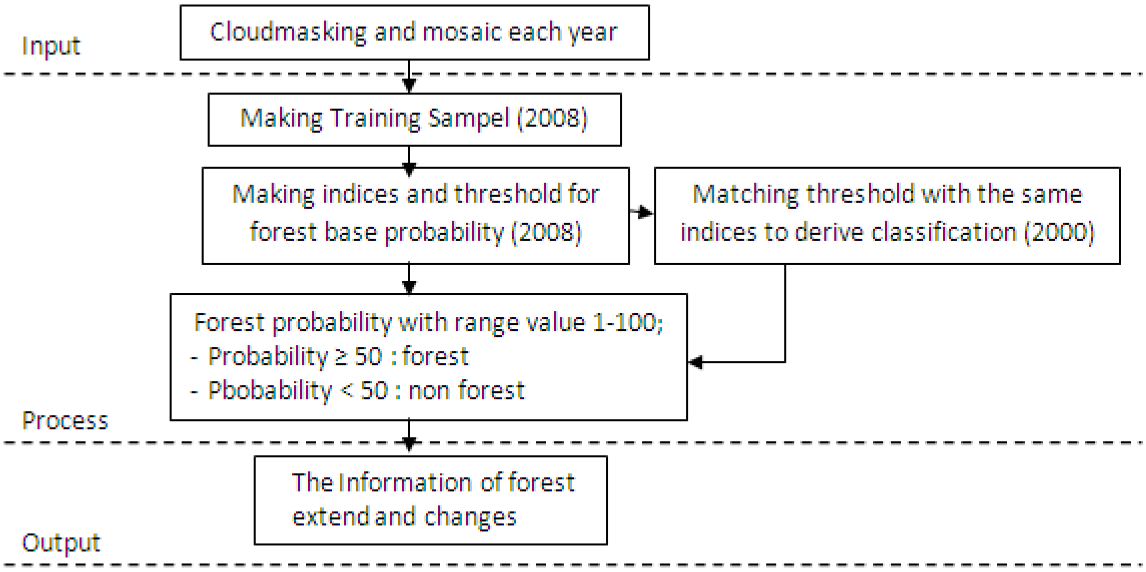


Figure 1. Work flow

Result and Discuss

a. Images mosaic

Central Kalimantan Province located at 0:48:40.72N - 3:35:16.25S dan 110:38:49.28E - 115:53:38.2E and for mosaicing Landsat 5 and 7, it needs path/row 117/61-62, 118/59-62, 119/60-62, 120/60-62.

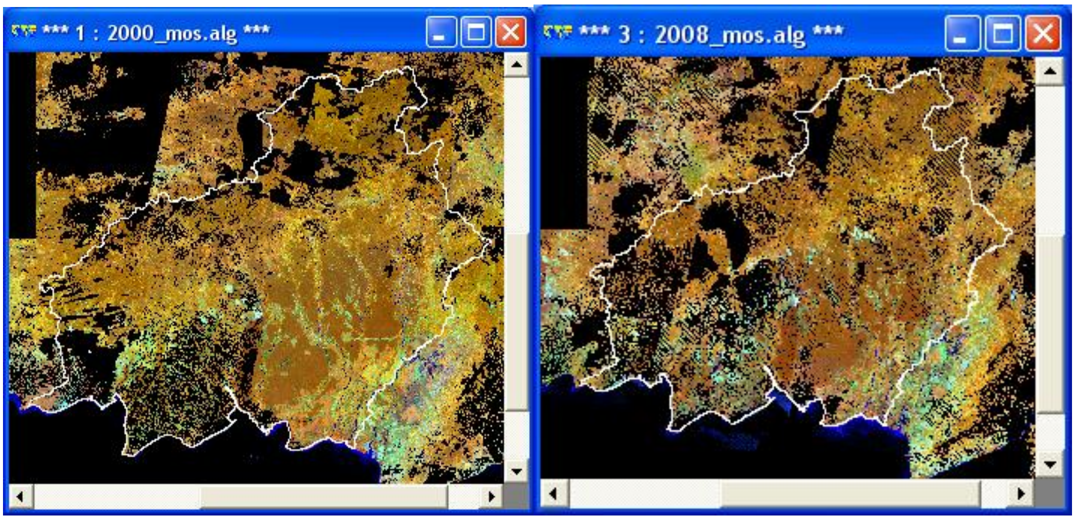
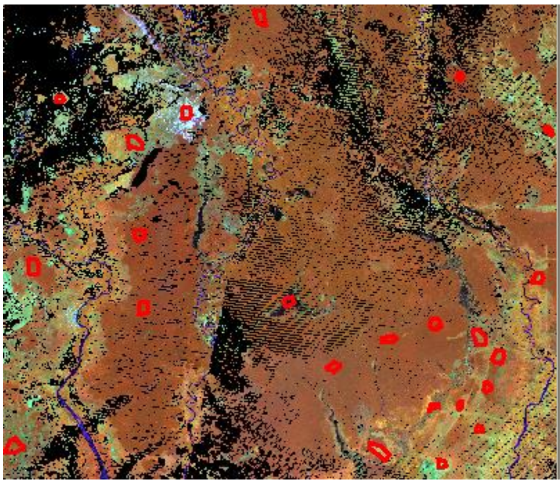


Figure 2. Mosaic year 2000 and 2008

b. Training Sample

The training sample contain of forest and non forest. This done by chosing region site in mosaic image 2008 with the accordance of secondary data. Definition of forest is a trees with canopy more than 20%, and 2m height. The forest selected is peat swamp forest, mangrove, lowlandforest, mountain forest, trees plantation ex. rubber, akasia, cinnamon, etc. Each site of training sampel contain 10-100pixel.



17	VECTOR	NH_453_sawit
18	VECTOR	NH_455_sawit
19	VECTOR	NH_451_sawit
20	VECTOR	NH_450_sawit
21	VECTOR	HT_445_dense
22	VECTOR	HT_444_dense
23	VECTOR	HT_443_dense
24	VECTOR	HT_441_dense
25	VECTOR	HT_440_dense
26	VECTOR	HT_431_dense
27	VECTOR	HT_430_dense
28	VECTOR	HT_429_dense
29	VECTOR	NH_432_sawit

Figure 3. Training sample distribution and labeling

c. Indices and threshold

The Indices and threshold for classifiying forest and non forest derive from year 2008. This image become forest base probability because the landcover condition near to present and based on the secondary data available. The next stage is to convert training sampel into ASCII format then to analyze its separataion between forest and non forest using canonical variate using software ***incas_cv_analysis_sig_v2.exe.*** The quality result of this analyze could be plot in R software using software ***plotcvmeans.R*** and stated in the information on Canonical root and Canonical vector. If the result of the maximum separation could not be achieved, the next stage is to make a contrast with minimum 5 pair of forest and non forest. After found an appropriate indices and threshold then transform it using ***Incas_enter_indeks_threshold.exe*** and then we make a final forest and non forest probability with probability scale between 0-100 using ***Image2prob_forest.exe***.

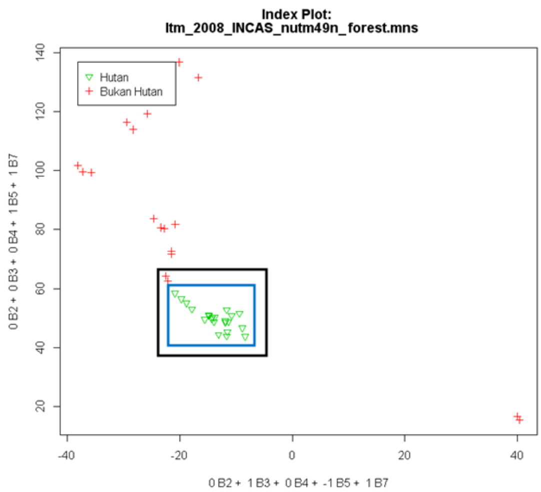


Figure 4. Example of plot bandmns using s/w R

The value of indices and threshold in 2008 stored in ASCII text file as shown in Figure 5. Zone 1 has 2 indices. Index 1 consist of band 2 – band 4 + band 5. Index 2 consist of band 4 + band 5. The certain forest located in threshold 1 (-40 to (-5)) and threshold 2 (83 to 127). The threshold for year 2000 might be different as the value of digital number in Landsat images in 2000.

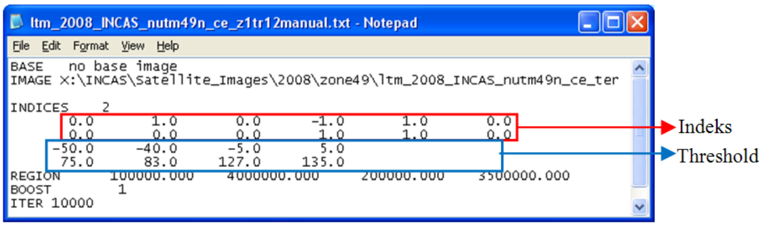


Figure 5. ASCII format of indices and threshold, zona 1 in 2008

d. Stratification

A region with different types of forest and land types need different indices and threshold to obtain an optimum classification of forest and non forest. Kalimantan has 10 stratification zones as shown in Figure 6.

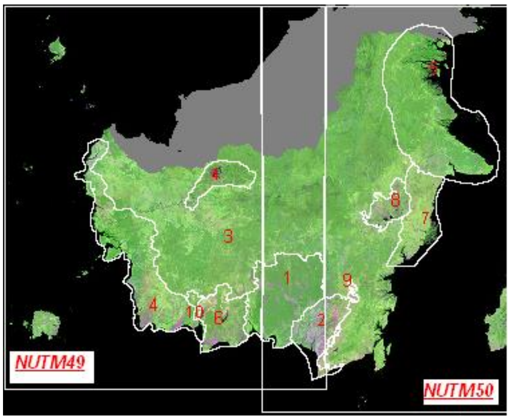


Figure 6. Stratification zone in Kalimantan

The Central Kalimantan Province has 6 stratification zone, they are zone 1, 2, 3, 4, 6, and 10. Each stratification zone needs different indices and threshold as the characteristic of forest and geographic.

e. Result of classification

The next stage of classification process after found threshold and stratification zones is to make forest base probability for year 2008. The probability would decide wheter it likely to be for forest or non forest. The probability transform into forest if it has a value more than 50 and otherwise it would called as non forest. This classification result has a possibility of missing class because of the cloudmasking process or no data. The same process to determine forest also done to image in year 2000. The result of forest classification for year 2008 in zone 1, displayed in Figure 7.

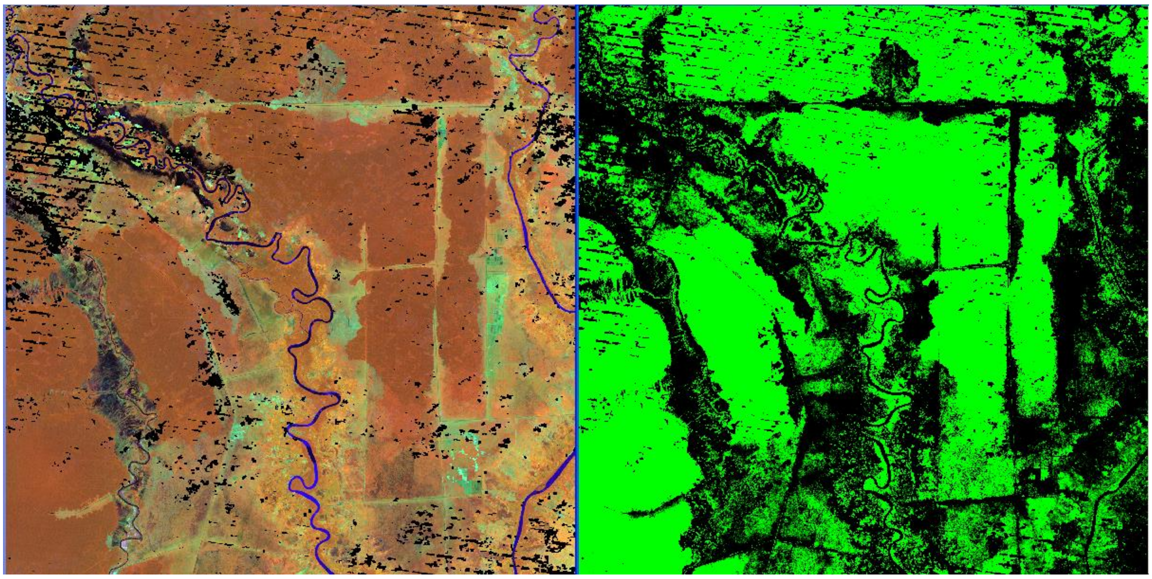


Figure 7. Forest in Central Kalimantan Province for zone 1, 2008

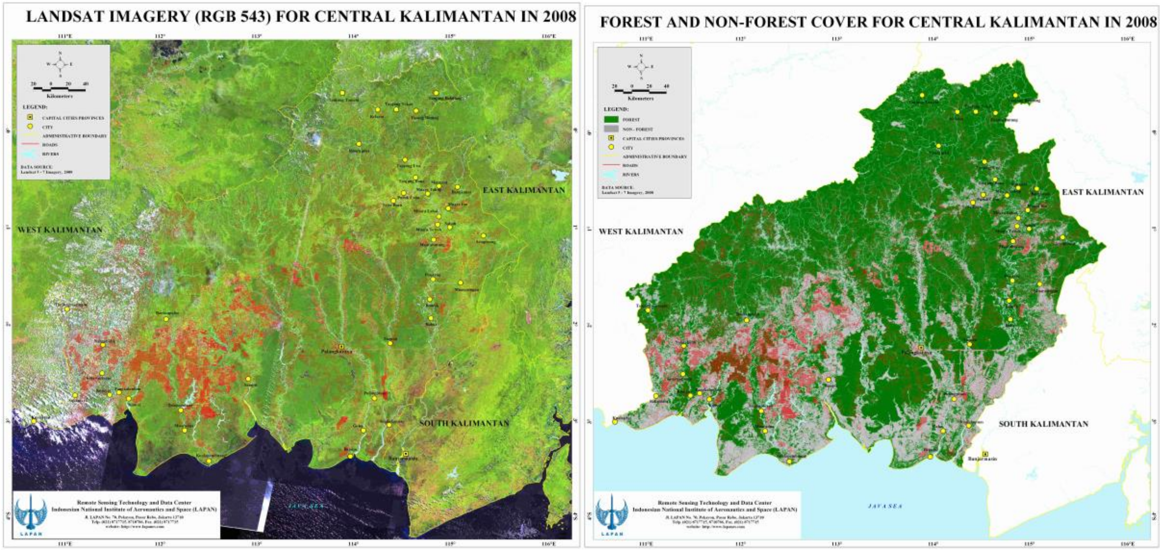


Figure 8. Landsat image mosaic and widespread of forest in Central Kalimantan Province, 2008

The tabulation of forest in 2000 and 2008 are shown in Table 1, the detail forest change in Table 2 and Figure 9 describe the widespead of Stable Forest, Loss and Gain di Central Kalimantan from 2000-2008.

Table 1. Widearea (Ha) of forest in Central Kalimantan Province using Landsat Image, 2000-2008

No.	Year	Widearea (Ha)	Precentage (%)
1	2000	10728416	69.7
2	2008	10110832	65.7

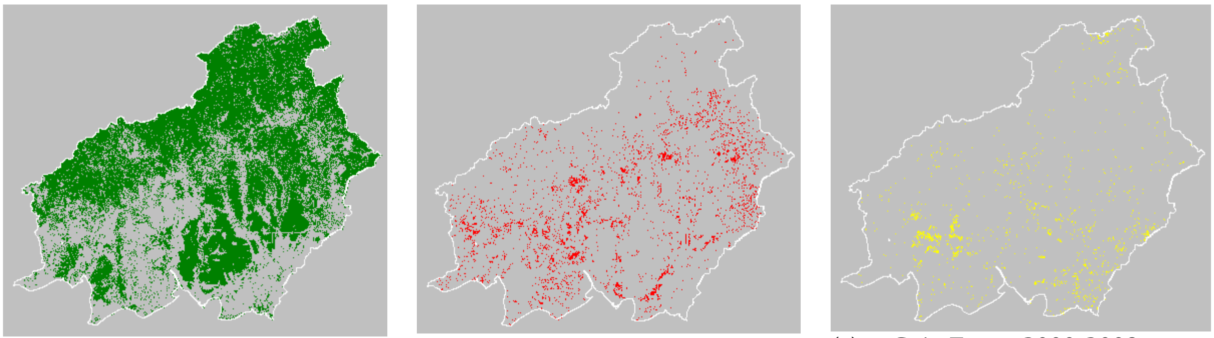
Source : analysist result with 100m resampling

Table 2. Widearea (Ha) of *Stable*, *Loss* and Forest *Gain* for Central Kalimantan Province using Landsat Image, 2000-2008

No.	Notes	Widearea (Ha)
1	*Stable* Forest (2000 and 2008)	9434772
2	*Loss*	1299044
3	*Gain*	676060

Source : analysist result with 100m resampling

The analysis result shows that in year 2000, almost 69.7% or 10,728,416Ha forest landcover dominates in Central Kalimantan Province but it is decreasing as much 617,584Ha for 8 year in 2008 become 10,110,832Ha or 65.7%. The stable forest for 8 year stays in 8,389,620Ha, deforestation/loss 8,421,56Ha, replanting 358,724Ha.



(a) Stable Forest 2000-2008 (b) Loss Forest 2000-2008 (c) Gain Forest 2000-2008

Figure 9 (a,b,c). The widespreadarea of Stable Forest, Loss and Gain for Central Kalimantan from 2000-2008

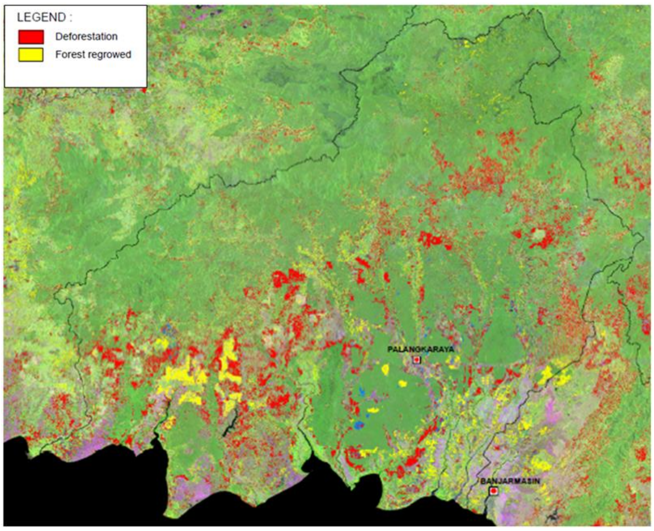


Figure 10. The widespread area of forest change for Central Kalimantan from 2000-2008

Conclusions

Landsat images had a high continuity, complete multispectral band and spatial resolution to mapping the forest extend and changes or forest monitoring. The methodology to classify is using canonical variate analysis to produce indices and threshold for matching forest in each year. The results are forest, non forest, forest loss, and forest regrowed. The next stage is produsing the multitemporal classification and verify the result by an attribution stage.

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DISTRIBUTION OF SECONDARY GRASSLANDS IN RELATION TO EDAPHIC CONDITIONS ESTABLISHED AFTER BURNING OF PEAT FOREST IN CENTRAL KALIMANTAN

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We examined the species composition and edaphic conditions of wet grasslands occurring after recent forest burning at three local sites around Palangka Raya in central Kalimantan. Six types of grassland communities were distinguished by TWINSPAN and occurrence pattern of the communities was characteristic. In conclusion, the differences of secondary grasslands among regions was expressed by the difference of mire types between peat soil and mineral soil conditions.

Study sites

Kalanpangan (2.3 S, 114.0 E) is located between rivers of Kahayan and Sebangau. Danau Lais (2.1 S, 114.0) is located in riparian wetlands at the left side of Kahayan River, and Lahei (1.9 S, 114.1 E) at 40km north-northeast of Palangka Raya. These sites might be burnt in 2009.

Figure 1. Study site

Methods

Totally 61 plots were set in the grasslands; 31 plots in Kalanpangan, 16 in Danau Lais and 13 in Lahei. In each plot, coverage values (%) of all species occurred 2*2 m^2 quadrats were measured. Soil type, water levels, soil water contents (% in volume), and water chemistries of peat-pore water (pH, electrical conductivity (EC), and major cation and anion) were measured. In addition, standing crops within 1*1 m^2 were examined at three communities.

Result 1. Species composition and distribution of communities extracted by TWINSPAN

Tabel 1. Occurence pattern of communities

	Blechnum community	*Xyris* community	*Stenochlaena* community	*Scleria–Blechnum* community	*Scleria* community	*Scleria–Imperata* communitty
Kalanpangan	9	6	17	0	0	0
Danau Lais 1	0	0	0	1	3	0
Danau Lais 2	11	0	1	0	0	0
Lahei	0	0	0	3	0	10

Figure 2. Landscape of Stenochlaena palustris community & Blechnum indicum community

Table 2-1. Species composition of communities. shibuya and KT: Kalanpangan, DL: Danau Lais and Lahei

Species	Life form	Scleria-Blechnum community				Blechnum community																			
		DL2-9	Lahei10	Lahei11	Lahei12	shibuya2	KT1-9	KT1-11	KT1-12	KT3-3	KT3-8	KT3-9	KT2-4	KT2-6	DL2-1	DL2-2	DL2-3	DL2-4	DL2-5	DL2-7	DL2-8	DL2-10	DL2-11	DL2-12	DL2-13
Blechnum indicum	fern	**70**	**70**	**75**	**50**	**60**	**60**	**40**	**90**	**60**	**70**	**60**	**70**	**80**	**80**	**80**	**90**	**90**	**70**	**60**	**95**	**95**	**70**	**95**	**95**
Baeckea frutescens	shrub	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella ensifolia	grass	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenochlaena palustris	fern	0	80	70	30	5	30	25	40	60	70	40	30	5	20	20	5	2	5	0	5	6	40	0	0
Rubiaceae sp	linear	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	25	0	0	0
Ficus sp	shrub	0	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum	fern	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xyris indica	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nephrolepis falcata	fern	0	0	0	1	0	0	0	0	0.1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Melastoma malabathricum	shrub	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Cratoxylum glaucum	shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scleria purpurescens	grass	**25**	**5**	**25**	**30**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imperata cylindrica	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca cajuputi	tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lygodium microphyllum	linear fern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euodia aromatica	tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eleocharis retroflexa	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schoenoplectus lacustris sp	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae sp	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uncaria gambir	shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Combretocarpus rotundatus	tree	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fern sp	fern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Timonius flavescens	tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scirpus cf. subcapitatus	grass	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Six types of grassland communities were distinguished by TWINSPAN and occurrence pattern of the communities was characteristic; *Blechnum indicum* community occurred in both Kalanpangan and Danau Lais, *Xyris indica* community and *Stenochlaena palustris* community exclusively in Kalanpangan, *Scleria purpurescens*–Blechnum community and *Scleria-Imperata cylindrical* community in Lahei, and *Scleria* community in Danau Lais.

Table 2-2. continued.

Species	Life form	Xyris community						Stenochlaena community																	
		KT1-7	KT3-1	KT3-2	KT3-5	KT3-6	KT2-5	shibuya	shibuya	KT1-1	KT1-2	KT1-3	KT1-4	KT1-5	KT1-6	KT1-8	KT1-10	KT1-13	KT3-4	KT3-7	KT3-10	KT2-1	KT2-2	KT2-3	DL2-6
Blechnum indicum	fern	30	25	10	40	30	30	30	25	2	0	1	30	30	2	25	25	20	15	40	20	25	35	30	30
Baeckea frutescens	shrub	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella ensifolia	grass	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenochlaena palustris	fern	30	0	7	35	20	25	**40**	**10**	**80**	**85**	**60**	**90**	**6**	**80**	**90**	**80**	**80**	**90**	**50**	**95**	**30**	**60**	**60**	**90**
Rubiaceae sp	linear	0	0	0	0	0	0	1	30	0	0	0	0	0	2	0	0	5	0	0	1	0	0	0	0
Ficus sp	shrub	0	15	0	5	0	0	1	25	15	5	30	10	10	5	2	0	25	1	0	0	30	3	0	0
Pteridium aquilinum	fern	0	1	0	0	0	0	0	0	70	0	20	3	0	0	0	0	10	0	0	0	0	0	0	0
Xyris indica	grass	**5**	**40**	**70**	**50**	**15**	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Nephrolepis falcatla	fern	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Melastoma malabathricum	shrub	2	3	2	3	0	5	0	0	0	0	0	0	2	1	2	0	0	0	0	0	0	0	0	0
Cratoxylum glaucum	shrub	0	0	5	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scleria purpurescens	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imperata cylindrica	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Melaleuca cajuputi	tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lygodium microphyllum	linear fern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euodia aromatica	tree	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eleocharis retroflexa	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schoenoplectus lacustris sp	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae sp	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uncaria gambir	shrub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combretocarpus rotundatus	tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fern sp	fern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Timonius flavescens	tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scirpus cf. subcapitatus	grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2-3. contunued.

Species	Life form	Soleria community			Soleria-Imperata communitty									
		DL1-1	DL1-2	DL1-3	Lahei1	Lahei2	Lahei3	Lahei4	Lahei5	Lahei6	Lahei7	Lahei8	Lahei9	Lahei13
Blechnum indicum	fern	0	0	0	0	5	2	10	0	20	10	2	0	0
Baeckea frutescens	shrub	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella ensifolia	grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenochlaena palustris	fern	0	0	10	2	5	2	10	20	30	10	5	2	2
Rubiaceae sp	linear	0	0	0	1	0	0	0	0	0	0	0	0	0
Ficus sp	shrub	0	0	0	0	0	0	1	5	0	0	0	2	0
Pteridium aquilinum	fern	0	0	0	1	2	0.1	0	0	0	1	0	0	0
Xyris indica	grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Nephrolepis falcatla	fern	0	0	0	1	0	2	1	1	1	0	0	4	0.1
Melastoma malabathricum	shrub	30	0	40	0	0.1	0.1	2	1	0	0	0	0	1
Cratoxylum glaucum	shrub	0	0	0	0	0	0	1	5	0	0	0	0	0
Scleria purpurescens	grass	**95**	**90**	**70**	**2**	**5**	**4**	**25**	**10**	**25**	**10**	**10**	**30**	**20**
Imperata cylindrica	grass	0	0	0	**60**	**40**	**50**	**95**	**95**	**90**	**95**	**90**	**30**	**95**
Melaleuca cajuputi	tree	0	0	0	0	0	0	0	1	0	0.1	0	0	0
Lygodium microphyllum	linear fern	0	0	0	0	0	0	0	2	0	0	0	5	0
Euodia aromatica	tree	0	0	0	0	0	0	0	0	0	0	0	0	0
Eleocharis retroflexa	grass	0	0	1	0	0	0	0	0	0	0	0	0	0
Schoenoplectus lacustris sp	grass	0	0	1	0	0	0	0	0	0	0	0	0	0
Poaceae sp	grass	0	0	1	0	0	0	0	0	0	0	0	0	0
Uncaria gambir	shrub	0	0	0	0	0	0	0	0	0	0	0	0	0
Combretocarpus rotundatus	tree	0	0	0	0	0	0	0	0	0	0	0	0	0
Fern sp	fern	0	0	0	0	0	0	1	0	0	0	0	0	0
Timonius flavescens	tree	0	0	0	0	0	0	0	0	0	1	0	0	0
Scirpus cf. subcapitatus	grass	0	0	0	0	0	0	0	0	0	0	0	0	0

Result 2. Occurance of communities in relation to edaphic variable

Table 3-1. Edaphic variables in each community.

Community type	SITE	Water level(cm)	Soil water content (%)	pH	EC µS/cm	Soil type	F mg/l	Cl mg/l	NO2 mg/l	Br mg/l	NO3 mg/l
Scleria-Blechnum	DL2-9	8	100	3.8	50	peat	0	5.43	0	0	0.186
Scleria-Blechnum	Lahei10	1	100	5.1	9	sand					
Scleria-Blechnum	Lahei11	1.5	100	4.8	11	sand					
Scleria-Blechnum	Lahei12	3	100	4.9	13	sand					
Blechnum	shibuya2	16	100	4.2	30	peat	0.222	4.07	0	0	0.016
Blechnum	KT1-9	10	100			peat	0.666	2.52	0	0	0.365
Blechnum	KT1-11	6	100	4.1	37	peat	3.2	15.1	0	0	0.542
Blechnum	KT1-12	-7	50.8	3.8	62	peat	2	7.93	0	0	0.235
Blechnum	KT3-3	-2	100	4.1	33	peat	0	1.81	0	0	0.111
Blechnum	KT3-8	-6	51	3.7	64	peat	0	3.4	0	0	0.054
Blechnum	KT3-9	7	100	4.0	35	peat	0	1.8	0	0	0
Blechnum	KT2-4	13	100	4.0	36	peat	0.78	3.34	0	0	0.106
Blechnum	KT2-6	6	100	4.1	32	peat	0.244	1.64	0	0	7.48
Blechnum	DL2-1	-14	75.5	3.8	86	peat	0	3.41	0	0	0.179
Blechnum	DL2-2	-4	52.3	3.6	60	peat	0	3.67	0	0	0.063
Blechnum	DL2-3	-5	43.3	3.4	75	peat	0	2.7	0	0	0
Blechnum	DL2-4	-6	76.6	3.6	64	peat	0	3.02	0	0	0
Blechnum	DL2-5	-7	95.5	3.2	104	peat	0	5.04	0	0	0
Blechnum	DL2-7	8	100	3.9	45	peat	0	4.78	0	0	0.371
Blechnum	DL2-8	-12	31.5	3.6	56	peat	0	2.69	0	0	0.302
Blechnum	DL2-10	-6	69.5	3.8	57	peat	0.725	3.81	0	0	2.35
Blechnum	DL2-11	-6	100	3.8	50	peat	0	4.93	0	0	0.568
Blechnum	DL2-12	-5	100	3.8	43	peat	0	3.98	0	0	0
Blechnum	DL2-13	5	100	4.0	41	peat	0.002	12.6	0	0	0
Xyris	KT1-7	14	100			peat	2.69	11	0	0	0.284
Xyris	KT3-1	-12	67.5	3.7	42	peat	0	4.64	0	0	1.94
Xyris	KT3-2	2	100			peat	0.821	4.41	0	0	3.95
Xyris	KT3-5	-1	100	4.0	32	peat	0	2.67	0	0	0.04
Xyris	KT3-6	5	100	4.0	33	peat	0.653	2.06	0	0	0.161
Xyris	KT2-5	-5	100	3.8	59	peat	1.29	7.73	0	0	0.035
Stenochlaena	shibuya1	15	100	4.2	30	peat	0.298	1.53	0	0	0
Stenochlaena	shibuya3	-13	39	3.6	25	peat	0	17.8	0	0	0
Stenochlaena	KT1-1	-20	27.8	3.6	72	peat	1.19	4.88	0	0	0.335
Stenochlaena	KT1-2	2	100	4.0	40	peat	2.23	17.6	0	0	4.66
Stenochlaena	KT1-3	-13	62.8	4.0	43	peat	2.19	11.2	0	0	0.348
Stenochlaena	KT1-4	-10	43.4	4.1	43	peat	1.25	5.04	0	0	0.146
Stenochlaena	KT1-5	4.5	100	4.0	39	peat	1.11	4	0	0	1.45
Stenochlaena	KT1-6	-12	42.5	3.8	46	peat	0.918	3.07	0	0	0.572
Stenochlaena	KT1-8	-7	85.3	4.0	61	peat	1.63	9.94	0	0	0.414
Stenochlaena	KT1-10	-10	28.8	3.9	45	peat	3.71	16.3	0	0	1.82
Stenochlaena	KT1-13	-6	84.4	3.8	41	peat	2.51	10.3	0	0	0.329
Stenochlaena	KT3-4	-10	69.6	4.0	36	peat	0	2.06	0	0	0.031
Stenochlaena	KT3-7	15	100	4.1	32	peat	0	1.89	0	0	0.016
Stenochlaena	KT3-10	-14	33.1	3.8	57	peat	0	5.07	0	0	0
Stenochlaena	KT2-1	-8	89.9	3.6	42	peat	0.849	5.23	0	0	1.27
Stenochlaena	KT2-2	-5	98.2	3.6	61	peat	1.29	5.09	0	0	3.2
Stenochlaena	KT2-3	7	100	4.0	35	peat	0.628	2.65	0	0	0.56
Stenochlaena	DL2-6	-8	29.8	3.6	67	peat	0.221	4.5	0	0	0.128
Scleria	DL1-1	-24	56.3	4.5	38	sand	0	3.18	0	0	1.34
Scleria	DL1-2	16	100	4.0	51	sand	0.001	5.97	0	0	3.42
Scleria	DL1-3	-26	34.5	4.2	92	sand	0.462	1.48	0	0	0.419
Scleria-Imperata	Lahei1	-16	46.2	4.2	40	sand	0.555	38.2	0	0	0.493
Scleria-Imperata	Lahei2	-3	44.8	4.4	28	sand	0.698	12.5	0	0	0.431
Scleria-Imperata	Lahei3	-5	43	5.1	30	sand	0.638	9.37	0	0	0.842
Scleria-Imperata	Lahei4	-5	40.4	4.4	20	sand					
Scleria-Imperata	Lahei5	-5	67.3	4.7	18	sand	0.001	12.4	0	0	0
Scleria-Imperata	Lahei6	-2	36.2	4.9	15	sand	0.408	15.7	0	0	2.05
Scleria-Imperata	Lahei7	-2	72.3	4.6	17	sand	0.018	16.7	0	0	3.69
Scleria-Imperata	Lahei8	9	63.4	4.2	38	sand	0.458	18.8	0	0	0.177
Scleria-Imperata	Lahei9	-18	34.4	4.5	37	sand					
Scleria-Imperata	Lahei13	-13	42.3	5.1	32	sand					

Table 3-2. continued.

Community type	SITE	PO4 mg/l	SO4 mg/l	Li mg/l	Na mg/l	NH4 mg/l	K mg/l	Mg **mg/l**	Ca mg/l
Scleria-Blechnum	DL2-9	0	1.17	0.127	4.94	0.013	4.46	1.2	1.36
Scleria-Blechnum	Lahei10								
Scleria-Blechnum	Lahei11								
Scleria-Blechnum	Lahei12								
Blechnum	shibuya2	0	2.43	0.004	3.46	0.763	2.18	0.373	0.625
Blechnum	KT1-9	0.092	0.29	0.033	2.04	0.42	1.43	0.271	0.358
Blechnum	KT1-11	0.184	0.776	0.133	11.8	1.04	5.52	0.554	1.12
Blechnum	KT1-12	0.191	0.812	0.149	6.72	0.777	3.9	0.422	0.813
Blechnum	KT3-3	0	0.838	0.002	1.86	0.676	1.34	0.131	0.302
Blechnum	KT3-8	0.623	1.59	0.002	3.11	0.548	1.88	0.201	0.006
Blechnum	KT3-9	0.121	0.606	0.003	1.92	0.252	1.34	0.213	0.337
Blechnum	KT2-4	0.026	0.646	0.011	2.77	0.636	1.22	0.175	0.332
Blechnum	KT2-6	0	0.825	0.006	1.57	3.39	1.37	0.133	0.379
Blechnum	DL2-1	0	2.22	0.24	3.67	0.021	4.94	1.17	1.25
Blechnum	DL2-2	0	2.3	0.045	3.43	0.74	2.97	0.454	0.758
Blechnum	DL2-3	0	1.52	0.163	2.55	0.013	3.61	0.724	0.887
Blechnum	DL2-4	0	0.518	0.088	2.6	0.039	2.9	0.684	0.828
Blechnum	DL2-5	0	1.13	0.234	4.79	0.016	4.75	1.39	1.63
Blechnum	DL2-7	0	1.79	0.124	4.55	0.387	4.67	1.18	1.42
Blechnum	DL2-8	0	1.6	0.084	2.84	0.255	2.58	0.621	0.963
Blechnum	DL2-10	0	2.73	0.026	2.44	2.17	2.76	0.653	1.13
Blechnum	DL2-11	0	2.9	0.049	4.21	0.216	2.8	0.888	1.45
Blechnum	DL2-12	0	1.92	0.323	4.5	0.009	6.63	1.72	1.7
Blechnum	DL2-13	0	2.94	0.758	11.9	0	17.5	2.6	1.78
Xyris	KT1-7	0.057	0.543	0.049	8.8	0.992	4.01	0.282	0.858
Xyris	KT3-1	0	1.21	0.008	4.33	2.09	2.61	0.163	0.408
Xyris	KT3-2	0	1.28	0.014	3.94	2.14	2.66	0.175	0.409
Xyris	KT3-5	0	1.16	0.003	2.14	0.698	2.17	0.233	0.345
Xyris	KT3-6	0.027	2.1	0.004	1.97	0.748	1.58	0.309	0.379
Xyris	KT2-5	0	1.49	0.018	6.07	0.74	2.38	0.38	0.641
Stenochlaena	shibuya1	0.066	1.17	0.008	1.25	0.346	0.932	0.386	0.555
Stenochlaena	shibuya3	0.128	2.71	0	10.9	0.365	0.955	0.282	0.348
Stenochlaena	KT1-1	0	1.11	0.29	4.79	0.266	8.6	1.05	1.16
Stenochlaena	KT1-2	0	1.72	0.09	11.8	2.56	5.5	0.433	1.29
Stenochlaena	KT1-3	0	0.503	0.077	8.75	1.09	4.42	0.329	0.832
Stenochlaena	KT1-4	0.101	0.524	0.024	4.02	0.73	2	0.208	0.624
Stenochlaena	KT1-5	0.383	0.43	0.024	3.3	0.926	2	0.198	0.363
Stenochlaena	KT1-6	0.054	0.457	0.034	2.61	0.884	1.48	0.202	0.338
Stenochlaena	KT1-8	0	0.383	0.049	8.1	1.2	3.9	0.272	0.682
Stenochlaena	KT1-10	0.593	0.746	0.146	12.3	1.44	6.34	0.51	1.18
Stenochlaena	KT1-13	0.387	0.578	0.053	8.18	0.861	3.88	0.322	0.768
Stenochlaena	KT3-4	0	1.74	0	2.18	0.527	1.61	0.258	0.362
Stenochlaena	KT3-7	0	1.61	0	1.92	0.441	1.56	0.222	0.349
Stenochlaena	KT3-10	0	0.363	0	4.35	0.234	3.07	0.33	0.665
Stenochlaena	KT2-1	0	1.88	0.043	4.49	0.788	2.89	0.371	0.546
Stenochlaena	KT2-2	0.084	1.93	0.017	4.1	1.57	1.86	0.249	0.469
Stenochlaena	KT2-3	0.02	1.21	0.007	1.98	0.784	1.41	0.176	0.363
Stenochlaena	DL2-6	0	0.973	0.028	4.01	0.466	3.57	0.523	1.01
Scleria	DL1-1	0.046	13.6	0.169	3.08	1.93	5.98	2.3	3.34
Scleria	DL1-2	0	16.3	0.321	4.99	1.87	7.32	3.4	2.83
Scleria	DL1-3	0	11.3	0.018	1.14	1.23	1.08	0.815	1.12
Scleria-Imperata	Lahei1	0	0.2	0.171	22.4	0.684	11	2.5	3.45
Scleria-Imperata	Lahei2	0	2.57	1.66	13.1	0	18.4	2.51	2.09
Scleria-Imperata	Lahei3	0	0.881	0.968	9.28	0	11.7	2.16	1.95
Scleria-Imperata	Lahei4								
Scleria-Imperata	Lahei5	1.15	1.14	0.756	10.8	0	16.2	1.64	2.6
Scleria-Imperata	Lahei6	0.168	1.42	1.09	13	0	17.5	2.14	2.27
Scleria-Imperata	Lahei7	0	2.13	1.07	15	0.02	16.3	1.54	1.76
Scleria-Imperata	Lahei8	0	5.01	2.34	18.4	0	25.3	2.8	1.9
Scleria-Imperata	Lahei9								
Scleria-Imperata	Lahei13								

The most prominent of gradient of secondary grassland communities in this region was from communities in peat soil (*Blechnum*, *Xyris* dan *Stenochlaena* communities) to chose in mineral soil (*Scleria* and *Scleria-Imperata* communities). Concentration of Cl^-, SO_4^{2-}, Na^+, K^+, $Mg^+$and Ca^{2+} and other ions were higher in *Scleria* and *Scleria-Imperata* communities than *Blechnum*, *Xyris* dan *Stenochlaena* communities. Accordingly, *Blechnum*, *Xyris* dan *Stenochlaena* made dominant communities in mineral-poor peat soil, but *Scleria* made community together with Imperata in mineral rich and soil.

Conclusion

The local difference of secondary grasslands was expressed by the difference of soil condition between mineral-poor peat soil (Kalanpangan) and mineral-rich sand soil (Lahei) conditions, and community variations within each local site was expressed by the water level gradient.

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TREE BIOMASS ON THE CHANGES OF FOREST TO OIL PALM PLANTATION IN HAMPANGEN, CENTRAL KALIMANTAN

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The study of biomass changes of forest to oil palm plantation was carried out in Hampangen Forest area, Central Kalimantan. In forest site, all trees DBH (diameter at breast height) > 4.8 cm in were measured within 0.5 ha (50 m x 100 m) rectangular plot, while in oil palm area all trees were measured its diameter on the base of stem. Total above ground biomass (AGB), in the forest area, the biomass reached 82.5 ton/0.5 ha and fitted to polynomial function and there were no significant difference (P>0.05). The total above ground, in oil palm area, was to be 13.5 ton/0.5 ha. The significant differences were observed to other allometric equations (P<0.001).

***Keywords*:** above ground biomass, Central Kalimantan, Hampangen, oil palm

Introduction

The oil palm (*Elaeis guineensis* Jacquin) is economically important for its oil and has become one of the major oil crops of the world. Indonesia, contributing 6.2 million tons (30.5 percent), after Malaysia, world's largest producer and exporter of palm oil and its by product. Environmentalists worldwide are focused on the conversion of pristine Indonesian rainforests to oil palm. Between 1980 and 2000, global palm oil production increased by 360% to 20.9 million tonnes in 2000 (Koh and Wilcove 2007) and it is forecast that global demand will double in the next 20 to 30 years (Sargeant 2001, Reinhardt et al. 2007).

The current issue of the unsustainability of palm oil production in Southeast Asia has largely been spurred by land use change that occurs by converting natural rainforest, peat swamp forest, cropland, or other land types to oil palm plantations. This land use change, in turn, has further environmental and social implications, such as the loss of biodiversity, emission of greenhouse gasses (GHG) from carbon stock changes in biomass and soil, peatland forest fires and related respiratory diseases, and land tenure and human rights conflicts (Colchester et al., 2006; Gibbs et al., 2008; Koh and Wilcove, 2008; Wicke et al., 2008).

Palm oil was the major oil traded with 13.6 million tons (40.2 percent), followed by soybean with 7.5 million tons (22.3 percent), sunflower oil with 2.9 million tons (8.7 percent), and tallow with 2.2 million tons (6.7 percent). Malaysia, world's largest producer and exporter of palm oil and its by products, produced 10.5 million tons (51.5 percent), followed by Indonesia, contributing 6.2 million tons (30.5 percent).

Recently, in Borneo and Sumatra, there has been a distinct move towards conversion of forests on peat soil into oil palm plantations. An option to provide land for oil palm planting without threatening the future of tropical rain forests is the rehabilitation of anthropogenic grassland, created by human clearance of natural forest biomes a long time. This paper concentrates on the above ground biomass on both forest and oil palm plantation areas.

However there is still few information of biomass of the converted forest to the oil palm plantation, especially in peat land area. Therefore, the aim of this study was to assess the above ground biomass (AGB) of forest and the AGB oil palm plantation.

Study site

This research was carried out in Hampangen Forest area which belongs to the Educational Forest of Palangkaraya University, Kasongan District, Central Kalimantan. The site located at at 1º53‘286“ S and 113º31‘41“ E, and oil palm plantation areas at 1º54'34.7“ S and 113º33'39.7“ E., altitude at 40 m above sea level. The forest area was covered approximately 4-6 m shallow peat soil. An average annual precipitation was 2,800 mm (1993-1997) at Palangkaraya, with monthly averages ranging from 80-370 mm. Mostly between July to October the dry season occurs with monthly rainfall lower than 130 mm and frequently apparent peat fire, while in the rainy season in other months with flooding appear some parts of hampangen forest.

Methods

In forest site, all trees DBH (diameter at breast height) > 4.8 cm in were measured within 0,5 ha (50 m x 100 m) rectangular plot. Tree circumferences were measured at breast height as 1.3 m from the soil surface identified species name and recorded. In oil palm area, all trees were measured its diameter on the base of stem. The topography of the both study sites was generally flat. All sample specimens in the plot were collected and transformed to Herbarium Bogoriense, Research Center for Biology-LIPI, for further identification.

In common allometric equation was applied for calculating the above ground biomass, as following equations:

$B = aD^2 – \mathrm{b}D + \mathrm{c}$ ……………………………………………………………………….. (1)

where B, D, a, b and c are, respectively, biomass (kg ha-1), diameter (cm) and constant values.

$\mathrm{Log\ V} = \mathrm{a}\ log\ D^2H^{\mathrm{b}}$ ……….. …………………………………………………………... (2)

where V, D, H a and b are, respectively, stem volume (kg ha-1), diameter (cm), height and constant values.

Analysis of variance (ANOVA) one-factor was used to compare the AGB in observed value to the other studies Chave et. al., (2005) and Brown (1997) for AGB in the forest area, and Brown(1997), Saldarriaga et al., (1988), Hudghes et al., (1999) and Hairiah et al., (2001) for AGB in oil palm plantation.

Results

Most founded species trees was coming from the *Cratoxylum glaucum* reaching 236 individuals (12,59% of the total individual trees), followed by *Garcinia rigida*, *Horsfieldia crassifolia*, *Combretocarpus rotundatus* and *Syzygium garcinifolium*. Pratama et. al., 2012 informed that the number of peat-swamp typical species showed that the characteristics of dynamic forest move toward succession.

Regarding the total biomass, in the forest area, the biomass reached 82.5 ton/0.5 ha, as shown in Figure 1. For estimating the tree biomass based on the diameter fitted in allometric equation with polynomial function (Table 1). No significant differences of tree biomass were observed to other allometric equations (P>0.05), such kind of Brown (1997) and Chave et. al., (2005).

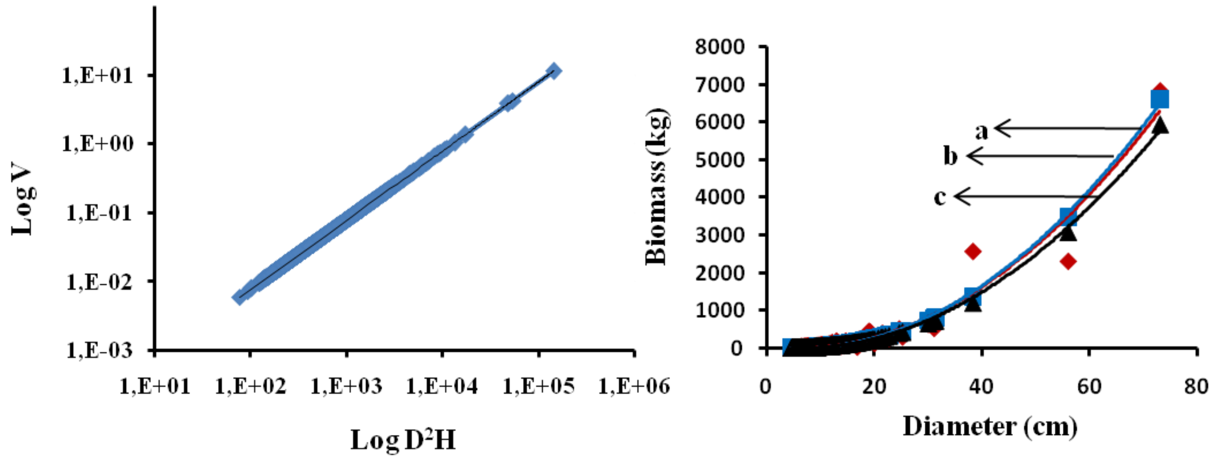

Figure 1. Relationships between D^2H-Stem Volume (left) and between D and Biomass (right), in the forest area. D, H and Bio, were respectively, the diameter (cm), height (m) and Biomass (kg). a, function of Chave et al (2005) for predicting biomass; b, observed biomass; and c, function of Brown (1997)

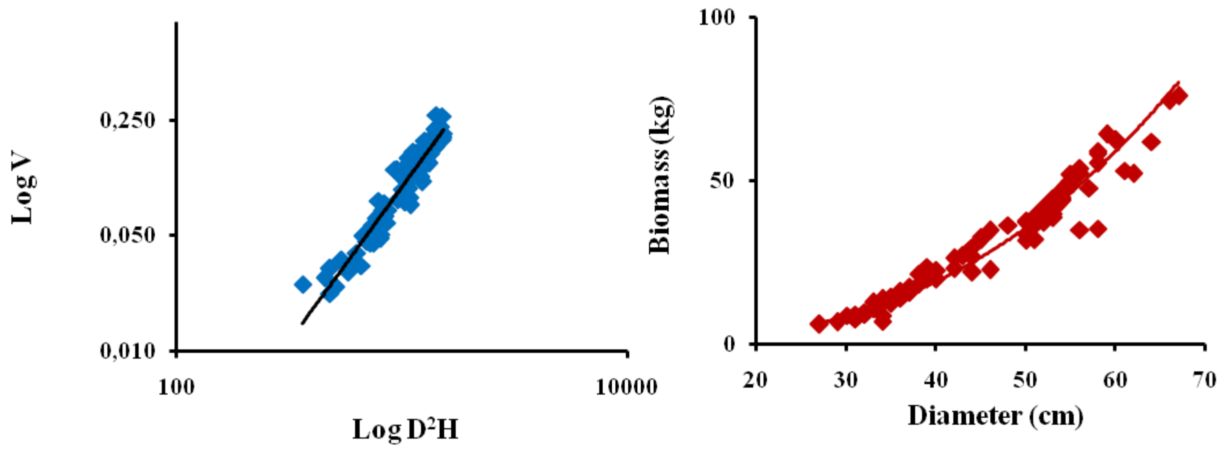

Figure 2. Relationships between D^2H-Stem Volume (left) and between D and Biomass (right), in the oil palm plantation. D, H and Bio, were respectively, the diameter (cm), height (m) and Biomass (kg)

The total above ground, in oil plam area, biomass was to be 13.5 ton/0.5 ha. The significant differences were observed to other allometric equations (P<0.001) by Brown (1997), Saldarriaga et al., (1988), Hudghes et al., (1999) and Hairiah et al., (2001). The power function of estimated AGB was more fitted than polynomial one, shown in Figure 2 and Table 1.

Table 1. The equation of stem volume and above ground biomass (AGB)

No	Equation	R2
1.	Log V = 8E-0.5 log D^2H	0,999*
2.	$Biomass = 1.450D^2 - 18.39D + 70.84$	0,997*
3.	$Biomass = 1.391D^2 - 16.49D + 67.19$	0,941*
4.	$Biomass = 1.285D^2 - 15.60D + 60.52$	0,996*
5.	Log V = 2E-0.7 log $D^2H^{1.876}$	0.925**
6.	$Biomass = 0.001D^{2.757}$	0.955**

Note: * The trendlines were shown in Fig. 1, respectively for a, b and c; ** the trend line was shown in Fig. 2.

Discussion

Total aboveground biomass (TAGB), in this study, was in the range of tropical forest region reaching 165 Mg/ ha^{-1}. Further, the different methods applied cause the considerable disparity between biomass estimation results. Brown and Lugo (1984) calculated tropical forest AGB from two distinct data sources, such timber volume and destructive sampling. Using volume data, they calculated 176 Mg ha^{-1} AGB of closed primary tropical forest, whereas destructive sampling yielded 283 Mg ha^{-1} AGB.

Cratoxylum glaucum species dominated in the burnt forest, in the study site, because of surviving from the base of burnt stem. Also *Combretocarpus rotundatus* also was found randomly in sampling plot, that grow in the open area or light demanding. Both species generally was found / dominated after burning in peatland.

The amount of AGB in the oil palm was a bit lower than the range of tree biomass, other plantation reached the AGB up to 50 - 100 Mg ha–1 towards the end of the plantation's economical live span after 25 years. Most of these figures represent the biomass at a certain palm age without stating actual and maximum trunk height. As timing for replanting is rather determined by palm height than by age, the suitability of these data to model biomass accumulation is limited. Further, the reviewed references often state the biomass without information on planting density and local environment, to both of which the vegetative development of oil palms responds distinctly (Germer & Sauerborn, 2004; Henson & Dolmat, 2003).

Regarding the allometric equation for the estimating AGB, it showed the different pattern between the forest and oil palm plantation, especially in correlation between log volume and log D^2H (Figs. 1 and 2). The correlation indicates that diameter and height is two independent variables that affected to the stem volume and estimates biomass, in the forest area was more fitted than the oil palm area. In addition, it was clear in coefficient of determination of each equation. Our analysis of AGB will be applicable to associate the carbon emissions driven by oil palm expansion in Hampangen area. Estimation of above ground biomass is an important aspect of studies of C stocks and the effects of deforestation and C sequestration on the global C balance.

Conclusions

- After the land conversion, the tree above ground biomass (AGB) decreased up to 83.6%.
- Allometric equation fitted to the polynomial equation for the forest area and power function for the oil palm area, and.
- The estimated AGB in forest area was somewhat similar to the other tropic forest area, in contrast to the plantation oil palm.

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HUMIC ACID INDUCES THE ENDOTHELIAL NO SYNTHASE ACTIVITION VIA HSP90 UPREGULATION IN HUMAN UMBILICAL VEIN ENDOTHELIAL CELLS

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Introduction

Humic acid (HA) is a dark-colored mixture resulting from the microbial degradation of organic matter. It is widely distributed in soil, coal, and well water [1] and is particularly abundant in peat soil [2]. HA has been implicated as a contributory factor for blackfoot disease, which is an endemic peripheral vascular disease occurring in the southwest coast of Taiwan [3]. An epidemiological study showed a causal association between drinking artesian well water and the occurrence of blackfoot disease [4]. Previous reports have suggested that HA treatment of endothelial cells stimulates NO production, which can elicit cell injury via the stimulation of Ca^{2+}-dependent endothelial nitric oxide synthase endothelial nitric oxide synthase (eNOS) activity [5]. In addition, the interaction between Heat shock protein90 (Hsp90) and eNOS increases the activity of this enzyme, with greater NO production as a result [6]. In the present study, we investigated the effect of HA on the regulation of eNOS in human umbilical vein endothelial cells (HUVECs) to evaluate the involvement of eNOS and Hsp90 in peripheral vascular impairment with HA exposure.

Materials and Methods

Sampling points

Palangkaraya, Kalimantan Island, Indonesia.

Extraction method

HA was extracted from the soil and purified by IHSS analysis.

Western blot analyses in the lysates from HA-treated HUVECs

Western blot analysis was performed using antibodies against eNOS, Hsp90α, Hsp90β, phospho-eNOS at Ser1177 and phospho-eNOS at Thr495. The HUVECs were cultured in EGM-2 with 0–50 µg/ml HA for 24 h. After treatment of the HUVECs with HA, the cells obtained were harvested using a scraper. The obtained cells were centrifuged at 2000 rpm for 3 min to remove the supernatant and washed twice in ice-cold PBS. BAPTA was dissolved in distilled water. In the experiment, 25µM BAPTA was added 30 min prior to the addition of HA to the cultured cells. For the detection of eNOS, Hsp90α, Hsp90β, phospho-eNOS at Ser1177 and phospho-eNOS at Thr495 cells were resuspended in a lysis buffer consisting of 2 mM HEPES, 100 mM NaCl, 10 mM EGTA, 1 mM PMSF, 1 mM Na3VO4, 0.1 mM Na2MoO4, 5 mM β-glycerophosphoric acid disodium salt, 50 mM NaF, 1 mM MgCl2, 2 mM DTT and 1% TritonX-100 and were disrupted by sonication for 1 min with a Sonifier 250 (Branson, USA). The protein concentration was measured by the Bradford method [7].

The same amount of protein from each lysate was electrophoresed on a 0.1% sodium dodecyl sulfate/ (eNOS, phospho-eNOS at Ser1177, and phospho-eNOS at Thr495: 5–20%; Hsp90α and Hsp90β: 12.5%) polyacrylamide gel. The proteins were electrophoretically transferred to nitrocellulose membranes with an iBlot Dry Blotting System (Invitrogen, Japan). The membranes were incubated overnight at 4°C in ODYSSEY blocking buffer (M&S Technosystems, Japan). They were then incubated for 45 min in a humidified incubator at 37°C and 5% CO2 with primary antibodies (eNOS dilution, 1:1000; phospho-eNOS at Ser1177 dilution, 1:1000; phospho-eNOS at Thr495 dilution, 1:1000; Hsp90α dilution, 1:1000; Hsp90β dilution), mouse monoclonal to actin (dilution, 1:400), and rabbit polyclonal to actin (dilution, 1:1000) in 40 mM Tris-HCl buffer, pH 7.4, containing 0.9% NaCl. The membranes were each washed 3 times for 3 min with 40 mM Tris-HCl buffer, pH 7.4, containing 0.9% NaCl and 0.3% Tween 20, and then incubated for 30 min in a humidified incubator at 37°C and 5% CO2 with secondary antibodies (anti-rabbit IRDye® 680CW and anti-mouse IRDye® 800CW dilution, 1:5000–15000). The membranes were washed 5 times each for 3 min in the same washing buffer. Protein bands that responded to antibodies were detected with an Odyssey Infrared Imaging System (M&S Technosystems, Japan).

Statistical analysis

Each value has been expressed in terms of mean and S.E.M. The significance of differences was determined by one-way analysis of variance with Tukey's tests. p values < 0.05 were considered to be statistically significant.

Results & discussion

Table 1. eNOS and related factors upregulation induced by HA was inhibited by the intracellular Ca2^{+} chelator BAPTA in western blot analysis

	BAPTA(25 μM)	HA(50 μg/ml)	Average	SE	
eNOS	−	−	100.000	3.674	
	+	−	94.407	2.925	
	−	+	140.770	7.474	**
	+	+	110.601	8.572	Ψ
eNOS(Ser1177)	−	−	100.000	9.347	
	+	−	96.099	10.682	
	−	+	177.839	15.408	**
	+	+	51.592	11.131	Ψ
eNOS(Thr495)	−	−	100.000	5.995	
	+	−	115.909	16.821	
	−	+	172.278	11.714	**
	+	+	118.747	10.299	ΨΨ
Hsp90α	−	−	100.000	15.205	
	+	−	129.776	25.544	
	−	+	180.247	8.416	**
	+	+	138.180	12.430	
Hsp90β	−	−	100.000	7.701	
	+	−	129.552	6.351	
	−	+	206.602	10.474	**
	+	+	167.582	11.344	**

**denotes $p < 0.01$ vs. control, Ψdenotes $p < 0.05$ vs. HA alone, ΨΨdenotes $p < 0.01$ vs. HA alone.

The present study showed that HUVECs treated with HA has significantly higher eNOS levels than the control, this result confirms those of previous studies [5]. eNOS phosphorylation at Ser1177 and eNOS phosphorylation at Thr495 produce NO and superoxide anions, respectively [6]. Cortes-González et al [6] showed that Hsp90α induced an increase in the NO level, an effect that was associated with increased eNOS phosphorylation at Ser1177. Additionally, Hsp90β transfection reduced NO and increased superoxide anion generation significantly, an effect that was associated with increased eNOS phosphorylation at Thr495. Previous studies have shown that peroxynitrite is generated from the reaction between NO and the free radical superoxide. The major cellular effect of peroxynitrite is membrane protein and cellular enzyme damage [8].

In the present results, treatment of HUVECs with HA induced upregulation of eNOS, eNOS phosphorylation at Ser1177 and eNOS phosphorylation at Thr495, Hsp90α and Hsp90β. To our knowledge, it is new discovery that HA induce both eNOS phosphorylation at Ser1177 and eNOS phosphorylation at Thr495 in HUVECs. Additionally, HA induce Hsp90α and Hsp90β in HUVECs. The present results indicated that an increase in eNOS phosphorylation at Ser1177 by HA was induced by Hsp90α upregulation and an increase in eNOS phosphorylation at Thr495 by HA was directly induced by Hsp90β upregulation. Several studies have shown that eNOS and Hsp90 are regulated by intracellular Ca2+ levels [9].The present study showed that the addition of BAPTA to the cell culture medium inhibited HA-induced upregulation of eNOS, eNOS phosphorylation at Ser1177, eNOS phosphorylation at Thr495, Hsp90α and Hsp90β. Thus, the present study demonstrated that HA induced the influx of Ca2+ which upregulates eNOS, Hsp90α, Hsp90β, eNOS phosphorylation at Ser1177, and eNOS phosphorylation at Thr495.

In summary the present study demonstrated that HA treatment leads to increases in cytosolic Ca2+ and subsequently to increases in both Hsp90α and Hsp90β proteins as well as increases in eNOS proteins. Hsp90α leads to eNOS phosphorylation at Ser1177, and Hsp90β leads to eNOS phosphorylation at Thr495. These results suggest that upregulation of eNOS phosphorylation at Ser1177 and eNOS phosphorylation at Thr495 by HA treatment leads to the production of excess amounts of NO and superoxide anions, respectively. Peroxynitrite generated from the reaction between HA-induced NO and superoxide anion may cause impairment of vascular endothelial cells (Figure 1).

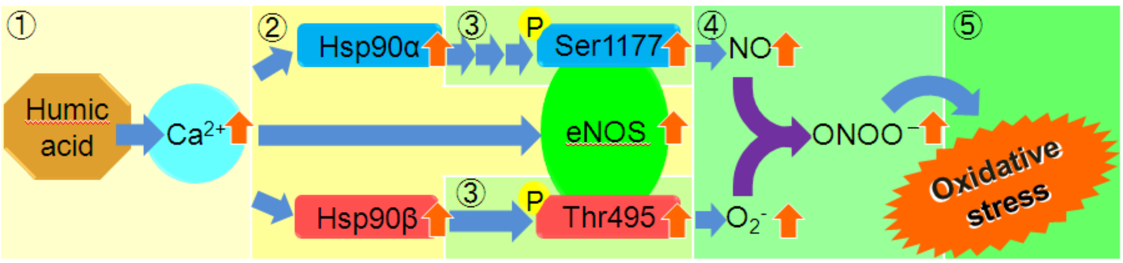

Figure 1. HA effects of metabolism in endothelial cells

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CARBON STOCK ESTIMATION OF PEATLAND USE ALOS PALSAR IN KAMPAR PENINSULA, RIAU PROVINCE, INDONESIA

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Global warming caused by increased greenhouse gases such as CO_2 in the atmosphere have caused climate change. Reduced Emissions from Deforestation and Degradation (REDD) Program is one of the schemes that enable developing countries to protect their forests in order to get the incentive of the carbon sequestration or reducing emissions from forest fires and other damage. Area of study is peatland in Kampar Peninsula in Riau Province. Radar remote sensing is used because of the ability to record data continuously without constrained cloud cover, smog, and fog throughout the year so that the monitoring of biomass can be done which the imagery used in this study is ALOS PALSAR HH and HV polarization in 2009. The method used in the estimation of carbon stocks using statistical regression model to estimate the depth, which is based on the backscattering coefficient and the depth of peat in the field, and supervised classification using Maximum Likelihood method used to get the kind of peat. Regression equation obtained is $y = -0.211x^2+4.117x-15.12$ with $R^2 = 0.786$. Based on these calculations obtained values of carbon is 95.123 Mt with the deepest peat depth is 7.4 meters.

Keywords: carbon stock estimation, ALOS PALSAR, peatland

Introduction

Global climate change in the last decade occurred due to disruption of the energy balance between the earth and the atmosphere due to increased concentrations of greenhouse gases, especially carbon dioxide (CO_2). Indonesia is the third largest contributor of CO_2 in the world (Wetlands International, 2006). The increasing concentration of CO_2 is caused by lack of proper land management, among other broad-scale forest fires simultaneously and draining of peatlands for various purposes. In the context of climate change, forests can act both as a sink / carbon storage as well as carbon emitters (source). Deforestation and degradation can increase the source, while afforestation, reforestation and other planting can increase sink.

Remote sensing is an alternative approach which is useful to map tropical environments at local and/or regional scale (Wijaya et al., 2010a). With the successful launching of recent satellites, vegetation monitoring in forested landscape becomes more effective and offer a great possibility for information updating on a regular basis. Although applications and methods development employing remote sensing for mapping of forest stands and forest properties modeling over tropical forest landscapes have been well established (Foody et al., 2003; Hajnsek et al., 2005; Houghton, 2005; Lefsky et al., 2002; Lu and Batistella, 2005; Lu, 2006; Rahman et al., 2005; Steininger, 2000), the knowledge of this approach for tropical wetlands is relatively poor (Wijaya et al., 2010b).

Applications of microwave remote sensing for biomass estimation allow the provision of additional information measured from the ground objects, since they are insensitive to the cloud-free daylight conditions for image acquisition. The application of SAR data for mapping of tropical forest properties has been widely applied (Fransson and Israelsson, 1999; Hajnsek et al., 2005; Isola and Cloude, 2001; Kuplich et al., 2005; Luckman et al., 1996), but few studies found applying this data in tropical wetlands. Besides, empirical models of microwave instrument data are known to be very sensitive to the density, shape, length, dielectric properties, and orientation of the scatterers (Kingsley and Quegan, 1992). The X-band (2.4 – 3.75 cm) SAR data is useful for terrain mapping and for discriminating the top canopy of vegetated lands. Some studies showed that the utility of single polarization C-band data (3.75 – 7.5 cm) may bring some limitations for distinguishing biomass in regenerating forests and deforested areas, because the radar backscatter becomes insensitive especially if the soil is dry and the influence of water is minimized (Saatchi et al., 1997). In contrast, L-band SAR data (15 – 30 cm) showed good ability for modeling the forest parameters under dense vegetation (Luckman et al., 1997; Rauste, 2005).

Radar sensors send out signals that penetrate ground cover and clouds and 'see' the underlying terrain as well as the top of the canopy. The radar signals returned from the ground and tops of trees are used to estimate tree height, which are then converted to forest carbon stock estimates using allometry. Different bands (e.g. C, L, P-bands) provide different information about forest canopies and are sometimes combined. Images collected at slightly different angles can be combined to create a 3D picture of forests using polarimetric interferometry (Mette *et al,* 2003; Kellndorfer *et al,* 2004; Shimada *et al,* 2005). Synthetic aperture radar (SAR) sensors on board several satellites (ERS-1, JERS-1, Envisat) can be used to quantify forest carbon stocks in relatively homogeneous or young forests, but the signal tends to saturate at fairly low biomass levels (~50–100 t C/ha; Patenaude *et al,* 2004; Le Toan *et al*, 2004). Mountainous or hilly conditions also increase errors. The phased array type L-band SAR (PALSAR) on board the Japanese Advanced Land Observing Satellite (ALOS) launched in 2005 has the potential to improve estimates of carbon stocks across the tropics for degraded or young forests but will be less useful for mature, higher biomass forests (Rosenqvist *et al,* 2003b; Shimada *et al,* 2005).

Material and Method

Study area

This study specifically considers the peatland forests in Kampar Peninsula, Riau Province, Sumatera, which is geographically located between 102°47'54.43" and 102°58'32.601" E and between 0°21'30.196" dan 0°27'59.952" N (Figure 1). The Kampar Peninsula is a wetland forest consists of great numbers of natural resources. The area has a size of approximately 700,000 ha, and peatlands in this region are mostly covered with 2-layer forest canopies. Peatlands in this region have depth from 50 cm (very shallow) to more than 20 meter (very deep). The peatland forests in Kampar Peninsula cover 17% of total peatlands in Riau Province (4.044 million ha), and for the entire country this province covers 56% of total 20.5 million ha of peatlands in Indonesia (Wahyunto et al., 2005).

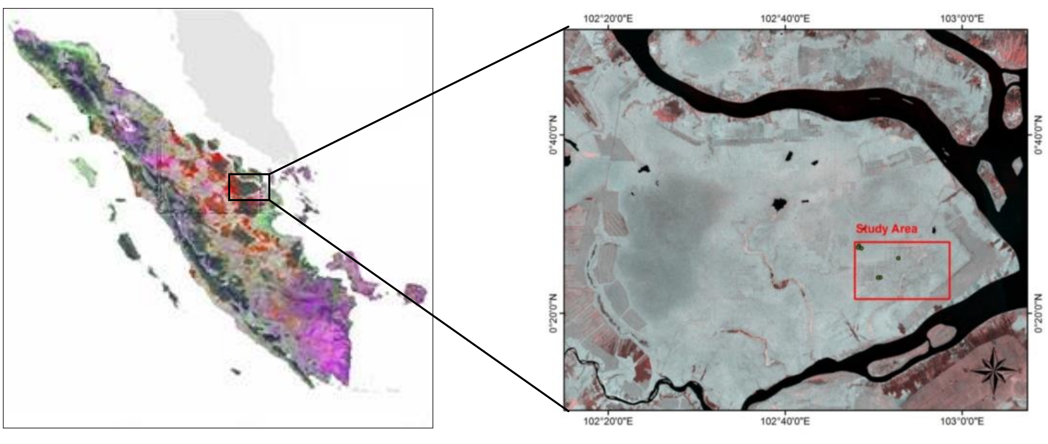

Figure 1. Study site of ALOS PALSAR data and sampling points

Most forest conditions in Kampar Peninsula relatively good and some very damaged by logging activities. Physical measurements of peat (pH, moisture and temperature) done on the top layer or the surface of the peat, and carried out during the dry season.

Peat is quite high relative humidity during the rainy season, which ranged between 90% - 96%, in the dry season decreased between 80% - 84%. While forest-covered peat temperatures between 27.5°C - 29.0°C. The acidity of the peat ranges from 3.0 to 4.5 (Rieley et al, 1996). Humidity is very high range due to sampling plots have varied land cover, which badly damaged the vegetation (percentage of canopy cover is low) until the vegetation is still relatively good (still a high percentage of canopy cover). This means that the more open areas will receive more sunlight, and this will affect the moisture and temperature. Similarly, the pH of the surface peat is relatively higher.

Ground and ALOS-PALSAR Data

Estimation of carbon content of peat swamp forests basically consists of two major parts namely aboveground carbon content or carbon contained in vegetation and belowground carbon content or carbon within the peat layer itself.

Subsurface carbon content is located in the carbon content of peat layers. Carbon content of the peat layer is influenced by the type / level of maturity of peat and peat layer thickness. Peat maturity will affect the specific gravity (bulk density) and levels of C-organic. Generally this type of peat in Sumatra is Hemik with an average density 0.1716 and C-organic content of an average of 48%. (Wahyunto et al, 2003 in Murdiyarso et al, 2004). From another study, Jonotoro (2011) said that value of bulk density in Kampar Peninsula is 0.1716 for hemist type, 0.2794 for saprist type, and 0.1028 for fibrist type. Besides, value of C-organic content in there is 48% for hemist type, 44.95% for saprist type, and 53.31 % for fibrist type.

To determine the level of maturity of the turf field is done by taking a handful of peat and squeezed. If 2/3 parts out through the cracks finger grip, it includes raw peat (fibrists). If the exit is only 1/3 part of the crevices finger grip, including peat half-baked (hemists). And if grasped and squeezed almost no part of the exit slit finger grip, including peat mature (Saprists).

Calculation of belowground carbon content (peat layer) using the formula (Murdiyarso, 2004):

$$KC = B \times A \times D \times C \ \ldots \ (1)$$

Where KC is carbon content in tons, B is bulk density (BD) of peat soil in g/cc, or tons/m³, A is peat land area in m², D is peat thickness in m, and C is levels of carbon (C-organic) in percent Scenes of ALOS PALSAR FBD imagery, acquired in 2009, were used for this study. PALSAR Mosaic images were processed to σ^o (power) values, 50-m resolution and terrain corrected using the Alaska Satellite Facility's (ASF) Mapready software and a 90-m Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) (Jarvis et al., 2006). Within the Mapready software, power values were calculated from raw digital numbers (DNs) using Eq. (2) from Shimada et al. (2009):

$$\sigma^o = 10 \times \log (DN^2) - 83 \text{ db} \ \ldots \ (2)$$

The images were then ortho-rectified to Universal Transverse Mercator (UTM) projection using Landsat ETM+ imagery, with a root mean square error (RSME) of < 0.65 Landsat pixels (30 m)(. Finally, a three-pixel, enhanced Lee filter was applied to reduce speckle in the images (Lee, 1980). For maximum likelihood classification (MLC) analysis a three-band image was analyzed, which consisted of bands HH, HV and a ratio of HV/HH. The ratio was used in order to reduce topographic effects, which have significant impacts on SAR backscatter. The bacscaterring coefficient images used to derive regression relationship of peat thickness. Carbon stock estimation obtained by thickness and peat type distribution from MLC that showed in figure 2.

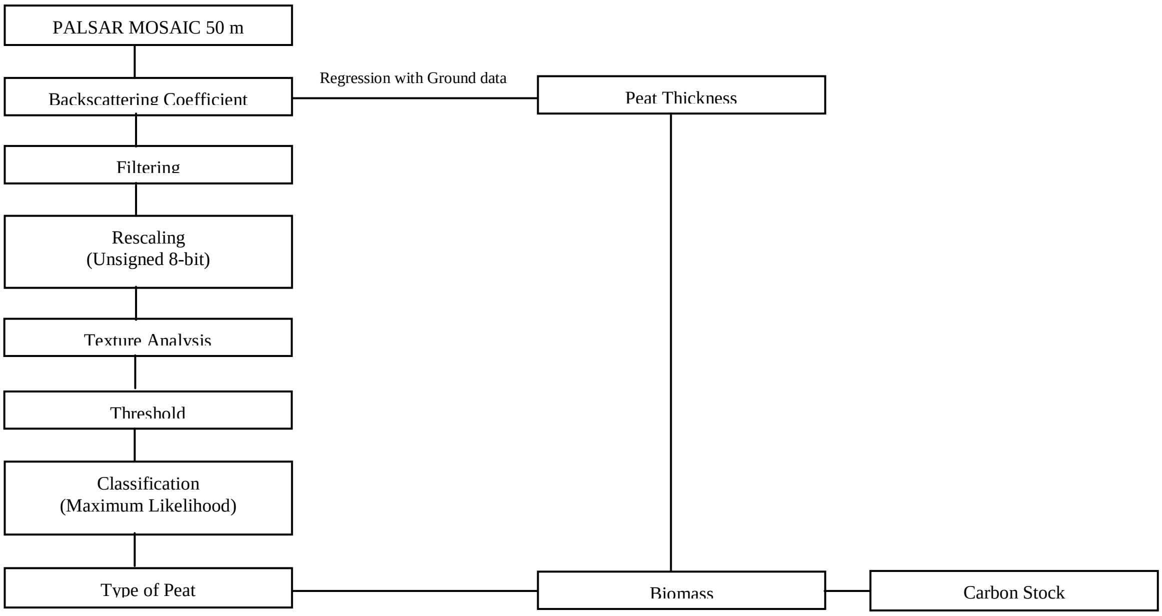

Figure 2. Methodology for carbon stock estimation

Result and Discussion

Peat distribution obtained from peat type classification derived from the image of polarization HV, HH, and ratio (HV / HH) using a maximum likelihood classification has R^2 = 0.657. Peat distibution is used to determine the peatland area, bulk density, and the value of C-organic contained in the study area.

Regression between the backscattering coefficient of HV polarization and the value of peat thickness measurements in the field (figure 3) generating formula:

$$y = -0.211x^2+4.117x-15.12 \ldots (3)$$

The formula has R^2= 0.786 and give overall accuracy 72.15% of carbon estimation. Based on the peat land area, bulk density, the value of C-organic, and thickness, eq. 1 is used to estimate carbon stock of belowground peat and the result obtained 95,123 Mt of carbon in study site.

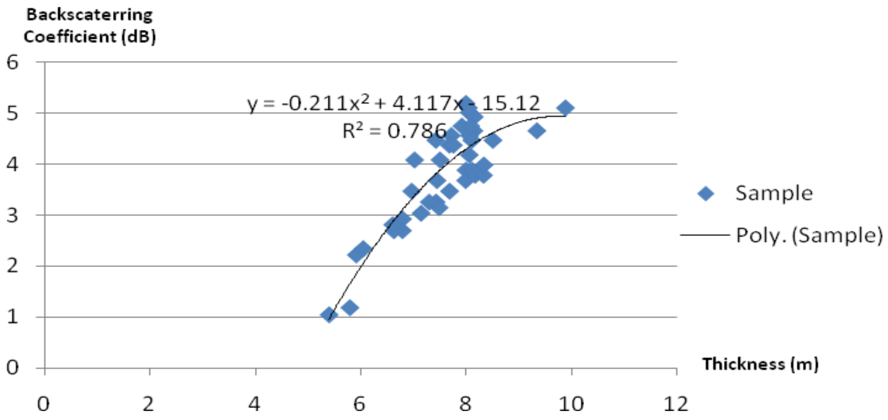

Figure 3. Thickness model from HV data

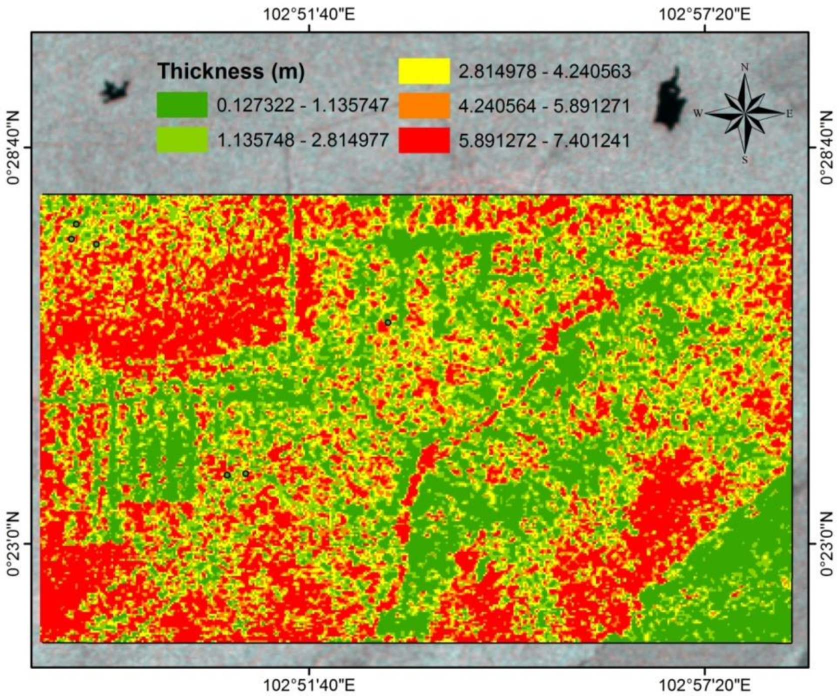

Figure 4. Peat thickness map in study area from regression model

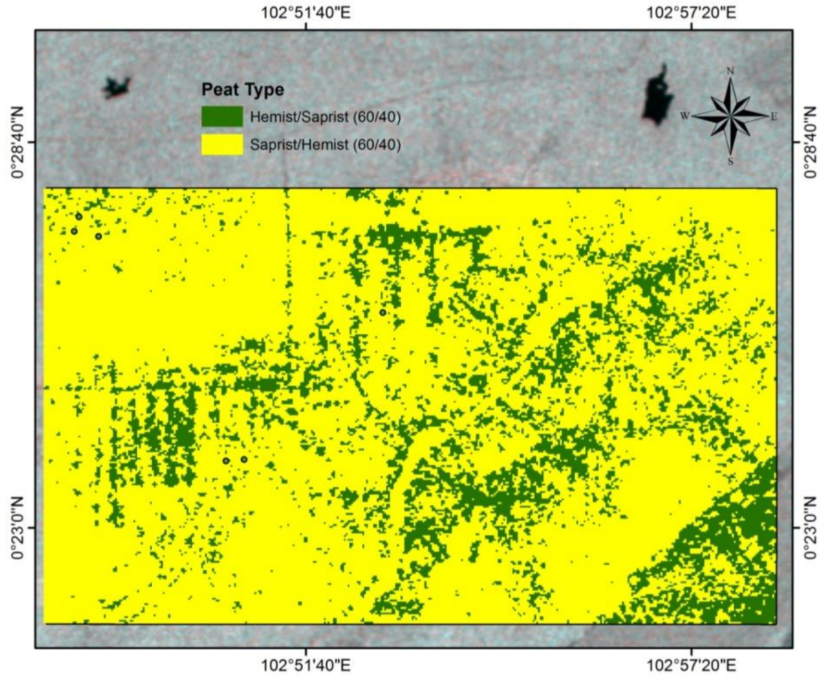

Figure 5. Peat type from Maximum Likelihood Classification (MLC)

Conclusion

Modeling of tree parameters over tropical peatland regions is relatively new for remote sensing application. This study observed different SAR data, using single and full polarimetry SAR for modeling the peat thickness, biomass and carbon stock. However, the modeling of belowground carbon stock using SAR data is another challenging task. The fitting process, selection of appropriate algorithm (i.e. linear or polynomial) should be taken carefully. Further study should be carried out to improve the accuracy of the model considering different SAR properties, and to include InSAR and PolinSAR parameters in the model.

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TROPICAL PEAT FIRE CHARACTERISTICS IN KALIMANTAN USING MODIS HOTSPOT AND IMAGERY DATA

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Kalimantan is the third largest island in the world, which has the second biggest tropical peat swamp forest with a higher amount of carbon storage in Indonesia. Nevertheless, there knows as one of largest contributor of carbon emissions during the period of active fire lasted decade. This paper was discussing the fire activity trends in Kalimantan and northern part of Mega Rice Project (MRP) areas to support Reducing Emissions from Deforestation and Forest Degradation plus (REDD+). The study was carried out using 0.5grid cell size of MODIS hotspots for regional Kalimantan and 0.01grid cell size for local the northern MRP. The results showed that two most fire prone areas in Kalimantan were H-1 at south (3.0^{o}-3.5^{o}S and 113.5^{o}-114.0^{o}E), and H-2 at north (2.0^{o}-2.5^{o}S and 114.0^{o}-114.5^{o}E) of the MRP areas. Across peatland areas in Kalimantan, fire spreading tended from western to the southern part due to their precipitation patterns. Furthermore, the most fire incidence in the MRP block C north was in 2009 as a result of the lowest total precipitation June to September in Palangkaraya and vicinity areas. Two active fire areas were in Kalampangan Canal (41%) and Main Canal North East (24%), where coincided with shrubs and forest areas. In 2009, total fire duration was 51 days, which nearly 60% of fires only occurred from DN 260 to 274. In addition, the MODIS images through the NASA Rapid Response System also show the fire location by a shape of burnt areas.

Keywords: MODIS hotspot, Kalimantan, MRP, peat fires, REDD+

Introduction

Tropical peatland is an enormous carbon sinks and store large amounts of carbon. The total carbon deposit on global tropical peatland is greater than 80Gt, which roughly 65% is distributing in Southeast Asia region. In Southeast Asia region, most of tropical peatland areas that associated with rain forest referred as peat swamp forest (PSF) eco-region. The areas usual covering the typically lowland near river valley and seacoast, with surrounded by lowland rain forests on non-peat soils, and mangrove forests near the coast. Indonesia has approximately 200,000km^2 of Southeast Asia peatland (Page et al., 2011), where about a quarter concentrated in the southern coastal areas and some spots in the interior of Kalimantan. Total forest area including PSF prior to 2011 is exceeding 200,000 km^2 and covers 45% of total land across the island (Table 1 and Figure 2).

The preliminary study previously explained that severe fires in Indonesia mostly were laid on the tropical forest and peatland areas of Kalimantan (~40%) and Sumatra (~30%).In 2006, about 80% carbon emission of drained peatlands in Southeast Asia estimated came from Indonesia, mainly from the island of Sumatra and Kalimantan (Hoijier et al., 2010). The recent annual number of fire only in the MRP of central Kalimantan was larger than the main land of Java and Papua, and clarified as the highest incidence across Indonesia (Yulianti et al., 2012). Considering to a high risk of fires, this region will be face a substantial challenge in the future. This study attempts to elucidate the following questions for the latest peat fire in local scale. Is the fire activity in the study area follows the national pattern of fire? How the density of fire incidence surveyed? How large fire size in a severe fire? The final result can be considered as a baseline of an effective strategy for suppressing the next severe fire. It aims to protect the remaining peat swamp forest and to reduce CO_2 emission under REDD+ scheme.

Methods

The total of a number of MODIS hotspot prior to 2012 in Kalimantan was 244,692 hotspots. In this paper, we selected hotspot data where belong to Indonesia areas. All hotspots outside the area interest were excluded by deleting the data beyond the borders. Further, the temporary boundaries drawn carefully that followed the fire distribution cells by latitude and longitude lines.MODIS hotspots analyzed two levels of grid cells, 0.5^o cells for Kalimantan, and 0.01^o cells for the Block C north. As the total number of hotspot depends on each grid area, hotspot density obtained as a unit of “hotspots/cell” or “number of hotspots per one grid cells” used for simplicity. Conversion from hotspots/cell to hotspot density unit of ”hotspots/km^2” can be obtained by dividing the number of fires with the area of one cell. Size of one cell averaged about 3,097 km^2 of 0.5 cells, and 1.21km^2 of 0.1 cells. The value can be obtained by dividing the fires density in 1,000km^2 with the fire duration in the areas.

In this study, a MODIS Terra 250m resolution bands 7-2-1 scenes October 17, 2009 (DN290). Combination bands 7-2-1 selected because they can identify burned areas, vegetation, and bared soils, which is useful for monitoring forest and peat fires also their effects. To obtain the extent of burn areas, the imageprocessed using ArcViewand Cartographica. The initial image analysis was cropping three images of FIRMS Borneo-South East subset into the area of interest in block C north. The images projected to the Universal Transverse Mercator (UTM) with map unit of decimal degrees automatically.

Precipitation data for Palangkaraya and vicinity areas Central Kalimantan was measured at TjilikRiwut Airport. Time series precipitation data for Pontianak was providing by Supadio Airport thought West Kalimantan Statictical Agency.

Table 1. Statistic data of hotspot incidence, peatland, and forest in Kalimantan

	Hotspot 2002-2011		Peatland areas (km^2)[a]	Forest areas in 2010 (km^2)[b]			Forest loss rate 2006-2009(km^2/yr)[b]			Land areas (km^2)[c]		
	Hotspots/yr	%		Primary	Secondary	Total	Primary	Secondary	Total	Total areas	% peatland	% forest
Central Kalimantan	11,905	52	30,106	13,080	56,940	70,020	26	748	774	153,565	20	46
West Kalimantan	6,646	29	17,300	23,822	30,549	54,371	265	59	323	147,307	12	37
South Kalimantan	2,869	13	3,316	593	6,990	7,583	47	14	60	38,744	9	20
East Kalimantan	1,518	7	6,970	39,181	72,933	112,114	334	37	371	204,534	3	55
KALIMANTAN	22,937	100	57,692	76,676	167,412	244,088	672	857	1,529	544,150	11	45

[a]WETLAND map, 2004
[b]Ministry of Forestry of Indonesia data, 2010
[c]BPS (National Statistical Agency) data, 2010

Results and Discussions

Fire prone areas in Kalimantan

Figure 1 shows 35 cells with a high number of fire incidences in the main land of Kalimantan. Two cells with most fire incidence where the number of hotspots exceeds 800 hotspots/(yr. cell) and two cells where the number of hotspots exceeds 600 hotspots/(yr. cell). Followed by eight cell areas with the fire incidence exceeds 400 hotspots/(yr. cell) and the rest exceeds 200 hotspots/(yr. cell). Top twelve of highest cells that numbered by 1 to 11 was only in West and Central Kalimantan region as shown in Figure 1. Other areas without color indicate cells with the number of hotspot less than 200 in a year (a part of outside Indonesia had excluded).

Seven of the noticeable cells with the highest fire incidences were covering the Mega Rice

Project and vicinity areas (named MRP+), H-1 to H-5 and H-8 to H-9. The H-1, a cell with the most fires, is in the southwest part of MRP+ area, at south latitude 3.0°-3.5° and east longitude 113.5°-114.0°. It had 971 hotspots/yr and a maximum in 2004 and 2006 with 2,033 and 2,417 fires, respectively. This cell mostly covered with peat swamp shrubs and open field as in Figure 2. Prior to 2006 fires, Hoscilo et al (2011) identified that there was the fresh water swamp forest and health forest patches in that area. In the northern part of the MRP+ area, there is a cell with the second highest fire (H-2). This cell is at south latitude 2.0°-2.5° and east longitude 114.0°-114.5°, and had an average of 804 hotspots/yr. A maximum of fire incidence occurred in 2009 with 2,289 fires over this area. It is located in the south of Palangkaraya (capital of Central Kalimantan Province), which has canals and transportation routes between the provinces. The next chapters will emphasize the fires incidences in this area (H-2) because its importance to the provincial capital.The other cells, H-3, H-4, H-5, H-8, and H-9 were adjacent to the southeast part of both highest cells in MRP area includes a small part of South Kalimantan. The cells with high fire incidences also were in the middle of the South West Coast region, Central Kalimantan. The H-7 and H-12 cells are the northern of Sampit areas, which at south latitude 2.0°-3.0° and east longitude 112.5°-113.0°. Figure 2 suggests these cells are outside the swamp forest area.

Figure 1 also shows three cells (H-6, H-10, and H-11) averaged 400 hotspots/(yr. cell) in West Kalimantan. The H-6 cell is at south latitude 2.5°-3.0° and east longitude 110.5°-111.0°, and the H-10 cell is at south latitude 1.5°-2.2° and east longitude 110.0°-110.5°. The cells are located in South Coast region of West Kalimantan, which coincides with wetland areas. A single cell, H-11, is located near border Indonesia and Malaysia in West Coast region. It had a mean 422 hotspots/yr and a maximum of 713 hotspots in 2005.

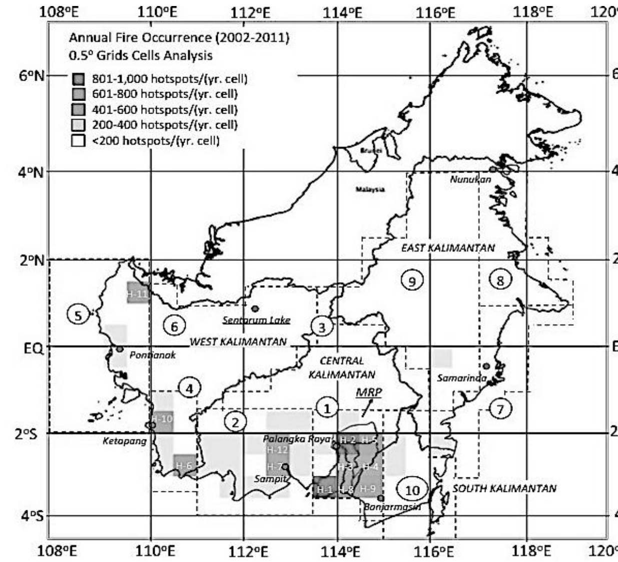

Figure 1. The cell with the high annual fire incidence in Kalimantan, 2002-2011

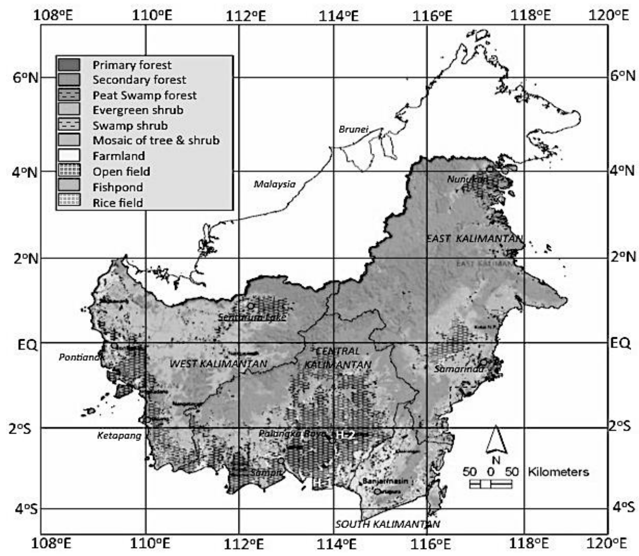

Figure 2. Land cover in Kalimantan (MoF Indonesia, Landsat ETM+ & BAKORSURTANAL)

Annual & seasonality fire in ten regions in Kalimantan

The annual fire of whole Kalimantan is 22,937±17,281 hotspots/yr (mean±1SD). About 80% of the annual number is in the regions of Central Kalimantan (51.90%), and West Kalimantan (28.97%). The numbers represent a high contribution of fire-prone areas in the swamp and seacoast areas of two provinces. In the year with the most fires, in 2006, the total number of hotspots was about twice (53,462) the annual mean. Times of the fires discussed using the annual mean of monthly fires during the period 2002 to 2011. Fires contribution of ten regions in Kalimantan clearly presented by Fig.4. Number of hotspots in August, September, and October had the noticeable of highest incidences with over 80% of fire through a year. Fires in August, September, and October represented 31.8% (7,315), 432.8% (7,515), and 21.1% (4,866) of the average annual number of fires. Most of all regions peaked fires occurrence in three months. Central Kalimantan had high incidences of fires in August, September, and October was 37.43%, 61.58%, and 68.77% of the total number of fires in each month, respectively. Fires in the MRP+ area were a rise from a number of 66 hotspots in June to a maximum of 2,308 hotspots in September. These most fire month contributed about 31% of the total number of fires in Kalimantan.

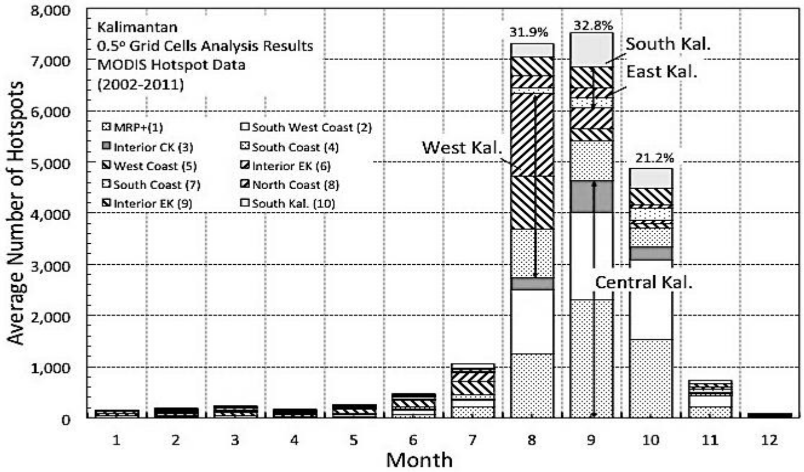

Figure 3. Annual fire period over ten regions in whole Kalimantan, 2002-2011

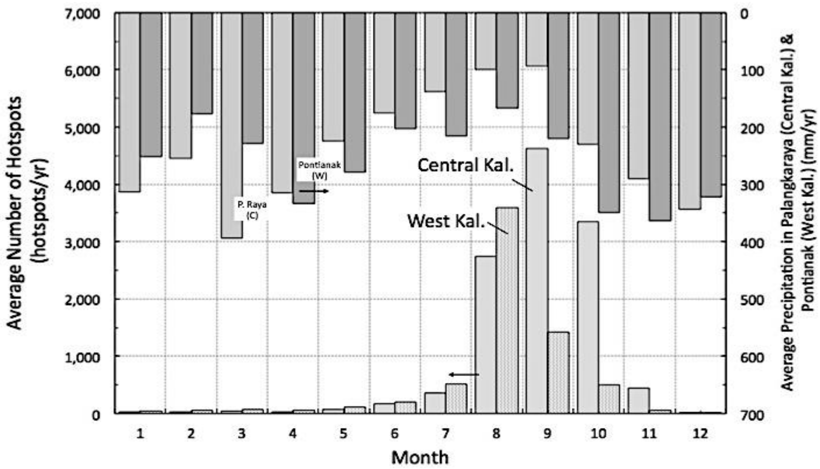

Figure 4. Monthly number of hotspots and precipitation in Central & West Kalimantan

Fire activities were the effect of the driest months, from July to September as shown in Fig.5. High fire in October under 230 mm of precipitation was the remains of the third month of the previous fires. Increasing rainfall caused fires drop about 7.6 times in November. In the other hand, West Kalimantan only had high incidences of fires in August and September were 49.11% and 18.94% of the total number of fires in each month, respectively. Fig.5 clearly showed a driest month 167 mm only occurred in August. Previous studies had clarified that the number of fires will be higher when the number of rainfall in July to August was below a normal critical point (Putra et al., 2008; Putra &Hayasaka, 2011; Yulianti et al., 2012). The modest relationship between total number of fires and precipitation of July to September in Palangkaraya, Central Kalimantan expressed as $y = 0.0416x^2 - 63.798x + 23{,}751$, which is $R^2 = 54\%$. In similar tendency, relationship of total number of fires and precipitation of July to September in Pontianak, West Kalimantan has $y = 0.0094x^2 - 30.552x + 21{,}548$ ($R^2 = 65\%$).

Fire Movement (2002-2010)

In Fig.5, mostly cells with exceeded 20 hotspots/(1,000km^2) occurred in West Kalimantan in August. However, the cell with highest fires incidence occurred at south latitude 2.0^o-2.5^o and east longitude 114.0^o-114.5^o and had 62.2hotspots/(1,000km^2). It was coincided to H-2 cell in Fig.1. Two other high cells in West Kalimantan had 60.8 and 59.9hotspots/(1,000km^2), respectively. A single cell was at south latitude 1.5^o-2.0^o and east longitude 110.0^o-110.5^o that close to Ketapang areas. The other cell was at north latitude 1.0^o-1.5^o and east longitude 109.5^o-110.0^o, coincided with evergreen shrub areas in northern of West Kalimantan. In September, live fire moved on the southern part of Central and West Kalimantan. Two highest cells exceed 80 hotspots/(1,000km^2) were cover MRP areas. The most fire was at south latitude 3.0^o-3.5^o and east longitude 113.5^o-114.0^o, and had 116.6 hotspots/(1,000km^2). It was located on the same cell with to H-1 in Fig.1. In the north of MRP area, south latitude 2.0^o-2.5^o and east longitude 114.0^o-114.5^o, that had 113.9 hotspots/(1,000km^2). Fires in Kalimantan became smaller in October, and concentrated in MRP+ and south west coast of Central Kalimantan areas. The cell with highest fires density had a maximum of 124.2 hotspots/(1,000km^2) in H-1 cell.

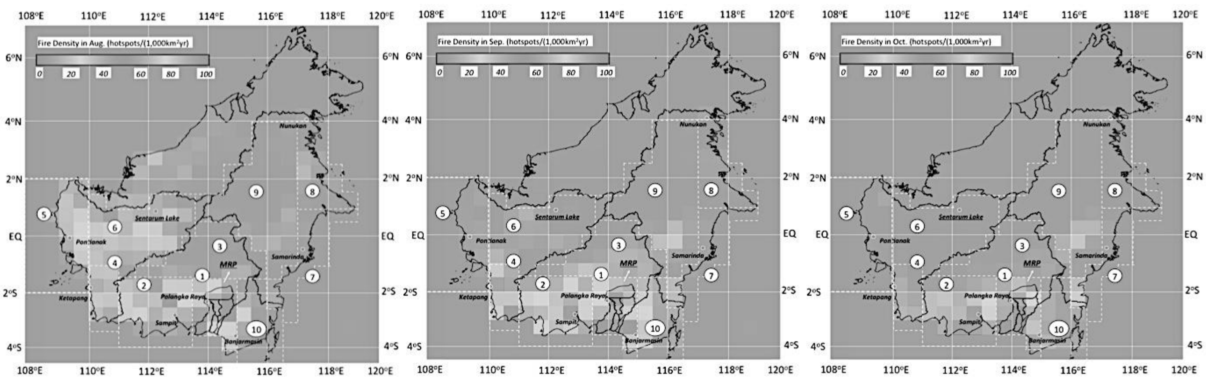

Figure 5. Fire density for the fire months 2002-2011 (left to right: Aug., Sept., & Oct.)

Peat fire trends & daily intensity in the MRP north

The area interest of block C north in Figure 6 covers smaller area but shifted slightly to the west compare to H-2 cell in chapter 1. There were several 0.01 cells, which had highest hotspot, such as in the intersection of Kalampangan canal (42 hotspots), middle of northeast main canal (35 hotspots), near Tumbang Nusa Highway (25 hotspots), Taruna canal (13 hotspots), and southeast part of Palangkaraya (9 fires). Hereafter, we used these five areas to explain local fire trends in block C north. The annual mean fire density is 3.47 fires/(km^2yr), increasing about 6.5 times in 2002 (23.97 fires/km2), and 2.1 times in 2009 (7.43 fires/km^2). As this study using 0.01degree cells, the cell with most fires among 480 cells in block C north and vicinity areas, which located at south latitude 2.32^o to 2.33^o and east longitude 114.02^o to 114.03^o, where positioned slightly south of Kalampangan canal intersection. It had a mean 4.2 fires/yr and a maximum of 29 fires in 2002. The area with the most fire is belonging to Kalampangan Canal, where about 20km southeastwards of Palangka Raya.

The mostly high fires incidence more existed on areas where close to the main road, canals, and Kahayan River. These fires clearly ignited by human, who had remarkably active rate over northern the MRP. Post forest conversion on 1997/1998, the MRP block C north areas, had converted for cultivation of rice and vegetables areas as well as transportation access. Mostly wasteland areas near canals and roads had over grown with pioneer plants such as ferns, herbs, shrubs, woodbines, and other cattails (Wardani et al., 2005). The supreme fern species were *Stenochlaenapalutris*, *Osmundacinnamomea*, and *Pteridiumaquilinum*. Three herbs species, *Eleochalarisdulcis*, *Chromolaenaodorata*, and *Cyperusrotudus.L* were also growing widespread on the MRP areas. Two types of fast-growing trees are *Combretucarpusrotundatus*and *Acacia mangiumsp.* These areas have potential fuels to experience recurring fires, even extending new fires to PSF arease.g. in 2009.

The annual number of fires in block C north averaged about 172±202 fires, where about 56% was falling within the Kalampangan Canal (31.6%) and Main Canal North East (23.9%). The total hotspot from 2002 to 2011 numbered 541 in Kalampangan Canal and 410 in Main Canal North East. Three other fires centers, Taruna Canal, Tumbang Nusa, and Palangkaraya South East, had 229 (13.4%), 221 (12.9%), and 139 (8.1%), respectively. Years with most intense fires occurred in 2002 for Kalampangan Canal, 2009 for Main Canal North East and Taruna Canals, 2006 in Tumbang Nusa, and 2004 in Palangkaraya South East. The number of distinct fires in Kalampangan Canal was 290 fires in 2002 and 218 fires in 2009. Their contribution was about 57% and 40% of whole total fire in block C north in each year.

The inversely bar graph in Figure 7 shows the annual precipitation of dry months, from June to September in Palangkaraya and vicinity areas. Two unusually active fires in block C north in 2009 and 2002 were coincided with lowest precipitation occur. In 2009, the most fire year had an earlier dry season in June as mentioned previously. Amount of precipitation in this month dramatically drop to 43 mm or only 16% of total precipitation in May. Since then, total precipitation over the study area decreased until September, about 12mm/month. The decreases in rainfall will be lead to a higher level of flammability due to ground water level factor, which can increases the dryness of peat and surface plants (Usup et al., 2004; Putra &Hayasaka, 2011).

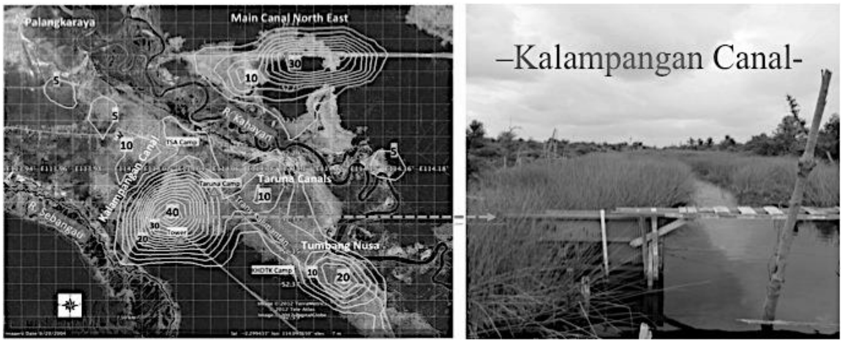

Figure 6. Contour map of fire centers & current condition in Kalampangan Canal (Sept. 2012)

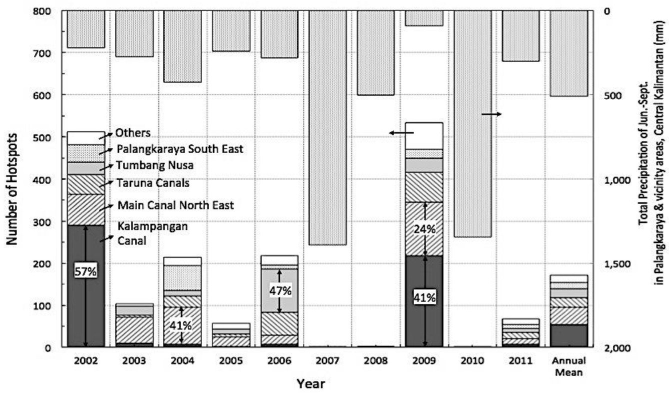

Figure 7. Annual peat fire and precipitation June-September, 2002-2011

Fire propagation & burnt area in 2009 severe fire

Figure 8 shows fire propagation in 2009. The first fire in 2009 occurred on DN 115 (April, 25), which located approximately 192m-east the Sebangau River. This fire only lived for a day. One month later, a single fire was visible at less than 500m from secondary canal between Kahayan River and the main canal north. Third fire occurred on DN 172 (June 21) at 84m-west Trans Kalimantan Highway (2.276^{o}S, 113.942^{o}E), but it only lasted a day as the two previous fires. Four following fire occurred 25 days later in the riverside Kahayan and the second east tributary. From the beginning of fire incidence up to DN 213, fires became noticeable only in two areas, along Main Canal North East and in most south of Kalampangan Canal. Five days of early August, from DN 215 to 220, fire in the middle of Main Canal North East became active. While, fires in Kalampangan Canal started near the intersection and in the most north of canal on DN 220. Fires period of 221-243 in the middle of Kalampangan Canal and northern part near Trans Kalimantan highway became gradually active. However, fires in the middle the Main Canal declined and only a few in the west.

In the period of DN 248 to 258, fire was not only adjacent to the primary canals but also in left-right side of the Tumbang Nusa Highway. There were several fire incidences started in DN 249 (September, 6) at between two secondary canals in Tumbang Nusa, approximately

11km to the south of the Kalampangan Canal. In DN 251-254, fires rate had spread to the north, where toward Kalampangan Canal and also to the south, where toward to tributary of Kahayan River. Other new fires started on DN 256 at south latitude 2.30^{o} to 2.3^{2o} and east longitude 114.15^{o} to 114.17^{o}, which located in the east bend of Kahayan River.

Fire incidence was highly active on the period of DN 260-262 and clustered in three areas. The most fire occurred along Main Canal North East, which apply southwards to near Kahayan River. Fire incidences peaked on DN 261 with 19 hotspots. In Kalampangan Canal, 17 fires incidence distributed from the intersection to the south part of the canal. Several fires in Taruna Canals also had started on DN 262. For the whole block C north and Kalampangan Canal, fire had a peak on DN 263, and number of hotspots reached 89. These fires were attacking a Meteorology tower at the edge of PSF (see Figure 8). However, due to study site blanked by clouds and dense smoke (source is *http://earthdata.nasa.gov/)*, DN 264 hotspot could not be detected by MODIS. Total number of hotspot in DN 265 was 59, which distinct as second peak fire day in block C north. About 69% of these fires were only found in Kalampangan Canal.

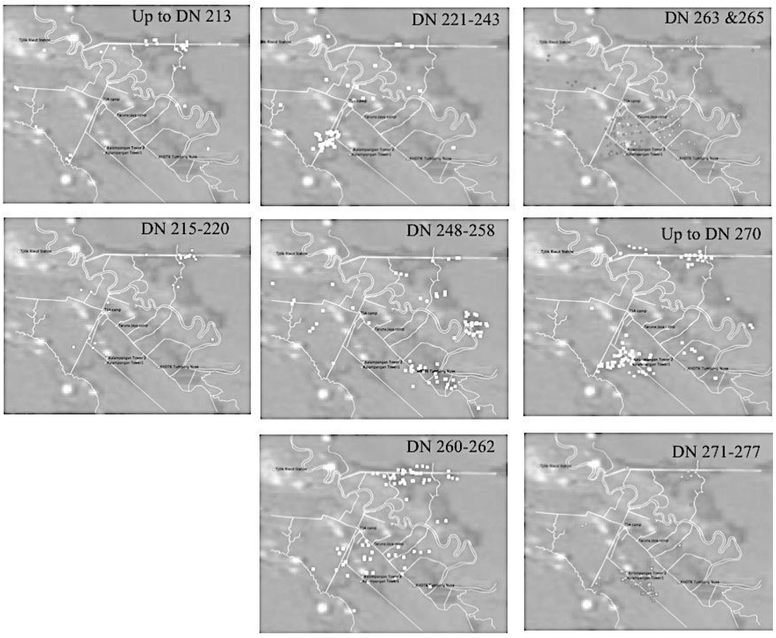

Figure 8. Fire propagation in block C north (background is 721 MODIS image Oct. 17, 2009)

Fire incidence in Kalampangan Canal up to DN 270 tended to move southeastward and burnedthe border of forest areas. In the middle and north part of Main Canal North East, fires were reactivated to 22 incidences. Period of DN 271-272, active fires in Kalampangan Canal still spread southeastward, which had consume the crown tree and also small surface vegetation at heart of PSF. Other fire was a move to most south of Kalampangan Canal, closed to Sebangau River. On the otherwise, fire in Main Canal North East was declined about 3 times than previous days. In the early October (DN 274 & 277), a total of 28 remaining fires were in Kalampangan Canal and the rest in between west tributary of Kahayan River. Finally, on the DN 348, a single last fire was visible on the east bend of Kahayan River.The changes of burned areas in each stage of fire propagation are in Table 2.

Table 2. Hotspot-affected areasin 2009 in Block C north

No	Day Number of 2009	Hotspot-affected areas (km^2)
1.	115-213	51.97
2.	215-220	42.08
3.	221-243	57.93
4.	248-258	103.41
5.	260-262	99.45
6.	263	101.32
7.	265	75.16
8.	266-268	46.32
9.	269-270	74.35
10.	271-272	45.72
11.	274 & 277	35.36
12.	289-348	29.21

Conclusions

The conclusion of fire situation on tropical peatland in whole Kalimantan for the last ten years can be summarized into three parts as follows:

1. Mostly fire occurrences over fire-prone areas in Central and West Kalimantan were coincidingto the disturbed peatland areas.
2. Precipitation pattern had good relationship (R^2>50%) to peat fire trends in whole Kalimantan and the MRP north.
3. The beginning of active fires in Kalimantan tends to start in western part, and then ended in southern part of Central Kalimantan.
4. Fire mobility in 2009 across the block C tends did not have correlation each other among five fire centers, suggesting their fire incidences may be caused by various factors.

Acknowledgement

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MAPPING FOREST IN WEST SUMATERA BY USING CANONICAL CORRELATION ANALYSIS FOR MULTITEMPORAL CLASSIFICATION PURPOSES

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This research is aimed to explore how to do forest mapping in west Sumatera by using canonical correlation analysis and utilize it for multitemporal data. First we prepare the data through preprocessing stages. Then we identify and find classifier for forest identification in one year data based on the training sites selection. Then the derived classifier is used to map the forest in another time of Landsat data. In this research, two years of Landsat data is used, which are 2008 as the primary data where we put the training sites, and 2009 where we test the classifier and do the same forest mapping. It is found that the canonical correlation can be used to derive a classifier which is formed as a linear combination of bands as variables. Then the same indices are applied to another year of data and show the same strong separability. Which means that this indices can be used for forest identification from year to year of data and valuable for multitemporal classification, and at the end can be used as the main source for carbon accounting system.

Keywords**:** canonical, forest mapping, multitemporal classification, west sumatera, linear combination

Introduction

Indonesia is one of the countries with the biggest forest in the world. Indonesian forest has a lot of variety and has high economic value. Therefore deforestation always threat Indonesian forest. So many efforts have been taken to control deforestation, one of them is monitoring through satellite data sets. DeFries found that remote sensing is the only tools that fits the need of deforestation monitoring in national scale (DeFries, etc. 2006). Since the beginning of 90's forest area's changes have been monitored confidently (Archard, 2008). Some countries like Brazil, India and Australia already have operational system for deforestation monitoring since a couple of years, and some are still developing the system. Indonesia so far has developed some methods to do the analysis for forest identification by digital image processing for forest monitoring.

Intergovernmental Panel on Climate Change (IPCC) in its report on 2007 has estimated that deforestation and forest degradation has contributed for about 17% of the overall greenhouse emission, even bigger than global transportation sector. One of scheme to reduce carbon emission is through REDD (Reduce Emission from Deforestation and forest Degradation) which is giving incentives for the countries who can reduce carbon emission by suppressing deforestation and forest degradation. This carbon accounting program can be perfomed by using image data such as optic, radar, lidar, IFSAR, and aerial photo. For optic image we can use Landsat, SPOT, ASTER, ALOS AVNIR-2, IRS, etc. While for radar image we can use TerraSAR X, X SAR, Radarsat, Cosmo SkyMed, ALOS PALSAR, etc.

There are some method that can be used to count carbon by using radar data, such as by using two bands from two different band data and by using one band which has through terrain correction, which is the correction that is performed to change surface model become elevation model and terrain model. While for optic data, carbon accounting can be performed by mathematical approach. Before doing carbon accounting, we need to do geometric correction, radiometric correction, and topography correction.

We can do forest mapping by using some methods, which are Canonical Correlation Analysis, Maximum Autocorrelation Factor, Minimum Noise Fraction, Multivariate Alteration Detection, Pseudo Invariant Feature, Principal Component Analysis, etc. In this research we perform canonical method. Canonical correlation measure of the strength of the overall relationship between the linear composites (canonical varieties) for the independent and dependent variables (Green, 1978). Canonical correlation analysis is multivariate statistical models that study the interrelationships among sets of multiple dependent variables and multiple independent variables. From the canonical correlation analysis, canonical varieties are defined which are linear combinations that represent the weighted sum of two or more variables and can be defined for either dependent or independent variables.

Methodology

Study area

The study area is located in West Sumatera which has conservation forest. So it is expected not to have too many changes from year to year.

Figure 1. Research location

Datasets

This research uses optical data (Landsat). There are two main data that is used. One is as the primary data that is used to derive the classifier, which is Landsat data mosaic for 2008. And the other main data is Landsat data mosaic for 2009.

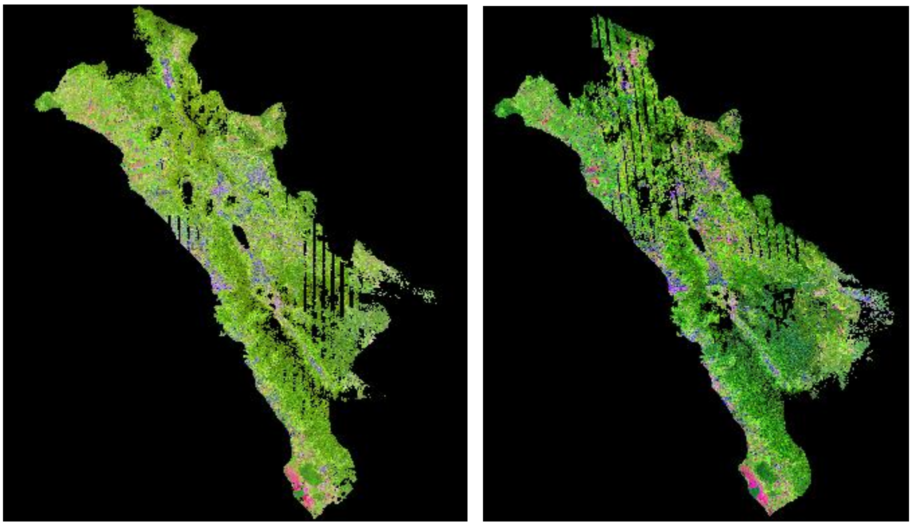


Figure 2. Mosaic Landsat image for West Sumatera 2008 (left) and 2009 (right)

Methods

This research uses Landsat data that have been through some preprocessing stages, which are geometric correction, sun correction, topography correction, cloud masking and mosaicing. Then some training sites are selected for two categories, forest and non forest. High resolution data is used for guiding training sites selection. After the selection of training sites, the analysis is performed to study the interrelationship among sets of variables (digital numbers for each bands) based on the training sites. From the analysis can be seen which band who has the greatest influence in separating these two groups of forest and non forest.

The index of each band is decided based on the canonical correlation matrices. At least two indices should be decided. Then those indices are applied to the image data. We can assess whether the indices are working good in separating two groups (forest and non forest). Then those indices are applied to another image year.

Spatial information of forest and non forest can be obtained by utilizing these classifier, for different time of data. But with exactly the same indices, by shifting the threshold until the separation is met.

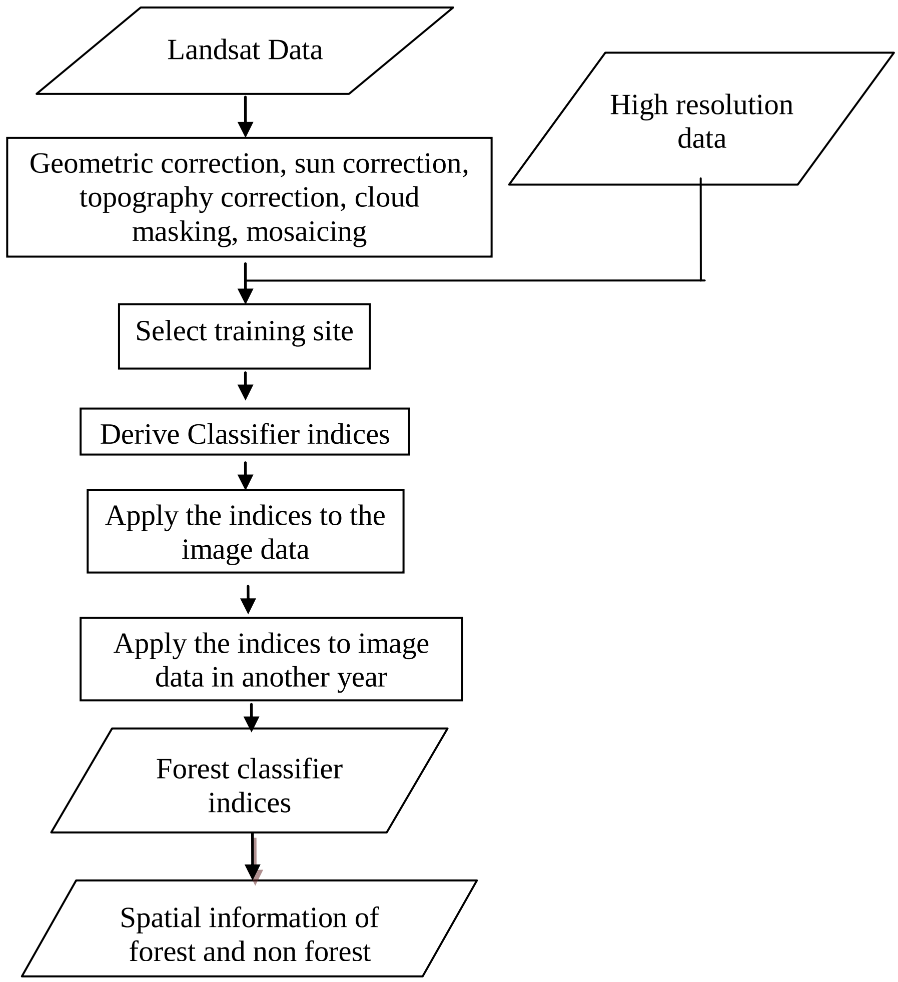


Figure 3. Research methodology

Results

From the training sites that have been selected for two categories, which are forest and non forest, correlation of each band is obtained.

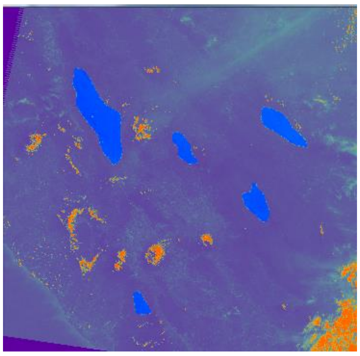
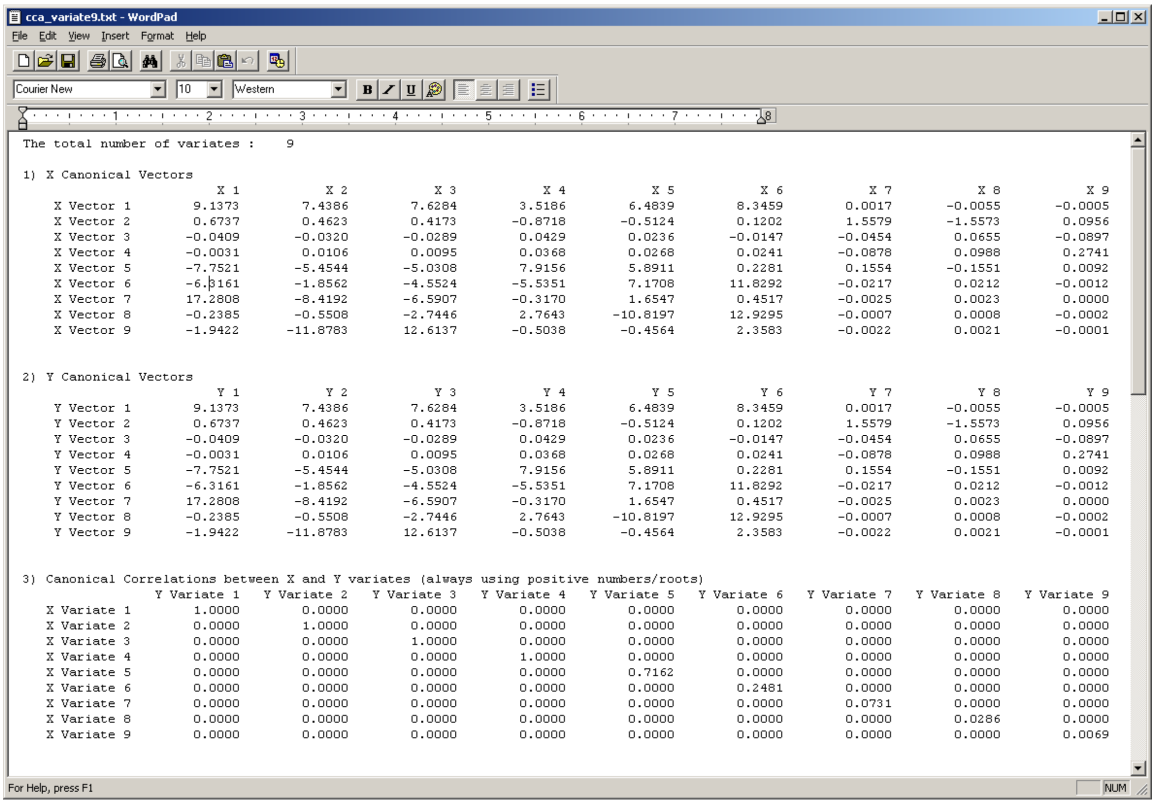


Figure 4. Training sites selection process

Then the canonical vectors metrics are obtained as shown in Figure 5.



cca_variate9.txt - WordPad

The total number of variates : 9

1) X Canonical Vectors

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9
X Vector 1	9.1373	7.4386	7.6284	3.5186	6.4839	8.3459	0.0017	-0.0055	-0.0005
X Vector 2	0.6737	0.4623	0.4173	-0.8718	-0.5124	0.1202	1.5579	-1.5573	0.0956
X Vector 3	-0.0409	-0.0320	-0.0289	0.0429	0.0236	-0.0147	-0.0454	0.0655	-0.0897
X Vector 4	-0.0031	0.0106	0.0095	0.0368	0.0268	0.0241	-0.0878	0.0988	0.2741
X Vector 5	-7.7521	-5.4544	-5.0308	7.9156	5.8911	0.2281	0.1554	-0.1551	0.0092
X Vector 6	-6.3161	-1.8562	-4.5524	-5.5351	7.1708	11.8292	-0.0217	0.0212	-0.0012
X Vector 7	17.2808	-8.4192	-6.5907	-0.3170	1.6547	0.4517	-0.0025	0.0023	0.0000
X Vector 8	-0.2385	-0.5508	-2.7446	2.7643	-10.8197	12.9295	-0.0007	0.0008	-0.0002
X Vector 9	-1.9422	-11.8783	12.6137	-0.5038	-0.4564	2.3583	-0.0022	0.0021	-0.0001

2) Y Canonical Vectors

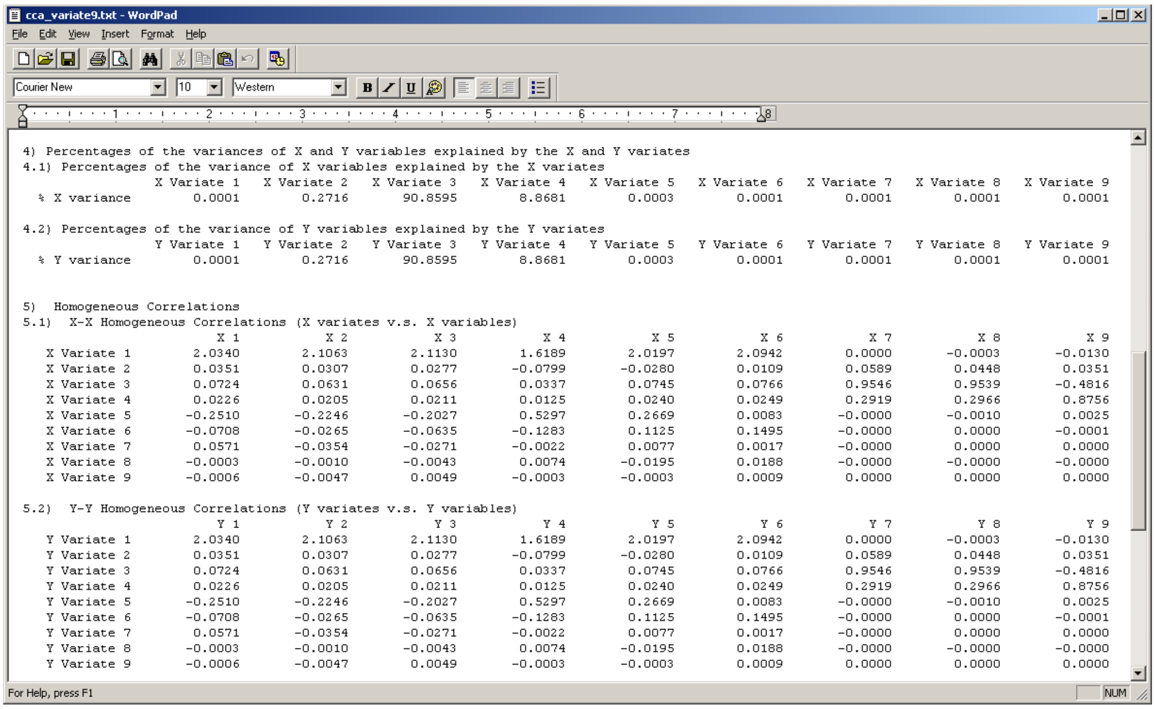
	Y 1	Y 2	Y 3	Y 4	Y 5	Y 6	Y 7	Y 8	Y 9
Y Vector 1	9.1373	7.4386	7.6284	3.5186	6.4839	8.3459	0.0017	-0.0055	-0.0005
Y Vector 2	0.6737	0.4623	0.4173	-0.8718	-0.5124	0.1202	1.5579	-1.5573	0.0956
Y Vector 3	-0.0409	-0.0320	-0.0289	0.0429	0.0236	-0.0147	-0.0454	0.0655	-0.0897
Y Vector 4	-0.0031	0.0106	0.0095	0.0368	0.0268	0.0241	-0.0878	0.0988	0.2741
Y Vector 5	-7.7521	-5.4544	-5.0308	7.9156	5.8911	0.2281	0.1554	-0.1551	0.0092
Y Vector 6	-6.3161	-1.8562	-4.5524	-5.5351	7.1708	11.8292	-0.0217	0.0212	-0.0012
Y Vector 7	17.2808	-8.4192	-6.5907	-0.3170	1.6547	0.4517	-0.0025	0.0023	0.0000
Y Vector 8	-0.2385	-0.5508	-2.7446	2.7643	-10.8197	12.9295	-0.0007	0.0008	-0.0002
Y Vector 9	-1.9422	-11.8783	12.6137	-0.5038	-0.4564	2.3583	-0.0022	0.0021	-0.0001

3) Canonical Correlations between X and Y variates (always using positive numbers/roots)

	Y Variate 1	Y Variate 2	Y Variate 3	Y Variate 4	Y Variate 5	Y Variate 6	Y Variate 7	Y Variate 8	Y Variate 9
X Variate 1	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
X Variate 2	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
X Variate 3	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
X Variate 4	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
X Variate 5	0.0000	0.0000	0.0000	0.0000	0.7162	0.0000	0.0000	0.0000	0.0000
X Variate 6	0.0000	0.0000	0.0000	0.0000	0.0000	0.2481	0.0000	0.0000	0.0000
X Variate 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0731	0.0000	0.0000
X Variate 8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0286	0.0000
X Variate 9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0069

For Help, press F1

Figure 5. The canonical vactors metrics



cca_variate9.txt - WordPad

4) Percentages of the variances of X and Y variables explained by the X and Y variates

4.1) Percentages of the variance of X variables explained by the X variates

	X Variate 1	X Variate 2	X Variate 3	X Variate 4	X Variate 5	X Variate 6	X Variate 7	X Variate 8	X Variate 9
% X variance	0.0001	0.2716	90.8595	8.8681	0.0003	0.0001	0.0001	0.0001	0.0001

4.2) Percentages of the variance of Y variables explained by the Y variates

	Y Variate 1	Y Variate 2	Y Variate 3	Y Variate 4	Y Variate 5	Y Variate 6	Y Variate 7	Y Variate 8	Y Variate 9
% Y variance	0.0001	0.2716	90.8595	8.8681	0.0003	0.0001	0.0001	0.0001	0.0001

5) Homogeneous Correlations

5.1) X-X Homogeneous Correlations (X variates v.s. X variables)

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9
X Variate 1	2.0340	2.1063	2.1130	1.6189	2.0197	2.0942	0.0000	-0.0003	-0.0130
X Variate 2	0.0351	0.0307	0.0277	-0.0799	-0.0280	0.0109	0.0589	0.0448	0.0351
X Variate 3	0.0724	0.0631	0.0656	0.0337	0.0745	0.0766	0.9546	0.9539	-0.4816
X Variate 4	0.0226	0.0205	0.0211	0.0125	0.0240	0.0249	0.2919	0.2966	0.8756
X Variate 5	-0.2510	-0.2246	-0.2027	0.5297	0.2669	0.0083	-0.0000	-0.0010	0.0025
X Variate 6	-0.0708	-0.0265	-0.0635	-0.1283	0.1125	0.1495	-0.0000	0.0000	-0.0001
X Variate 7	0.0571	-0.0354	-0.0271	-0.0022	0.0077	0.0017	-0.0000	0.0000	0.0000
X Variate 8	-0.0003	-0.0010	-0.0043	0.0074	-0.0195	0.0188	-0.0000	-0.0000	-0.0000
X Variate 9	-0.0006	-0.0047	0.0049	-0.0003	-0.0003	0.0009	0.0000	0.0000	0.0000

5.2) Y-Y Homogeneous Correlations (Y variates v.s. Y variables)

	Y 1	Y 2	Y 3	Y 4	Y 5	Y 6	Y 7	Y 8	Y 9
Y Variate 1	2.0340	2.1063	2.1130	1.6189	2.0197	2.0942	0.0000	-0.0003	-0.0130
Y Variate 2	0.0351	0.0307	0.0277	-0.0799	-0.0280	0.0109	0.0589	0.0448	0.0351
Y Variate 3	0.0724	0.0631	0.0656	0.0337	0.0745	0.0766	0.9546	0.9539	-0.4816
Y Variate 4	0.0226	0.0205	0.0211	0.0125	0.0240	0.0249	0.2919	0.2966	0.8756
Y Variate 5	-0.2510	-0.2246	-0.2027	0.5297	0.2669	0.0083	-0.0000	-0.0010	0.0025
Y Variate 6	-0.0708	-0.0265	-0.0635	-0.1283	0.1125	0.1495	-0.0000	0.0000	-0.0001
Y Variate 7	0.0571	-0.0354	-0.0271	-0.0022	0.0077	0.0017	-0.0000	0.0000	0.0000
Y Variate 8	-0.0003	-0.0010	-0.0043	0.0074	-0.0195	0.0188	-0.0000	-0.0000	-0.0000
Y Variate 9	-0.0006	-0.0047	0.0049	-0.0003	-0.0003	0.0009	0.0000	0.0000	0.0000

For Help, press F1

Figure 6. The canonical vectors metrics

Based on the percentages of variances can be seen that Band 3, Band 4 and Band 2 has the highest percentage consecutively. It gives those bands as calculated bands for deriving indices. And the coeficient of each of those bands can be seen in Figure 6. For band 2, band 3 and 4 the obtained coefficients are 0.0307, 0.0656, and 0.0125 consecutively. Then we round those number into integer. So we get 3, 7 and 1 for coefficient of band 2, 3 and 4. The complete indices are as follow

Index 1 : 3*b2+7*b3+b4

Index 2 : 7*b3+b4

Index 3 : b4-b3

Index 1 and 2 are obtained from the canonical correlation process while index 3 is the common vegetation index. Then these 3 indices are applied to the image data of 2008 mosaic imagery. And the thresholds are defined to meet the seperability between forest and non forest.

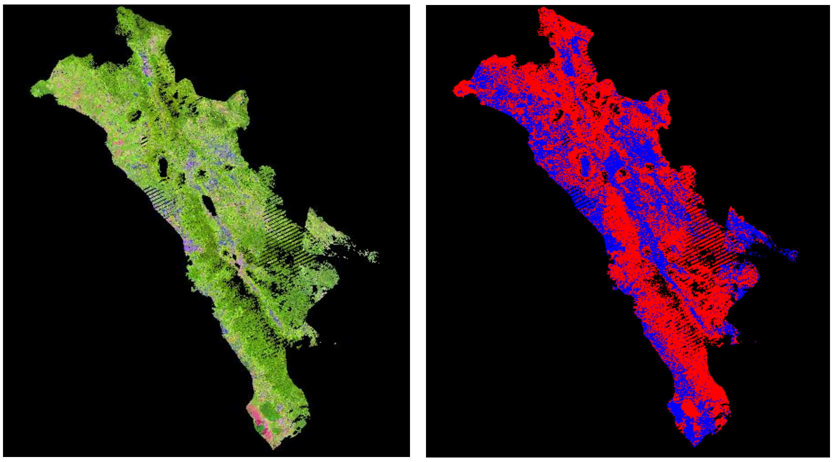


Figure 7. Landsat image of West Sumatera (left) in 543 RGB and the forest identification result (right) by using the obtained indices

If we zoom closer, we can see the pattern of forest more closely and how good the separation is as shown in Figure 8.

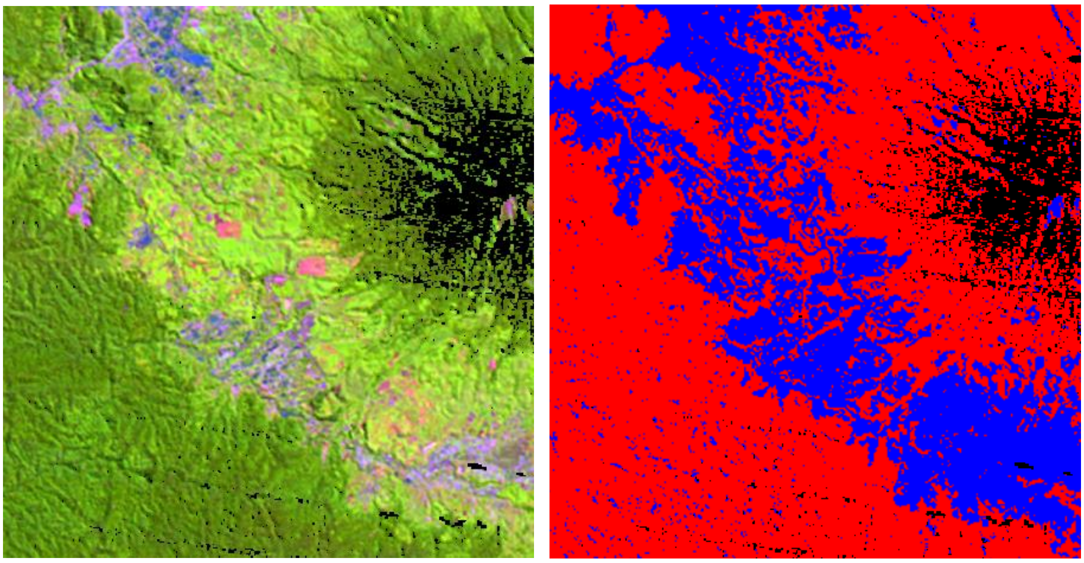


Figure 8. Landsat image of West Sumatera (left) in 543 RGB and the forest identification result (right) by using the obtained indices

The next step to test the classifier whether it can be used for multitemporal classification is by testing it to another time of data. In this case we use 2009 data of Landsat. And the threshold could be shifted to meet the separation between forest and non forest by using exactly the same indices.

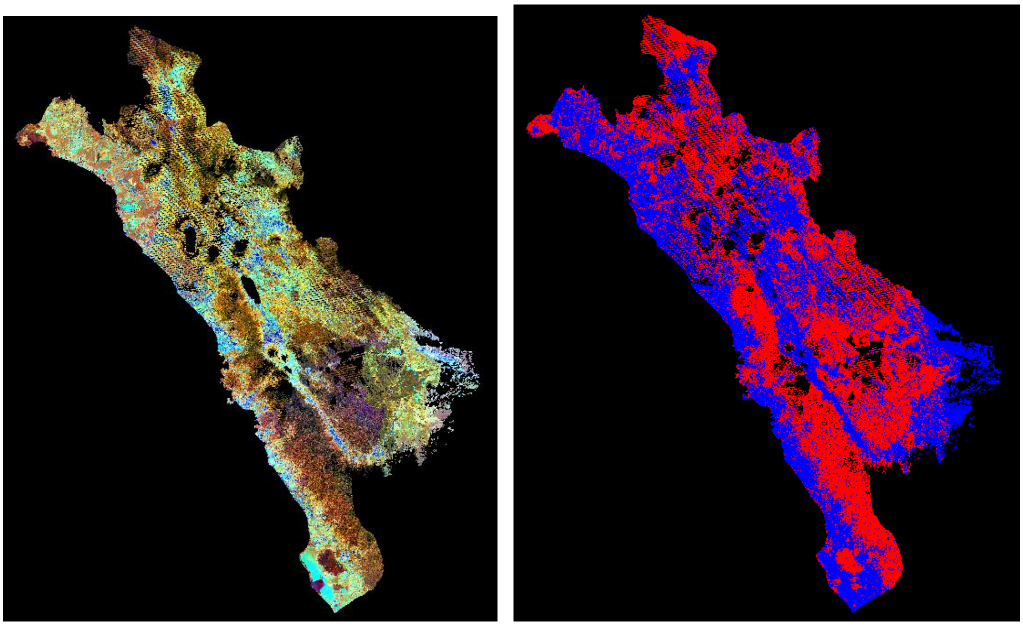


Figure 9. Landsat image of West Sumatera (left) in 453 RGB and the forest identification result (right) by using the obtained indices

If we zoom in to the closer places we can assess the separability visually as shown in Figure 10a until 10c.

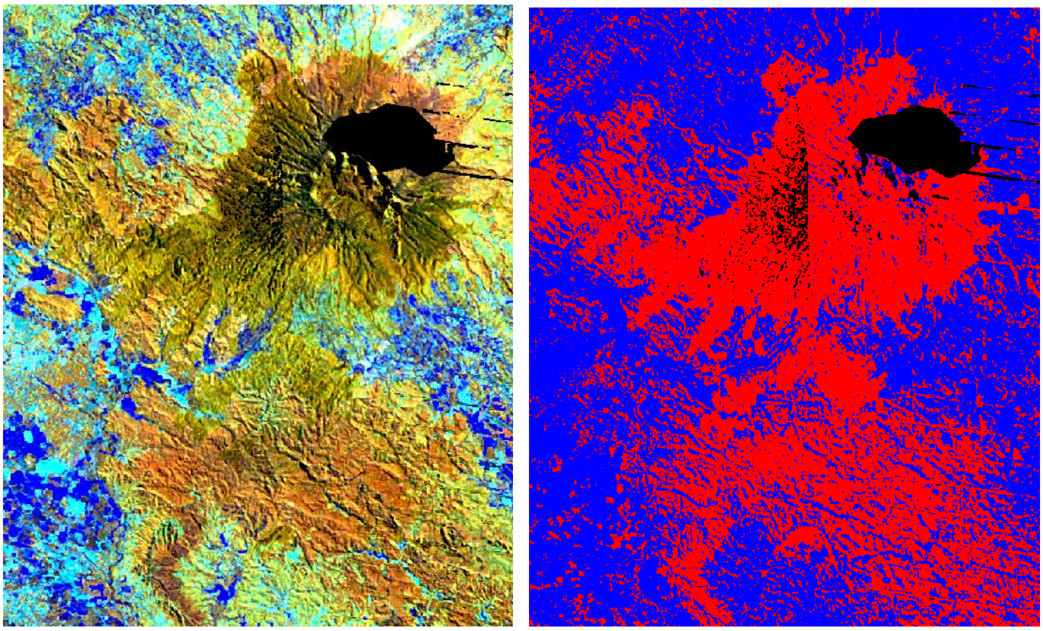


Figure 10a. Landsat image of West Sumatera (left) in 453 RGB and the forest identification result (right) by using the obtained indices

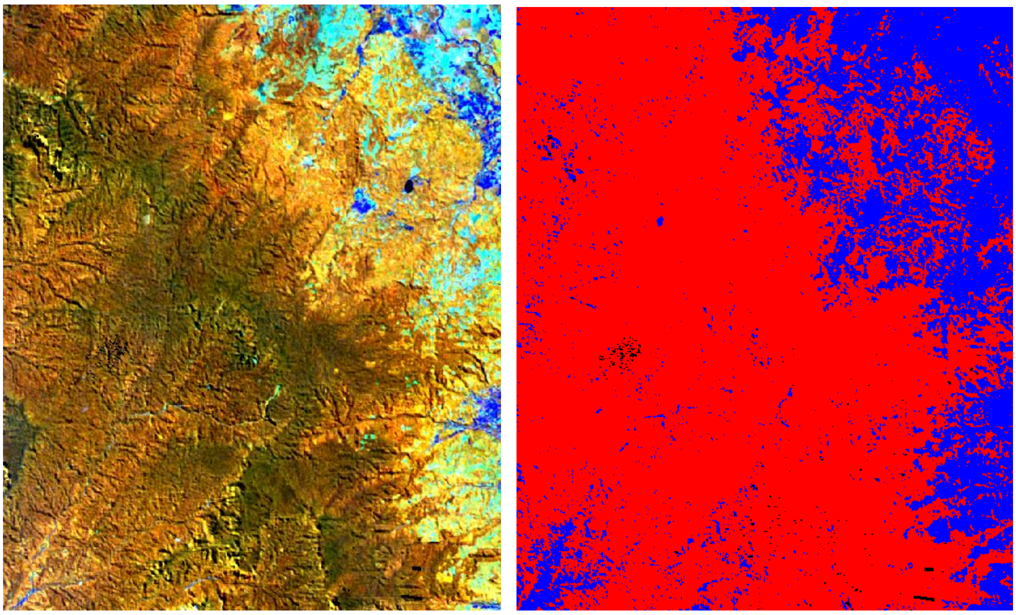


Figure 10b. Landsat image of West Sumatera (left) in 453 RGB and the forest identification result (right) by using the obtained indices

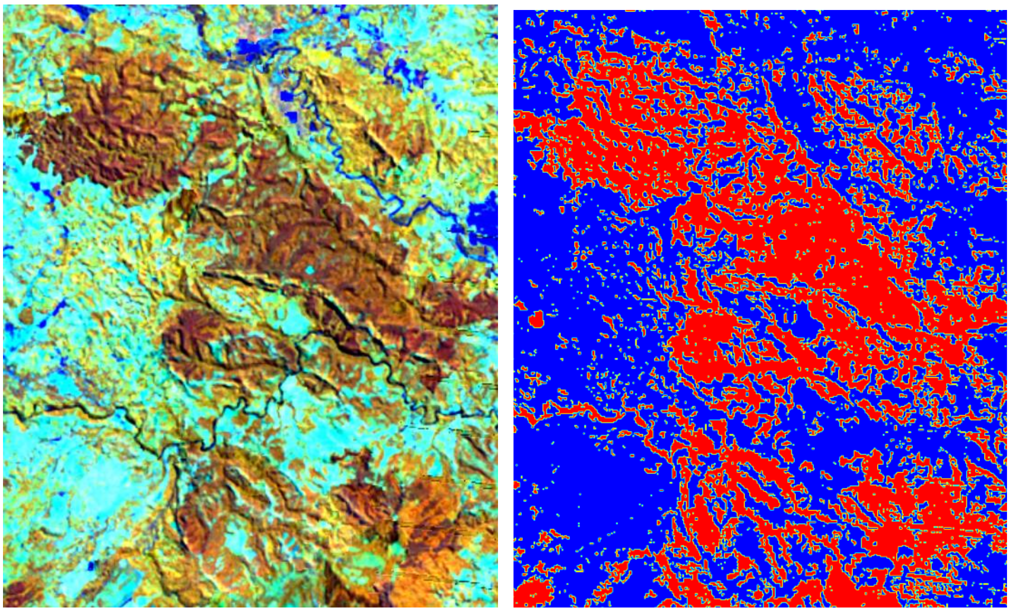


Figure 10c. Landsat image of West Sumatera (left) in 453 RGB and the forest identification result (right) by using the obtained indices

Discussion

Preprocessing stage is a very important stage where we prepare the data until the data is ready for the analysis. Starting from geometric correction, radiometric correction, sun correction, terrain illumination correction (topography correction), cloud masking and then we mosaic all the data within the same year.

From the result above obviously seen that it is possible to find the classifier for forest mapping which can be used in different time of the same type of data. In this case we derive a linear combination of bands to define classifier for forest identification. And the seperability can be assessed visually or digitally. We can use exactly the same indices from year to year of data just by shifting the threshold. And in the next stage multitemporal classification can be perfomed based on the indices that we have derived. From the multitemporal classification we can identify forest change (deforestation or revegetation) which is very important for carbon accounting system.

Acknowledgement

The Indonesian National Carbon Accounting System who has build the remarkable system which has so many reliable stages in making data preparation. For JICA to hold the symposium. And many thanks to Suzanne Furby for every knowledge that has been taught. And for LAPAN who has made the INCAS project run.

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STATUS OF MTSAT WILDFIRE DETECTION SYSTEM IN LAPAN

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The construction process of the system to detect hotspots using infrared (IR) data in LAPAN is presented. The system are processed in the SATAID system using the nighttime (11:00 - 20:00 UTC) IR channels' data of MTSAT received directly by LAPAN. Taking advantage of the geostationary meteorological satellite, the system can provide hotspots frequently and in real time. Hotspot detection algorithm and results of processing for bushfires in Palangkaraya, Indonesia in August 2012 are also presented. In addition to that, the results are displayed in the Google Earth.

Keywords**:** hotspot detection, MTSAT, IR channels, SATAID, LAPAN, Google Earth

Introduction

MTSAT-1R and -2 observe the earth globally for every hour. MTSAT's onboard 3.8μm channel (IR4) is suitable to detect wildfire since it has sensitivity in high temperature. However, the use of the channel is limited to night because energy observed in daytime contaminates both longwave and shortwave radiation. Nevertheless, information of wildfire obtained hourly in nighttime from MTSAT is useful to prevent the disaster caused by the wildfire.

We developed a method to extract hotspot data in nighttime by using all IR channels' data of MTSAT in the SATAID (Satellite Animation and Interactive Diagnosis) system. The method is based on the relation between brightness temperature difference between IR4 and IR1 and IR1 brightness temperature of a pixel covered by fire.

After the improvements were performed to increase detective accuracy and to use of SATAID data effectively, we built MTSAT wildfire detection system in LAPAN. In this paper, we introduce the process of developing the MTSAT wildfire detection system in LAPAN including hotspot detection algorithm. In addition to that, results of processing for bushfires in Palangkaraya, Indonesia are presented in both the SATAID and the Google Earth.

Process of the development of MTSAT wildfire detection system

We started to develop an algorithm to extract hotspots from MTSAT data by man-machine interactive processing in SATAID system in 2009. The core of SATAID system is GMSLPW and LRITAPL. GMSLPW is a viewer program to display satellite imagery and other data. It has many functions such as making vertical cross-section chart and time-series chart, and outputting digital data to a CSV file. We added a function for extracting hotspots in GMSLPW. Using the function, we can get the distribution of hotspots colorized by the confidence level as shown in Figure 1.

In 2010, we developed the same monitoring system (MODIS-SATAID) using MODIS data. Firstly, MOD021KM-Level1B data received from LAADS is converted to the SATAID formatted data. Next, hotspots data extracted by MOD-14 are visualized in the MODIS-SATAID system. Auxiliary data such as land cover characterization are also visualized in the system. An example is shown in Figure 2. In this way, we enable comparing hotspots of MTSAT with those of MODIS. Concerning to MTSAT, we installed the software to convert MTSAT HRIT data received in LAPAN to SATAID data in windows PC. And then, we installed the software to extract hotspots data from MTSAT data by man-machine interactive processing in SATAID in LAPAN.

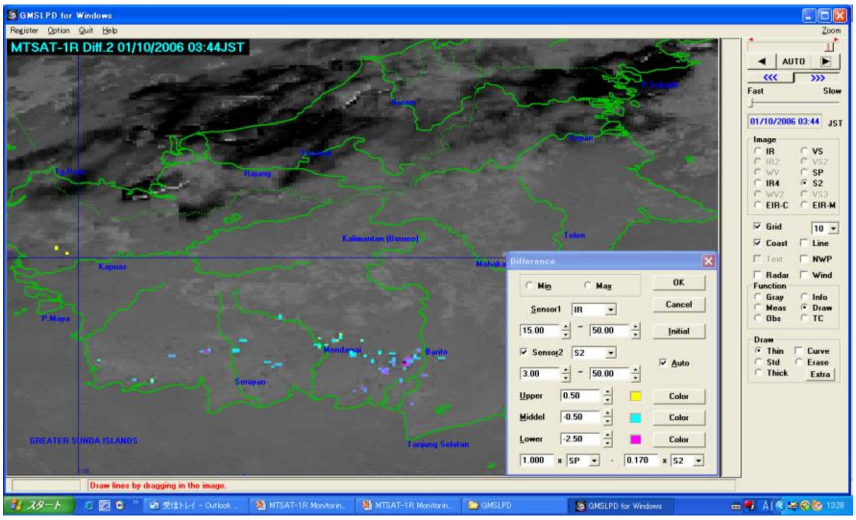


Figure 1. Example of extracting hotspots from MTSAT image in SATAID

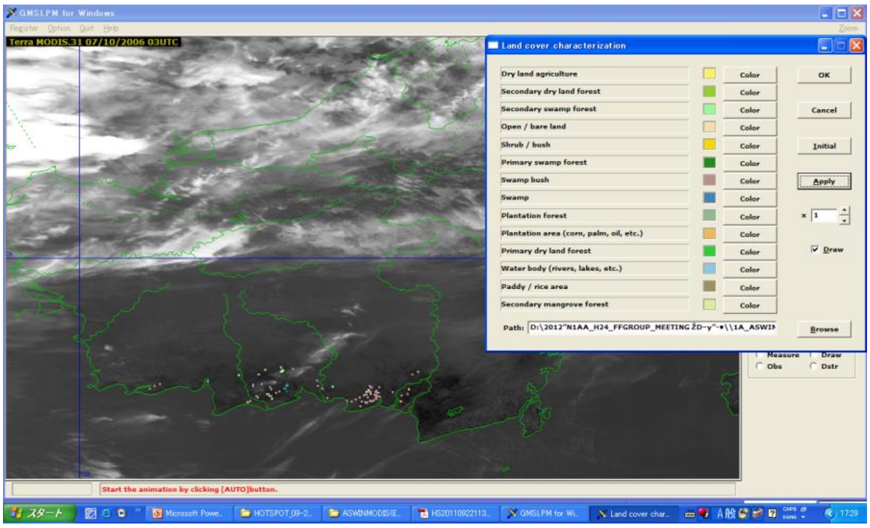


Figure 2. Example of displaying hotspots from MODIS image including surface classification in MODIS SATAID

In 2011, we developed MTSAT wildfire detection system which has the following functions.

- Realization of the automatic processing by the Windows task scheduler.
- MTSAT HRIT data received in LAPAN is automatically converted to SATAID data, Png. images, and simplified floating data.
- Extract hotspots data automatically and store the information of hotspots data such as the position (latitude and longitude), the temperature of IR1, IR2, IR4 and reliability (%) in a file of the Excel format.
- Land and sea judging processing is added and data over land is processed.

The system has been worked since September 20, 2011 in LAPAN.

In 2012, we get ready to display hotspots data on web. We made software to convert the file of the Excel format to the file of the KML format. It enables displaying hotspots data in the Google Earth.

Algorithm

The algorithm to extract hotspots is the same as the algorithm of hotspot detection in the Sentinel Asia developed by M. Tokuno (Kaku and Tokuno, 2010), which is presented schematically in Figure 3. The method is based on the relation between brightness temperature difference (BTD) between IR4 and IR1 (IR4-IR1) and IR1 brightness temperature of a pixel covered by fire. If a fire happens, the fire pixel shows an increase in radiation of IR4 than that of IR1. For example, if only 5% of the pixel is at 500 K and the other at 300 K, BTD between IR4 and IR1 is 40 K (Weaver, J.F. et. al., 1995). Thus, on a clear day the fire pixel can be extracted relatively easy by using BTD (IR4 - IR1).

However, cirrus typically occurs in the equatorial region, and it is difficult to discriminate completely fire pixels from cirrus pixels. Therefore, it is proposed to extract hotspot pixels with confidence level shown in Figure 4. If α shown in Figure 3 is lower, then the confidence level, i.e. a possibility that a detected hotspot is a fire, becomes higher, and if α is higher, then it becomes lower.

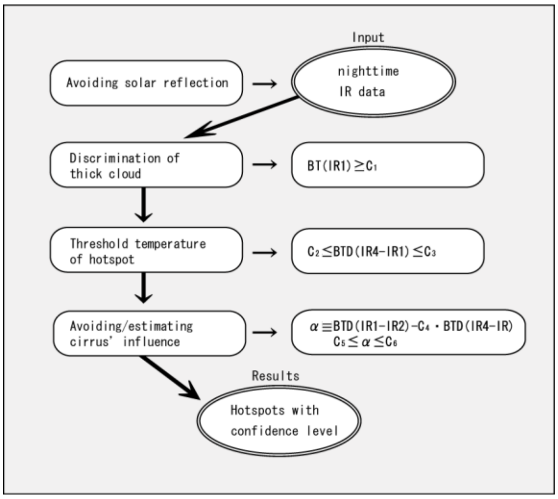


Figure 3. Schematic diagram of hotspot detection algorithm (from Kaku and Tokuno, 2010)

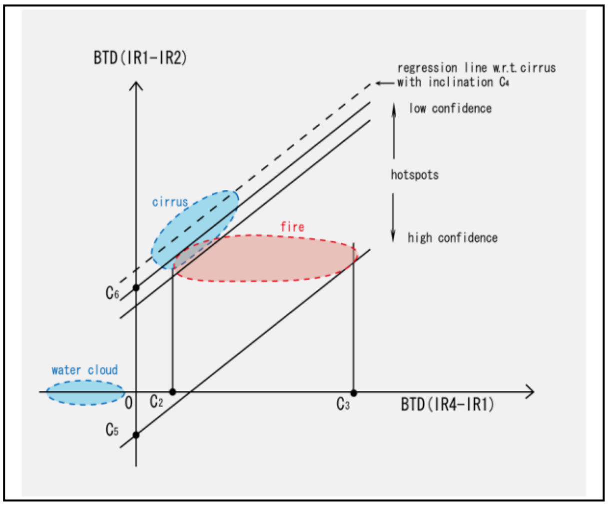


Figure 4. Schematic illustration of cirrus pixels, fire pixels, etc. on scatter diagram (from Kaku and Tokuno, 2010)

System at LAPAN

HRIT data of MTSAT is received directly and converted to HiRID data in LAPAN by using the Dartcom LRIT/HRIT systems (http://www.dartcom.co.uk). After that, full disk images and partial images including Indonesia are produced and archived as shown in *Figure 5*. MTSAT wildfire detection system is placed in near Dartcom system in order to be able to use HRIT data easily in the MTSAT wildfire detection system. The conceptual diagram is shown in Figure 6.

MTSAT wildfire detection system

Processing flow of MTSAT wildfire detection system is shown in Figure 7. The system has two main functions. One is to produce image data in CnvSataid.vbs. HRIT files divided into ten segments are combined and one full disk image called as HiRID file is produced. Sataid data file, sataid png image file, and sataid raw data file are made by HiRID file. The other is that hotspots are extracted and stored to a CSV file in ExeSataid.vbs. An example of hotspots data of the CSV file is shown in Figure 8. The following information of each hotspot is stored; number, location (latitude and longitude), brightness temperature (IR1, IR2, and IR4), and probability (%).

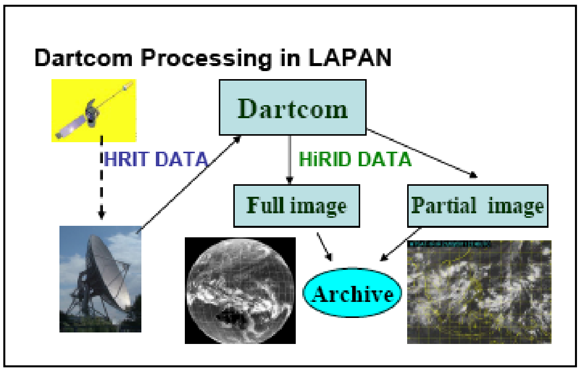


Figure 5. Schematic diagram of Dartcom processing

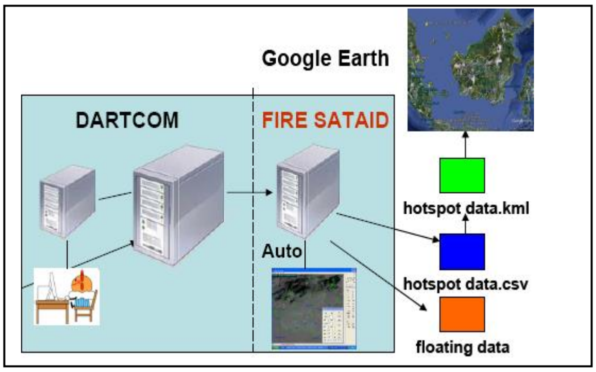


Figure 6. Schematic diagram of MTSAT wildfire detection system

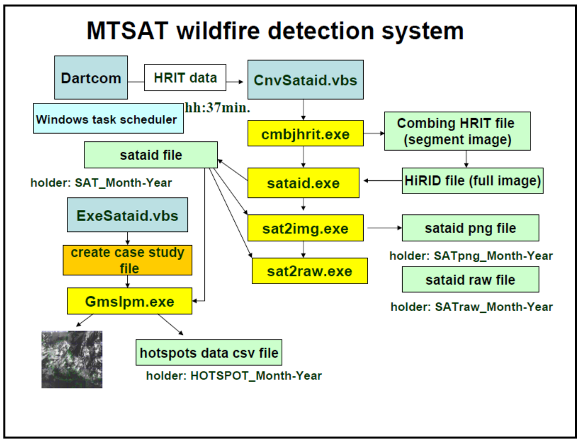
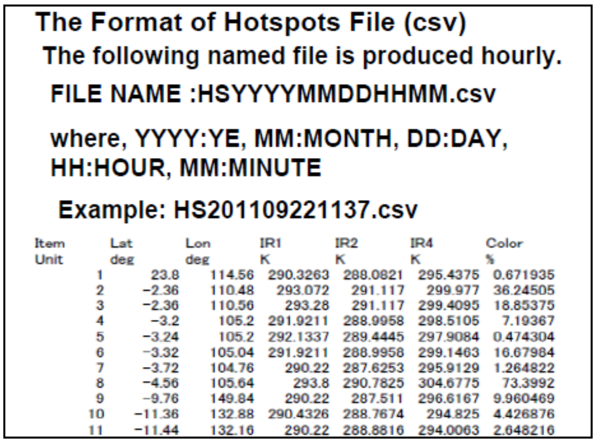


Figure 7. Processing flow of MTSAT wildfire detection systerm


The Format of Hotspots File (csv)

The following named file is produced hourly.

FILE NAME :HSYYYYMMDDHHMM.csv

where, YYYY:YE, MM:MONTH, DD:DAY, HH:HOUR, MM:MINUTE

Example: HS201109221137.csv

Item	Lat	Lon	IR1	IR2	IR4	Color
Unit	deg	deg	K	K	K	%
1	23.8	114.56	290.3263	288.0821	295.4375	0.671935
2	−2.36	110.48	293.072	291.117	299.977	36.24505
3	−2.36	110.56	293.28	291.117	299.4095	18.85375
4	−3.2	105.2	291.9211	288.9958	298.5105	7.19367
5	−3.24	105.2	292.1337	289.4445	297.9084	0.474304
6	−3.32	105.04	291.9211	288.9958	299.1463	16.67984
7	−3.72	104.76	290.22	287.6253	295.9129	1.264822
8	−4.56	105.64	293.8	290.7825	304.6775	73.3992
9	−9.76	149.84	290.22	287.511	296.6167	9.960469
10	−11.36	132.88	290.4326	288.7674	294.825	4.426876
11	−11.44	132.16	290.22	288.8816	294.0063	2.648216

Figure 8. An example of the hotspots CSV file

Test operation

A test operation is carried out for bushfires in Kalimantan, Indonesia in August 2012. We can detect four hotspots by MTSAT visible image (Figure 9-A) at 09 UTC August 14, 2012. Smokes from fires are clearly seen in visible image. Two hours later, those four hotspots are clearly detected as high brightness temperature in IR4 image (Figure 9-C), although they aren’t detected in IR1 image (Figure 9-B). As a result, MTSAT hotspots are clearly classified by colour as shown in Figure 9-D.

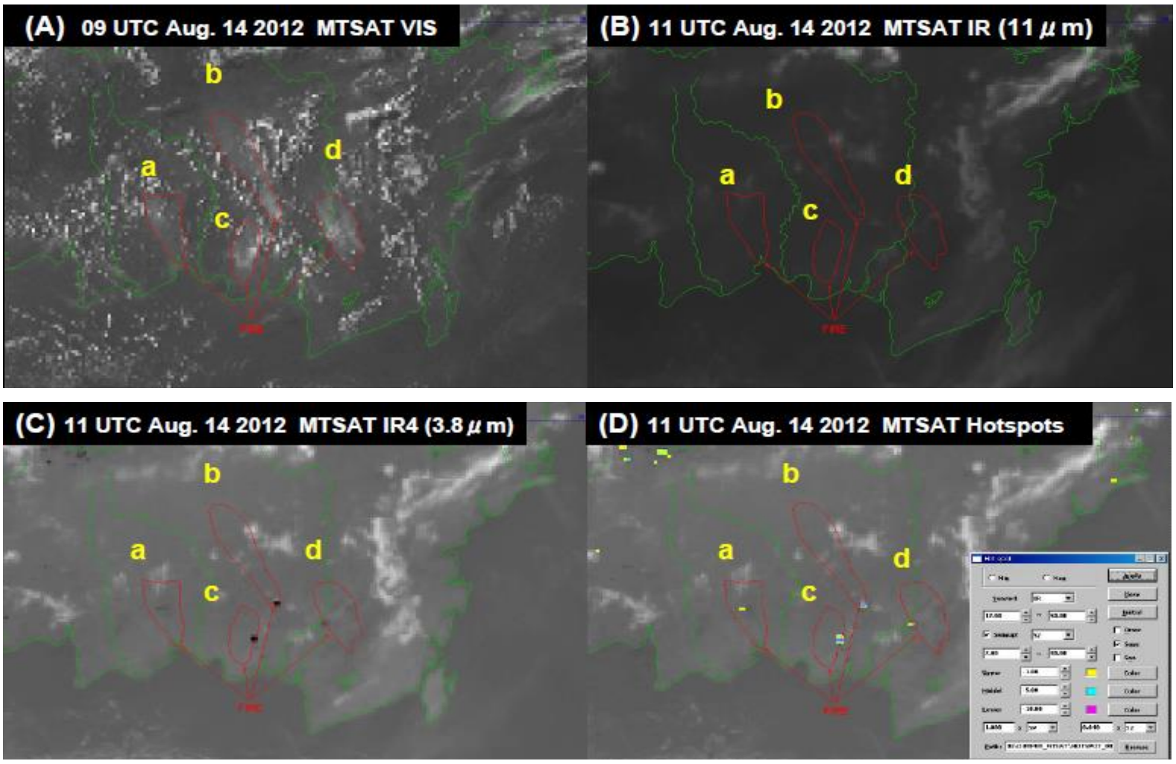


Figure 9. Example of extracting MTSAT hotspots in Parankalaya, Indonesia

Furthermore, we can extract MTSAT hotspots successively as shown in Figure 10. It enables monitoring the situation of the fire successively.

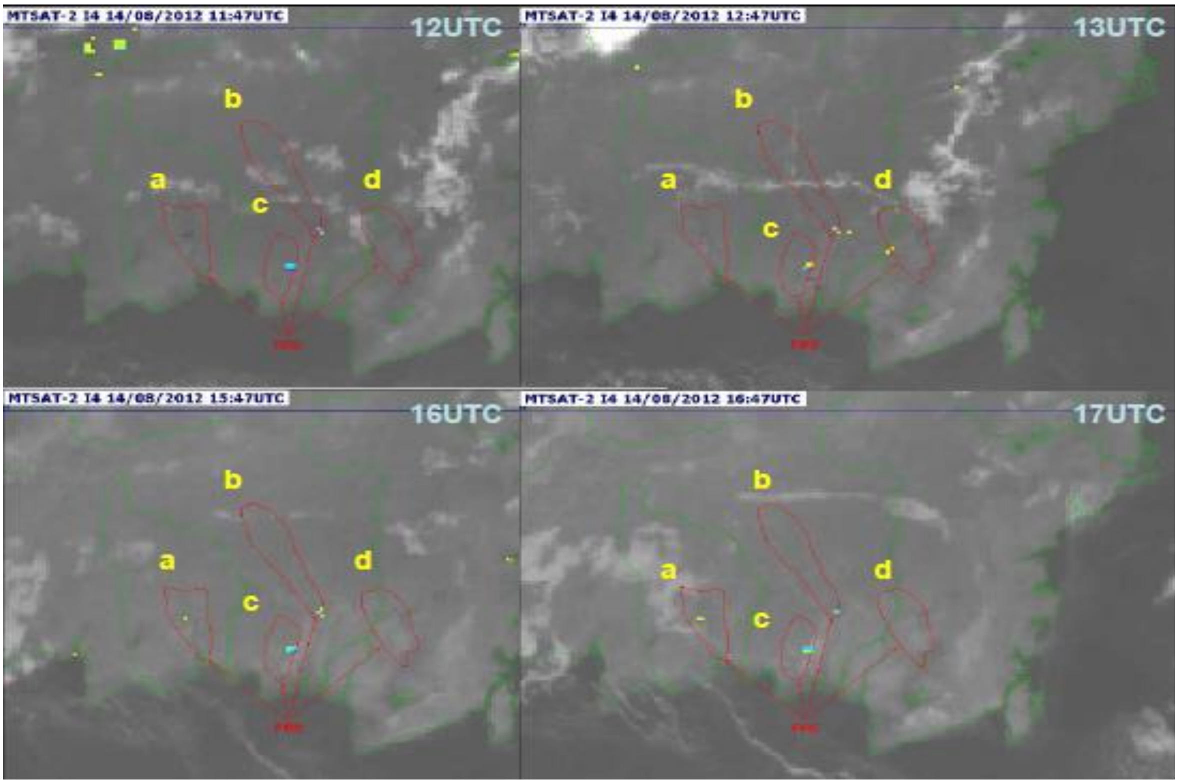


Figure 10. MTSAT hotspots at 12, 13, 16, 18 UTC August 14, 2012

Use of hotspots data with the Google Earth

We developed software in which the hotspot CSV file is converted to the KLM file. It enables monitoring MTSAT hotspots easily in the Google Earth. As an example, we can see the information of hotspots with possibility as shown in Figure 11. Also, we can monitor the distribution of hotspots with topography as shown in Figure 12.

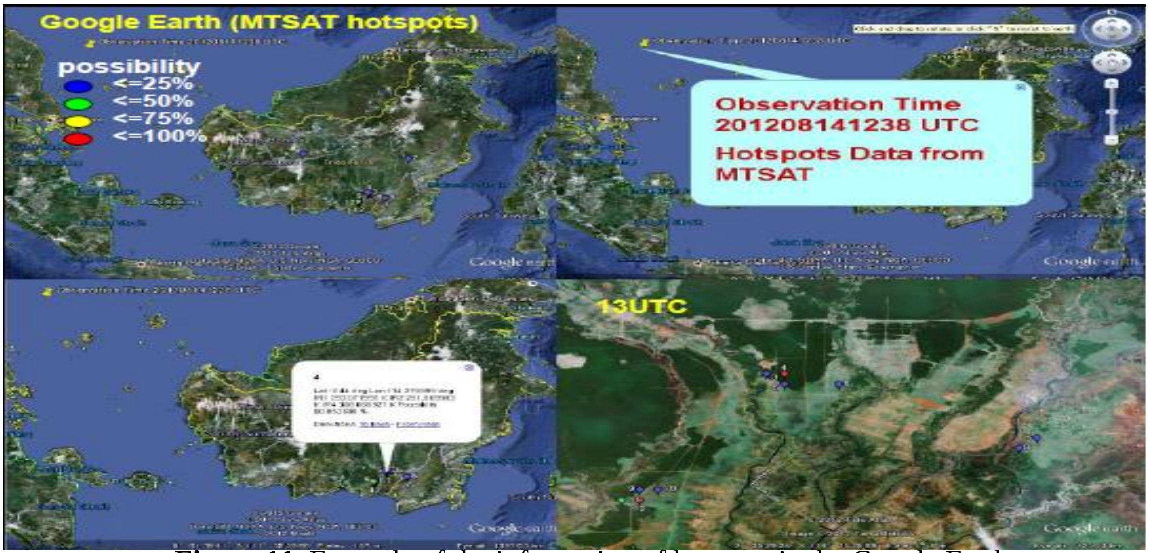


Figure 11. Example of the information of hotspots in the Google Earth

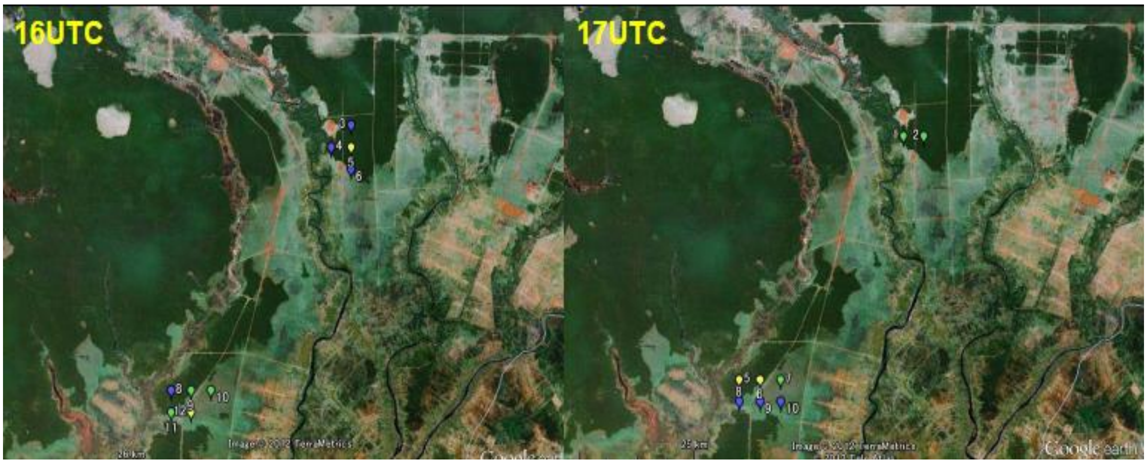


Figure 12. Monitoring the distribution of hotspots in the Google Earth

Conclusions

An automatic hotspot detecting system which uses MTSAT infrared data received directly in LAPAN has been developed. An algorithm for detecting hotspots based on a simple absolute threshold method has been applied. MTSAT hotspots are characterized by high frequency of observation with relatively large spatial resolution. To monitor MTSAT hotspots easily, a method to show MTSAT hotspots in the Google Earth has been developed. In the future, an automatic hotspot monitoring system on Web will be developed in LAPAN.

Acknowledgement

Many thanks to Mr. Masaru Sasaki, JMA for providing lot of useful technical assistance for completion of work.

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MECHANICAL-QUALITY EVALUATION FOR YOUNG PLANTATIONS OF SHOREA BALANGERAN

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We tried the tree bending test to make evaluation for the modulus of elasticity (MOE) of tree trunks of *Shorea balangeran*. Comparing the MOE obtained from the tree bending test and longitudinal vibration test on log specimens, the tree bending test could be used for nondestructive evaluation for mechanical-quality of *S. balangeran* plantation in early stages.

Keywords: *Shorea balangeran*, tree bending test, modulus of elasticity, no-destructive test

Introduction

Tropical peat swamp forests in Southeast Asia which contribute carbon stock, biodiversity and lumber resource, have become barren area by logging and development. Therefore, reforestation is an important task. *Shorea balangeran*, an indigenous tree species of dipterocarpaceae, is considered to be a promising species for the plantation in peat swamp forest of Kalimantan, because of its high resistance against waterlogged condition and strong light (Saito *et al*. 2011, Takahashi *et. al.* 2006, Takahashi *et al.* 2002, Shibuya *et al.* 2007). In addition, its wood, one of the primary sources of red meranti, is known to be strong enough for structural use. Wood of a planted tree was found to have the same performance as that of natural regenerated sources (Koide et al. 2011). However, there will be great variability in mechanical properties within a species. So it is desirable to evaluate the mechanical quality of the sources nondestructively in their early stages to get high quality wood.

We tried the tree bending test (Koizumi et al. 1986) to make a nondestructive evaluation for the MOE of tree trunks for young planted trees. The aim of this study is to validate the reliability of the MOE evaluated by the tree bending test. In addition, the MOE of tree trunks of two species (*Combretocarpus rotondatus*, *Melaleuca leucadendron*) were evaluated and we compared the MOE among sites and species.

Materials and Methods

Study sites are 5 plantations around Palangka Raya, Central Kalimantan, Indonesia. Fifty three trees of 3 species, *Shorea balangeran, Combretocarpus rotondatus, Melaleuca leucadendron* were tested (Table 1). The modulus of elasticity (MOE) for sample trees was evaluated by the tree bending test (Koizumi et al. 1986).

Table 1. Study sites and material data

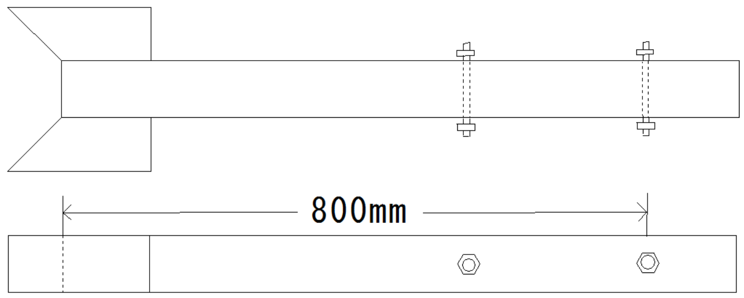
Site	Species	Number of Sample Trees	Age (year)	Height(cm)		DBH(mm)		MOE of Trunks (GPa)	
				Mean	S.D.	Mean	S.D.	Mean	S.D.
UNPAR1	*S. balangeran*	6	10	–	–	97.6	10.1	12.9	1.25
UNPAR2	*S. balangeran*	3	6	–	–	94.8	11.4	11.8	1.59
Kapuas Border	*S. balangeran*	10	10	–	–	83.4	12.0	11.8	2.82
Taruna Nursery	*S. balangeran*	10	7	572.4	74.5	77.5	11.8	13.6	2.01
Taruna Nursery	*C. rotondatus*	10	6	669.1	98.1	89.8	18.9	9.1	1.95
Moyai plantation	*S. balangeran*	10	7	802.5	154.9	124.7	38.4	12.1	3.20
Moyai plantation	*M. leucadendron*	5	7	764.6	40.5	89.9	11.1	7.9	1.63

Method and tools for the tree bending test are shown in Figs.1-3. A gauge sensor of 5mm stroke (Kyowa DTH-A-5) was set at center of a middle-ordinate gauge. We set up a middle-ordinate gauge at 80-160 height of a tree trunk. A lever arm was set above the middle-ordinate gauge (Figure 3). Bending moment was evoked by applying downward force at the tree end of the lever arm. Force and displacement were recorded in a dynamic strain recorder. The measurements are made twice per tree in two directions at the right angles to each other. Perimeter of trunk at breast height and base of a lever arm were measured. In addition, bark thickness of a breast height was measured by inserting a calibrated driver. The MOE of tree trunks was calculated using Eq. 1.

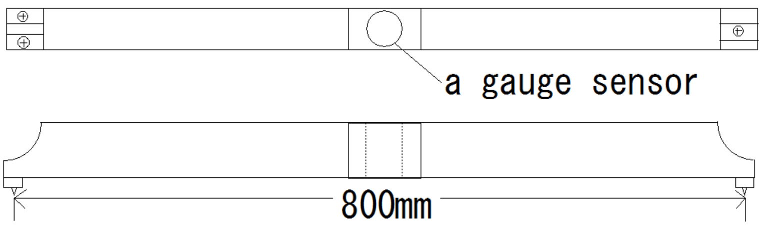
$$MOE = \frac{s^2 F(L_1 + r_{170})}{2\pi\delta(r_{120} - t_b)^4} \quad . \quad . \quad . \quad . \quad (1)$$

MOE: the modulus of elasticity of tree trunk
s: a middle-ordinate gauge length
F/δ: calculated young modulus using force and stem deflection
L_1: a lever arm length
r_{170}: radius at 170 height of a tree trunk
r_{120}: radius at 120 height of a tree trunk
t_b: bark thickness

After the bending tree test, total 9 trees from UNPAR1, UNPAR2, Kapuas Border were felled at the height of 10 cm. Five 500 mm long logs were cut from the butt end of the felled tree in sequence and the MOE of logs were evaluated by longitudinal vibration method.



a) lever arm



b) middle-ordinate gauge

Figure 1. Device for the tree bending test

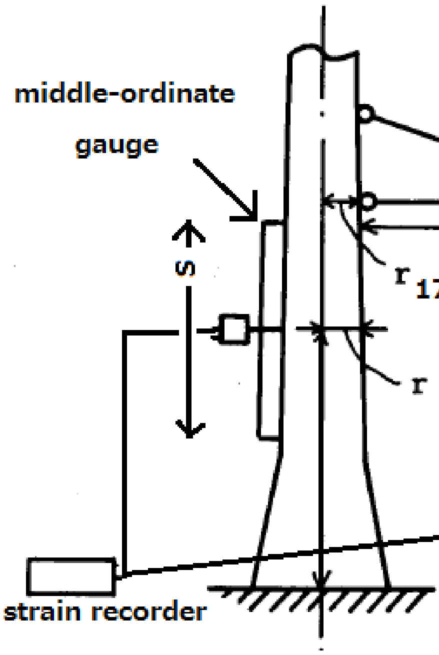


Figure 2. Schematic diagram of the tree bending test

Figure 3. The tree bending test on a trunk of *Shorea balangeran*

Result and Discussion

Reliability of the MOE evaluated by the tree bending test

High linear (elastic) relation was found between applied force and stem deflection in the tree bending test (Figure 4). Furthermore, significant positive correlations were found between the MOE of tree trunks and dynamic MOE of logs (R^2=0.89) (Table 2) (Figure 5). So the MOE of tree trunks can be evaluated by the proposed the tree bending test. The tree bending test could be regarded as nondestructive evaluation method of mechanical-quality for plantation trees in their early stages.

Table 2. Static MOE of tree trunk and dynamic MOE of logs

ID	Site	Age (year)	DBH (mm)	MOE of tree trunk(GPa)	MOE of the log (GPa)
KB1	Kapuas Border	10	104.5	18.5	16.0
KB2	Kapuas Border	10	62.7	13.0	12.4
KB3	Kapuas Border	10	92.7	11.8	10.7
KB4	Kapuas Border	10	81.8	11.1	11.6
KB5	Kapuas Border	10	81.8	14.3	13.3
KB6	Kapuas Border	10	77.1	12.0	12.2
C-1	UNPAR1	10	109.9	12.5	11.2
J824	UNPAR2	6	91.1	13.6	11.7
J877	UNPAR2	6	110.2	9.7	9.8

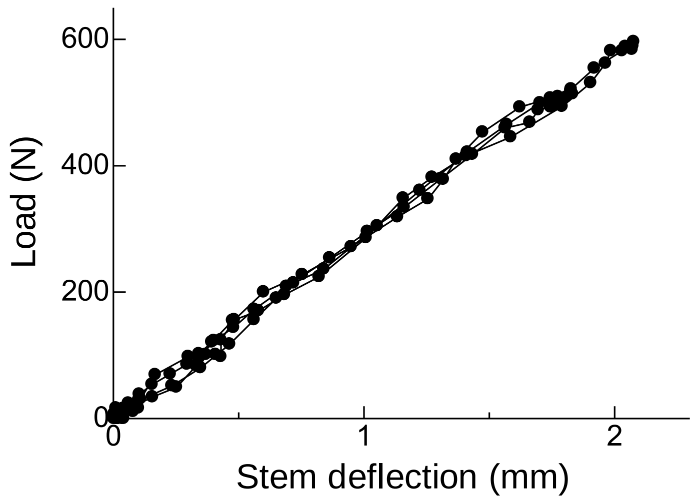


Figure 4. An example of relationship between load and stem deflection

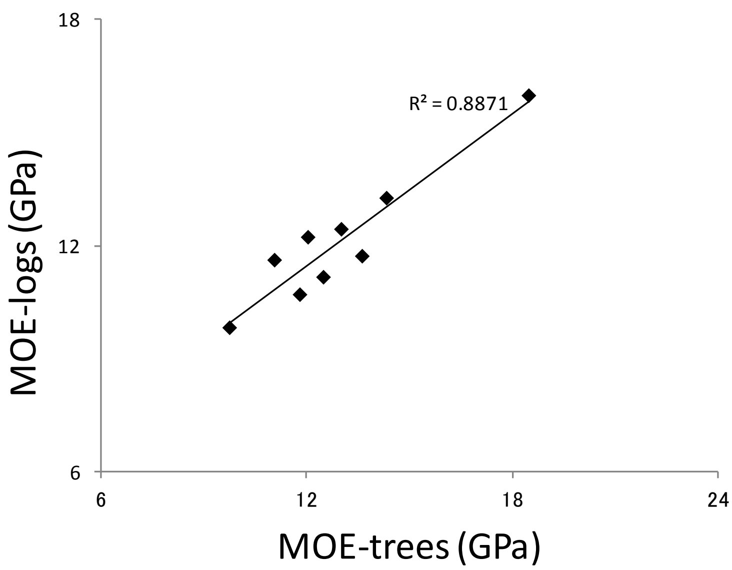


Figure 5. Correlation between the MOE of tree trunks and dynamic MOE of logs

MOE variation of tree trunks of S. balangeran among sites

No difference in the MOE was found among sites of *S. balangeran* which have different ages (Table 1) (Figure 6). The result suggested that *S. balangeran* has little mechanical quality variation within a juvenile wood.

The MOE of tree trunks showed negative correlation with DBH in Moyai site. It might be attributed to small wood density caused by rapid growth. Further research for the wood density is necessary.

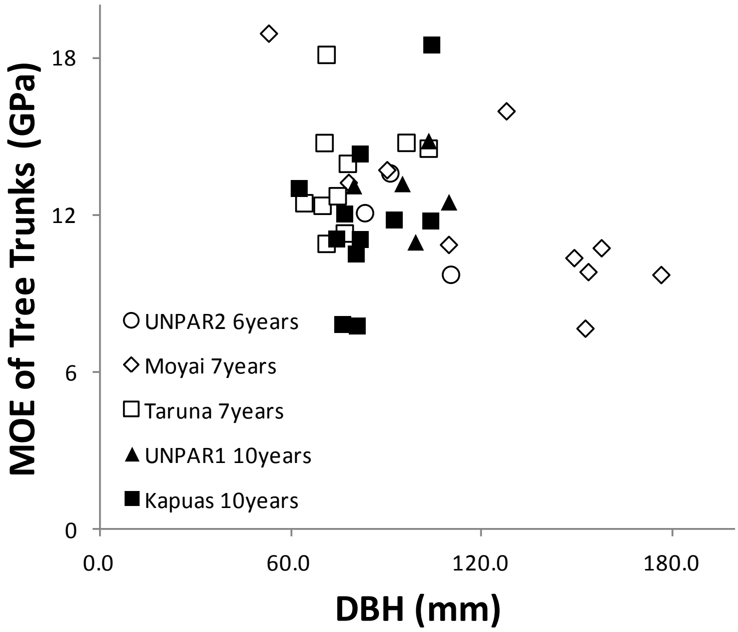


Figure 6. MOE variation of tree trunks of *S. balangeran* among sites

MOE variation of tree trunks among tested 3 species

S. balangeran has comparatively high MOE of tree trunks among 3 species (Table 1) (Figure 7). In addition, tree form of *S. balangeran* was more straight than other 2 species, which is suitable for lumber use. The result indicates the high applicability of *S. balangeran* wood for structural use.

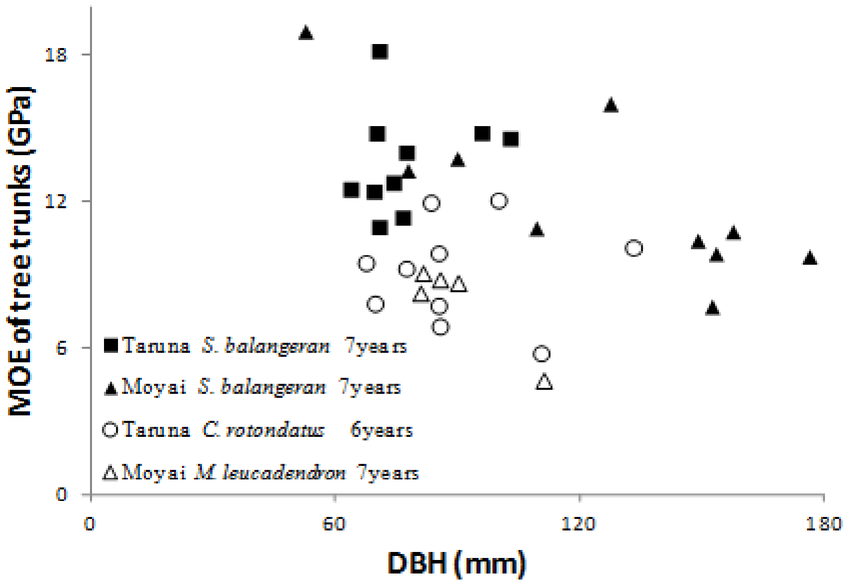


Figure 7. MOE variation of tree trunks among tested 3 species

Conclusions

1. The tree bending test could be used for nondestructive evaluation for mechanical-quality of *S. balangeran* plantation in early stages.
2. *S. balangeran* trees showed no significant difference in MOE among tree ages of 6 to 10 years, which suggested little quality variation within juvenile wood. Furthermore, *S. balangeran* has comparatively high MOE of tree trunks and straight trunk form among 3 tested species. Therefore, *S. balangeran* is considered to be a promising species for production lumber for structural use.

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MONITORING FOREST THREATS WITH C- AND L-BAND SAR, LANDSAT, AIRBORNE LIDAR AND ORTHO-MOSAICS: A CASE STUDY IN SABANGAU NATIONAL PARK (CENTRAL KALIMANTAN)

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We evaluated the potential of ALOS/PALSAR and the ASAR/ENVISAT for the monitoring of forest threats (i.e. by forest logging and deforestation). As a test site we selected the Sabangau National Forest (SNF) located in Central Kalimantan (Indonesia). In the period of April 2007 and April 2011 all available quad-polarization PALSAR and dual-polarization ASAR were selected for this investigation. The motivation was the availability of airborne Light Detection And Ranging (LiDAR) acquired on August 2007 and 2011 as well as high spatial resolution aerial Hasselblad photographs from August 2011 that were used for validation purposes. Relatively large deforested areas were identified from 2009 to 2011. Landsat was unable to detect early deforestation stages due to the frequent cloud coverage bringing late response in a simulated deforestation system. LiDAR derived Canopy Height Model (CHM) and high resolution photographs were useful for the identification of small threats in the forest caused by illegal logging and hunting practices. Small degradation patches were not detected in either SAR or Landsat data. We argue that the joint analysis of SAR with optical data and airborne LiDAR and orthorectified photographs performs even better forest monitoring and thus encourage the further development of joint techniques. The techniques here reported will be improved under the recent "Reducing Emissions from Deforestation and Degradation" (REDD+) protocols.

Keywords**:** Peat Swamp Forest, forest monitoring, SAR, REDD.

Introduction

Tropical peat swamp forests (PSF) are known for their rich biodiversity and underground carbon reservoir (Page et al., 2002). Extensive oil palm and acacia plantations, forest logging and excessive drainage contribute for the current decreasing of this particular ecosystem. As a result, high release rates of CO_2 into the atmosphere by peat degradation have been reported (Sorensen 1993, Page et al., 2002, Jaenicke et al. 2008). Therefore, there is need for a continuous monitoring of these endangered environments.

In PSF environments the great variety of tree species and its ecological rule is still not fully understood (Dommain et al., 2010). The influence of PSF degradation on regional change issues also remain a big challenge. Consequently, a better understanding of how remote sensing measurements can be used for ecological studies in such critically endangered forests is still necessary.

Landsat scenes have been acquiring information in the tropics since the early 1970s. However, optical data deliver measurements of the topmost of the vegetation cover and are strongly dependent on atmospheric conditions (e.g. haze, smoke and clouds). The frequent cloud and haze coverage in PSF environments may limit the number of cloud-free imagery.

On the other hand, Synthetic Aperture Radar (SAR) systems have the advantage of providing systematic, cloud-free observations of the earth surface. SAR may provide unique information on forest enabling the characterization of the canopy architecture with scattering mechanism.

Yet, the advantages of the integration of both optical and SAR data with airborne Light Detection and Ranging (LiDAR) for forest monitoring are also still novel.

In this investigation, we evaluated the potential of the Advanced Land-Observing Satellite (ALOS) on board the Phased Array L-band Synthetic Aperture Radar (PALSAR) and the Advanced SAR (ASAR; C-band) on board the Environmental Satellite (ENVISAT) for the monitoring of forest threats (i.e. by deforestation and degradation). Additionally we complement the analysis with Landsat, aerial orthorectified photographs and airborne LiDAR data.

Study Area Description

Our study area consists on a subset of the *Sabangau* National Park (SNP) (Figure 1). Some transects inside this areas were also surveyed by airborne LiDAR technology during August 2007 and 2011. The PSF over the region were impacted with extensive logging activities in the 90s and by the implantation of the Ex-Mega Rice Project (EMRP). The failed EMRP with its 4000km channel system leads to severe peat damages with reasonable amount of carbon released to the atmosphere, especially during peat fires in 1994, 1997, 2002, 2006 and 2009.

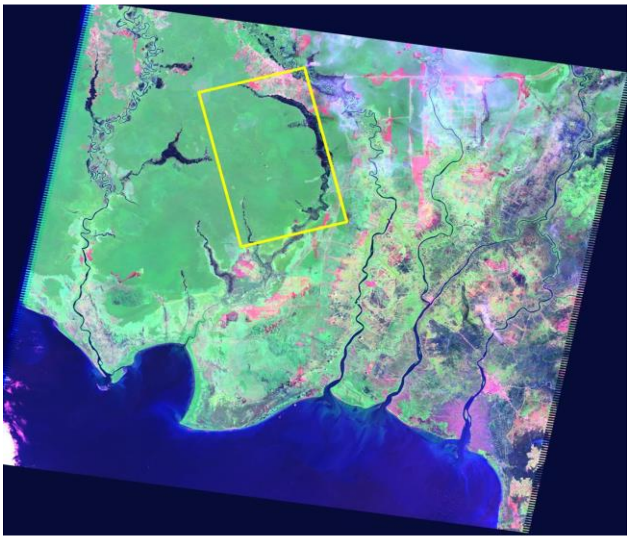

Figure 1. Landsat scene acquired on February 10, 2010.
The yellow square indicates the location of the study area.

Material and Methods

In the period of April 2007 and April 2011 all available quad-polarization PALSAR and dual-polarization ASAR were selected for this investigation. The motivation was the availability of airborne Light Detection and Ranging (LiDAR) acquired on August 2007 and 2011 as well as high spatial resolution aerial Hasselblad photographs from August 2011 that were used for validation purposes.

The SAR data were multi-looked, geocoded at a spatial resolution of 30m and finally converted to backscattering coefficients. Polarimetric features, decomposition techniques and interferometric coherence were also extracted from the datasets. During the above mentioned period all cloud-free Landsat-5/TM and Landsat-7/ETM+ images were selected.

The Landsat images were atmospherically corrected and converted into surface reflectance. A visual interpretation over the Landsat and SAR scenes taking into account the temporal changes in both reflectance and the backscattering coefficients were analysed. Additionally, variations of the scattering mechanism (i.e. surface or volumetric scattering) were performed over the PALSAR scenes. Since an effective monitoring system at a regular basis does not exist in Central Kalimantan, a simulation of the presence and absence of optical Landsat according to the SAR datasets for a PSF monitoring was then proposed.

Results and Discussion

Figure 2 shows the four available quad-polarization ALOS/PALSAR scenes during the period of April 2007 and 2011. According to the scenes presented in this figure, relatively large deforested areas can be visually identified from 2009 to 2011 (Figure 2c).

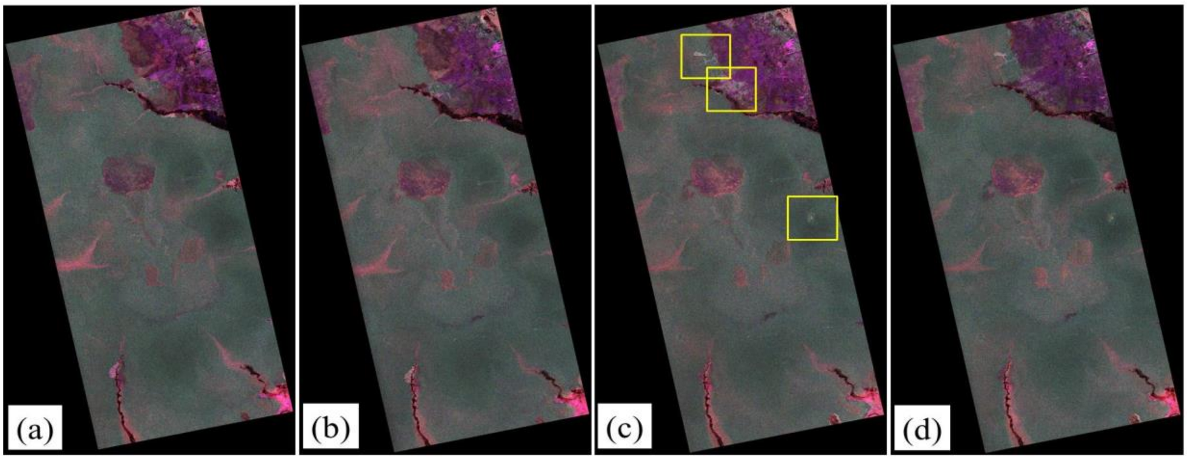

Figure 2. ALOS/PALSAR scenes ($R\sigma^0_{HH}G\sigma^0_{HV}B\sigma^0_{VV}$) acquired on April 3, 2007 (a), April 8, 2009 (b), January 12, 2011 (c), and April 14, 2011 (d). The yellow square indicates the earliest three major possible SAR detection of deforestation

The lowest square polygon presented in Figure 2 (i.e. *Bakung* watershed) is shown in more detail in Figure 3. Relatively large deforested areas were identified only with SAR scenes from 2009 to 2011. Landsat was unable to detect early deforestation stages due to the frequent cloud coverage bringing late response in a simulated deforestation system as shown in Figs. 2a, 2d. However, the deforestation event could be detected and monitored with SAR scenes.

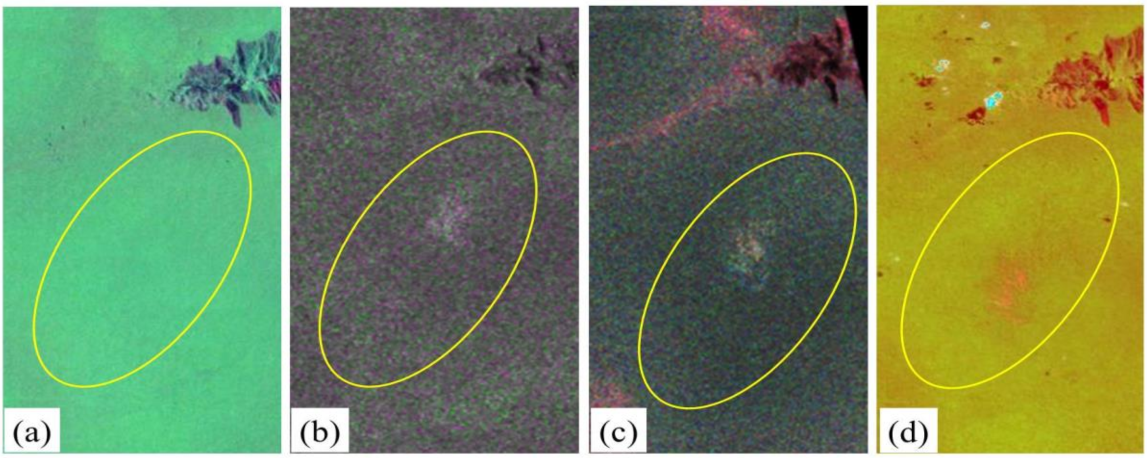

Figure 3. Subsets of the TM/Landsat-5 acquired on February 10, 2010 (a), ASAR/ENVISAT (C-band; $R\sigma^0_{VV}G\sigma^0_{VH}B\sigma^0_{VH-VV}$) on November 08, 2010 (b), ALOS/PALSAR (L-band; $R\sigma^0_{HH}G\sigma^0_{HV}B\sigma^0_{VV}$) on January 12, 2011 (c) and ETM+/Landsat-7 on June 13, 2011 (d). The yellow ellipse shows the deforestation path.

The ever first clear evidences of forest threats at the *Bakung* watershed were noticed on summer 2009 with ASAR/ENVISAT. Landsat was unable to detect early deforestation stages (up to 150ha in 2010) due to the frequent cloud and haze coverage over the region. In other words, in a simulated PSF monitored system based only in Landsat scenes, there would be a two years delay for quantification of the forest degradation. As an impact, counteracts could only take place after a loss of 150ha of PSF.

Small degradation patches that were smaller than the spatial resolution of one pixel (i.e. 30×30m) were usually not detected in either SAR or Landsat scenes. On the other hand, LiDAR derived digital surface model (DSM) as well as high resolution photographs were useful not only for the characterization of the vertical structure of the vegetation but also for the identification of small threats (Figure 4) in the PSF. In this figure, the small path identified was most probably caused by illegal logging and hunting practices as demonstrated by *in-situ* photographs (Figure 5).

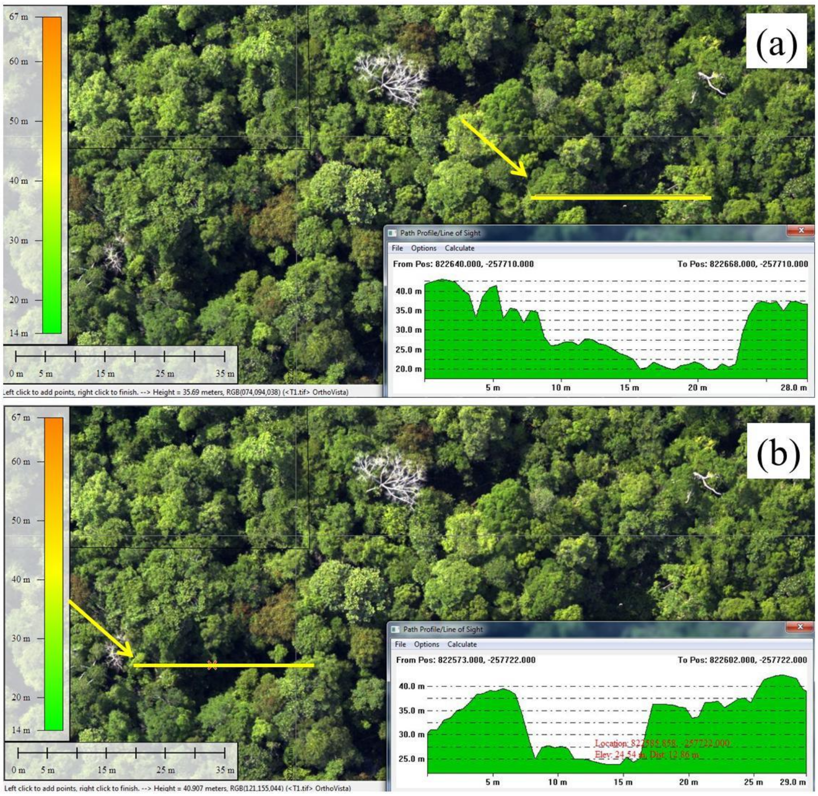

Figure 4. Subset of the aerial orthorectified photographs with detail to the vertical profile of the digital surface model (DSM).The yellow arrow indicates the beginning of the horizontal profile

Backscattering coefficients (sigma nought; dB) of both ASAR/ENVISAT and ALOS/PALSAR (Figure 6) were efficient to characterize PSF and deforested areas (Romshoo, 2006). Undisturbed PSF showed constant backscattering values and differences in the order of 1dB were most probably related to precipitation events prior data acquisition. On the other hand, for the deforested areas the backscattering differences were in order of at least -2dB depending of the selection of the polarization channel (Figure 6). The results corroborate with those results reported by Kuntz and Siegert (1999).

Figure 5. Temporary hunter's lodge installed in a couple of tree canopies (a). Bats exposed in the local market. Sources: Liesenberg (Figure 5a) and Panoramio (Figure 5b)

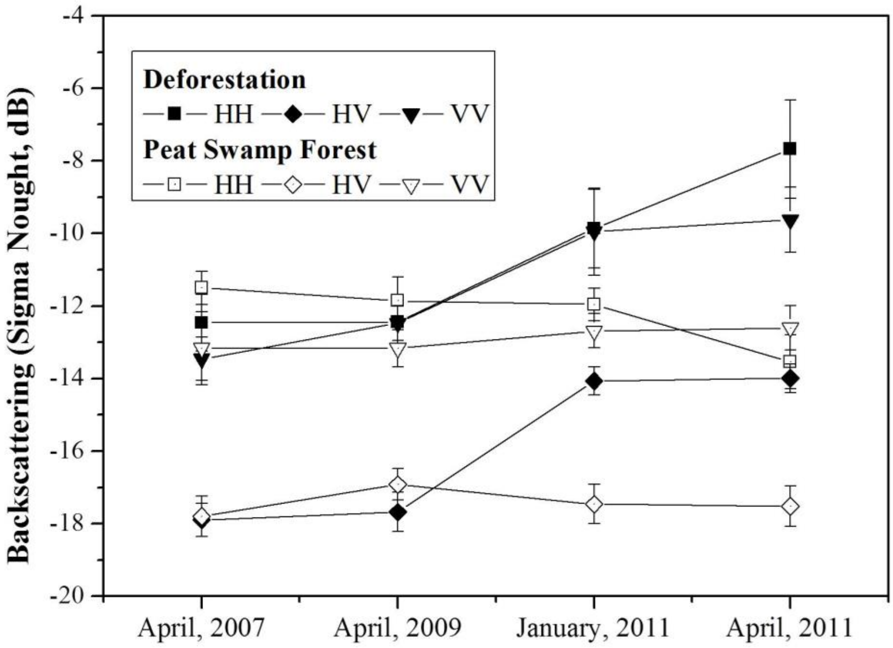

Figure 6. Temporal backscattering coefficient values (dB) for the four quad-polarization scenes of ALOS/PALSAR

Conclusion and Future Work

We argue that the joint analysis of SAR with optical data and airborne LiDAR and orthorectified photographs performs even better forest monitoring. The techniques here reported will be improved under the recent "Reducing Emissions from Deforestation and Degradation" (REDD+) protocols.

Forthcoming research would be on the quantification of different forest threats using not only backscattering coefficients, but also on proper SAR change detection analysis based on polarimetric and interferometric features. A final deforestation and forest degradation map based on multitemporal SAR data and aerial orthorectified photographs will be provided soon.

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GROUND PENETRATING RADAR MAPPING OF PEAT DEPTH

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Ground penetrating radar (GPR) has been applied successful to the measurement of peat depth by several authors. Data interpretation may be difficult if there is no clear lower boundary to the peat layer. Typically, GPR peat depth measurements are calibrated by manual core measurements, which allow determination of the conversion factor and identification of the peat lower boundary. Precision of measurement is around +/– 0.5 m at up to 10 m depth. We performed trials of GPR equipment at Wicken Fen, a peatland nature reserve near Cambridge, UK. Measurements were made with 100, 250 and 500 MHz shielded dipole antenna sets. Applying rectification and smoothing to the data allowed us to set an intensity threshold corresponding to the lower boundary. This led to GPR peat depth measurements in the range 0.7 – 2.1 m that agree well with core measurements. Several possibilities are worth exploring to improve the technique and apply it to measuring total carbon content in Indonesian tropical rainforest peat. We have demonstrated that low-frequency waves and improved data analysis allow depth measurements in peat of high conductivity and low contrast. Further possibilities are to employ electromagnetic dispersion at several frequencies to determine the conversion factor and unambiguously measure total carbon content. It would be helpful to conduct in near future a GPR-pilot-study on thick tropical peat in Kalimantan.

Keywords**:** Peatland, Peat Swamp Forest, Ground Penetrating Radar, relative permittivity, Peat Depth and Thickness and REDD

Introduction

The site at Wicken Fen has a surface layer of undisturbed peat approximately 5000 years old. We performed the measurements on a section of Sedge Fen enclosed by two drainage canals: Gardiner's Drove and Wicken Lode. Along Gardiner's Drove, the water table was approximately at the surface, the ground was soft and covered in reeds. Along Wicken Lode, the water table was perhaps around 50 cm below the surface, a footpath has been made consisting of compacted dry peat covered with grass. The total circular path length was about 3 km.

Study Area Description and Data Analysis

We can examine the reflection profiles to see if there are qualitative differences between shallow and deep peat that we can exploit. Fig 4 shows average profiles for deep and shallow sections of the 100 MHz and 250 MHz surveys respectively. For the 100 MHz survey, we take 1.1 – 1.8 km as “deep” and 2.0 – 3.0 km as “shallow”. For the 250 MHz survey, we take 1.4 – 2.4 km as “deep” and 2.8 – 3.3 km as “shallow”.

The initial few waves (~0.5 m in 100 MHz data, ~ 0.1 m in 250 MHz data) shows the reflection of the transmitted pulse by the ground, and the ringing of both source and receiving antennae. The frequency of these waves is equal to the frequency of the transmission.

Then follows a slower wave of period ~ 84 ns and 46 ns for 100 MHz and 250 MHz data respectively. The period of this wave is apparently twice the period of the first wave packet of

48 ns and 23 ns respectively. This is caused by a lower frequency emission from the transmitter of 12 MHz and 22 MHz respectively. These lower frequencies are apparently more penetrating into the peat.

It is difficult to see any qualitative difference in the deep and shallow profiles, except that radio wave penetrates to greater lengths in the "deep" compared to the "shallow". There is no clear boundary or step change in the decay of the wave in the region above 1 m. We explored several analysis methods on the raw data including deconvolution, subtraction of average profiles, separation of frequencies and rectification, smoothing and thresholding.

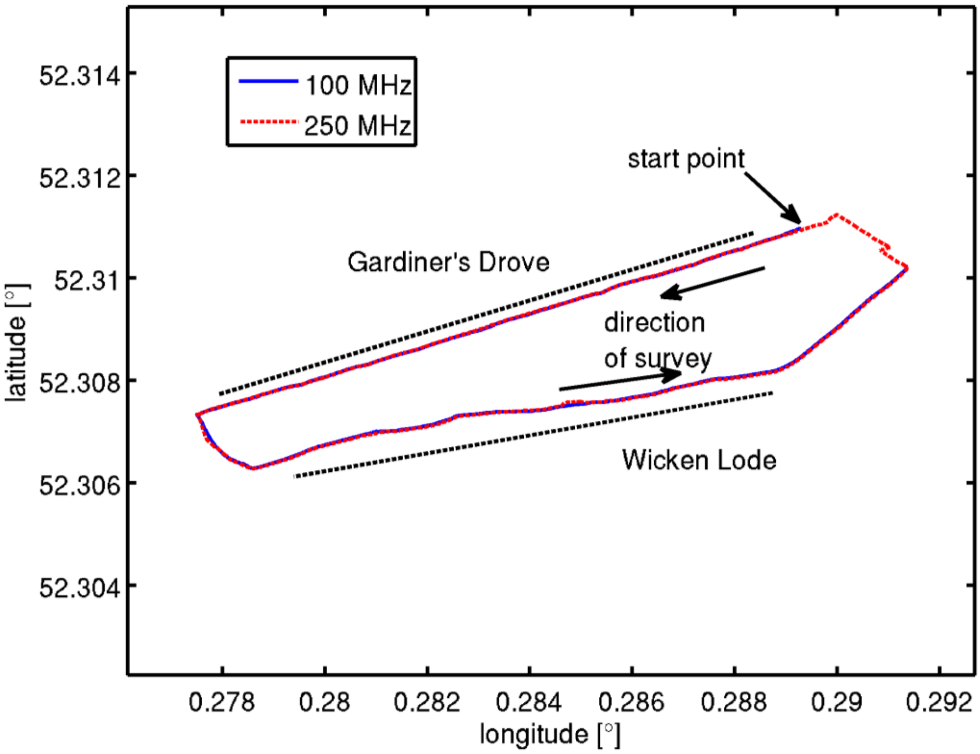


Figure 1. Path of survey with both antenna sets. The circular path length is approx. 3350 m

Figure 2. View of Wicken Fen (right) with GPR equipment

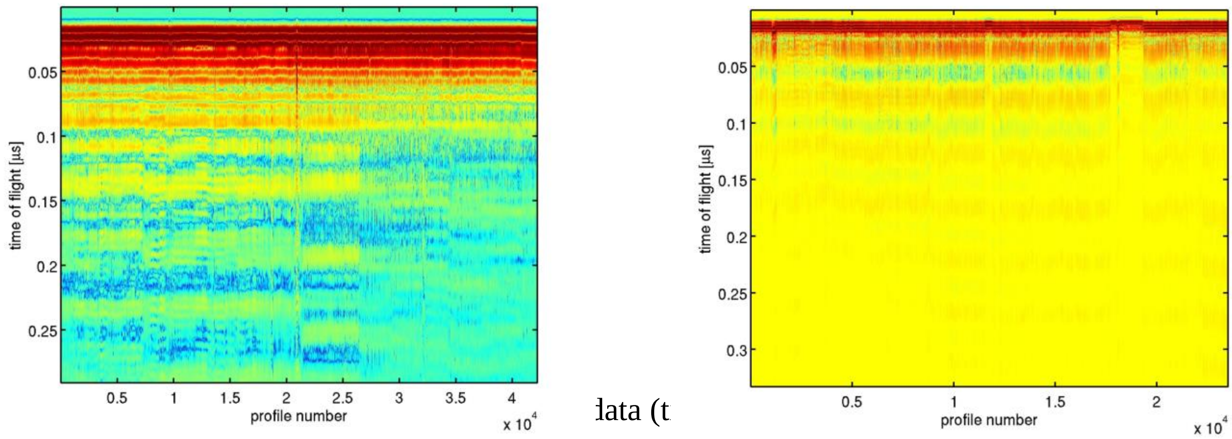
Raw Data

The raw data consists of received traces, measured as a function of time. The instrument automatically collects and averages a set of traces to reduce measurement noise and interference. The resulting profile consists of reflection amplitude as a function of time. The instrument was set to record a new profile at a set spacing, triggered by movements of the odometer wheel.

The raw data is plotted below in Figure 3. The colour axis red – blue represents log (abs (amplitude)). No clear boundary is seen in terms of a strong reflection at any depth. However, we see that the middle section of the path, corresponding to the south-west corner of Sedge Fen has reflections from about twice the depth of the start and end of the path, which corresponds to the north-east part.

We can convert time-of-flight to distance if we know the speed of the wave in the ground. Ideally we would identify the bottom reflection and plot a calibration curve against peat core measurements. Here we use an approximate literature value for velocity of 25ns/m, which corresponds to a relative permittivity of 56. The permittivity is dominated by the water content: water has a relative permittivity of 80. The time-of-flight is for the wave to travel in both directions, therefore the conversion factor is 50ns/m.

In the 250 MHz data there are many local changes in the profile within horizontal distance ~ 1 m (Figure 4). These apparently come from debris under the ground, or moving off the peat onto built walkways. Except for these, the profile changes only gradually, over > 100 m. In the 100 MHz data, there are fewer of these features presumably due to the longer wavelength. However, the profiles seem to change suddenly. These are perhaps artefacts caused by sudden changes on the surface, as we move from reeds to cleared land.



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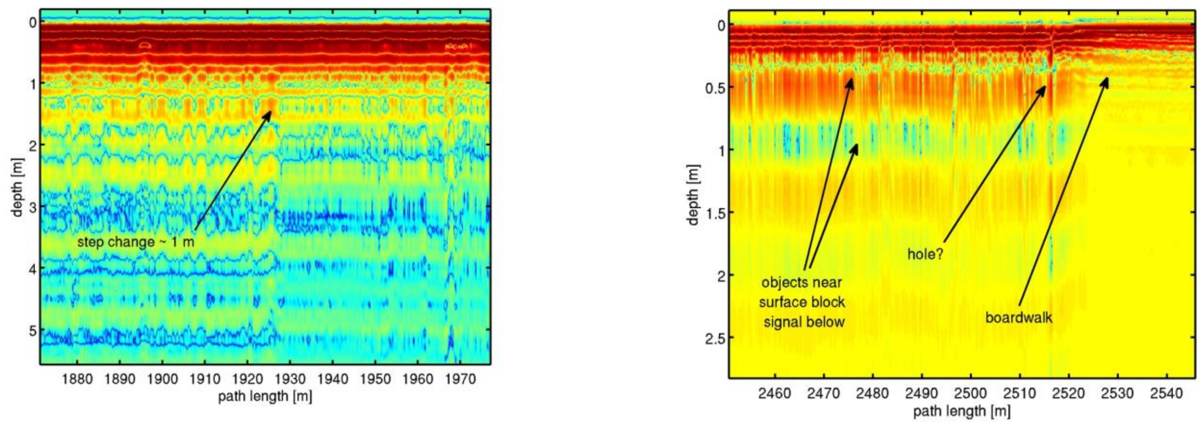

Figure 4. 100/250 MHz short length-scale features

Data Analysis

We can examine the reflection profiles to see if there are qualitative differences between shallow and deep peat that we can exploit. Fig 4 shows average profiles for deep and shallow sections of the 100 MHz and 250 MHz surveys respectively. For the 100 MHz survey, we take 1.1 – 1.8 km as "deep" and 2.0 – 3.0 km as "shallow". For the 250 MHz survey, we take 1.4 – 2.4 km as "deep" and 2.8 – 3.3 km as "shallow".

The initial few waves (~ 0.5 m in 100 MHz data, ~ 0.1 m in 250 MHz data) shows the reflection of the transmitted pulse by the ground, and the ringing of both source and receiving antennae. The frequency of these waves is equal to the frequency of the transmission.

Then follows a slower wave of period ~ 84 ns and 46 ns for 100 MHz and 250 MHz data respectively. The period of this wave is apparently twice the period of the first wavepacket of 48 ns and 23 ns respectively. This is caused by a lower frequency emission from the transmitter of 12 MHz and 22 MHz respectively. These lower frequencies are apparently more penetrating into the peat.

It is difficult to see any qualitative difference in the deep and shallow profiles, except that radio wave penetrates to greater lengths in the "deep" compared to the "shallow". There is no clear boundary or step change in the decay of the wave in the region above 1 m. We explored several analysis methods on the raw data including deconvolution, subtraction of average profiles, separation of frequencies and rectification, smoothing and thresholding.

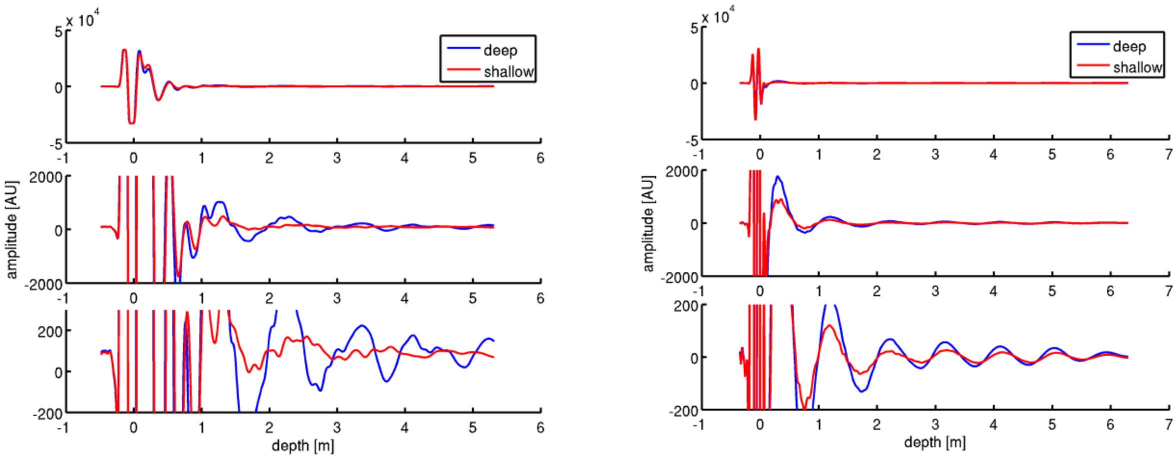

Figure 5. Mean profile of 100/250 MHz survey in deep and shallow regions (same data at three y-axis scales.)

Analysis: Rectification, Smoothing, Threshold

We performed the following operations: rectification of profile (amplitude squared) followed by smoothing by convolution with a Gaussian function, length scale 0.5 m. These are sufficient to convert the profiles to data that can be thresholded. The effect on the averaged "deep" and "shallow" profiles is shown in Figure 6.

Next we applied this to all profiles in the survey. Each path was further smoothed horizontally, with smoothing length scale 50 m. The data is smooth enough to be thresholded: so far we have only applied arbitrary thresholds, but later we could try fitting this to peat core measurements. Results are shown in Figure 7.

Finally we can plot the depths on a 2D map of the survey paths as shown in Figure 8.

Results for the 250 MHz survey are roughly consistent with the existing peat depth data, showing peat depth gradually varying from about 1 m in the north-east to 2 m in the south west of the plot.

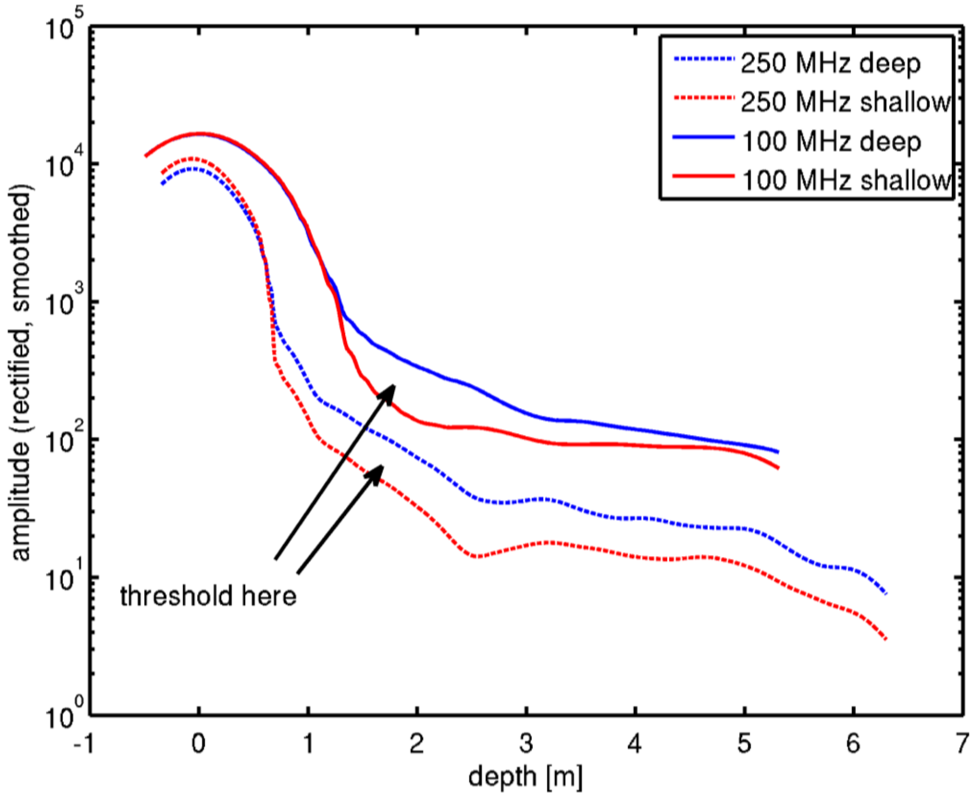

Figure 6. Rectified and smoothed amplitudes of “deep” and “shallow” averaged profiles, from 100/250 MHz surveys

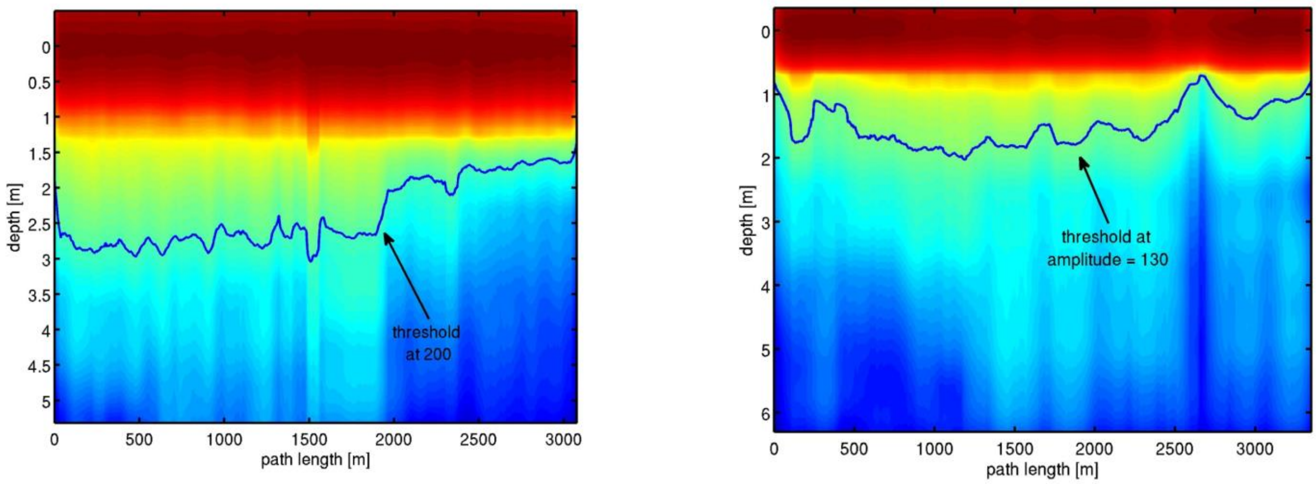

Figure 7. 100/250 MHz survey, rectified, smoothed, thresholded

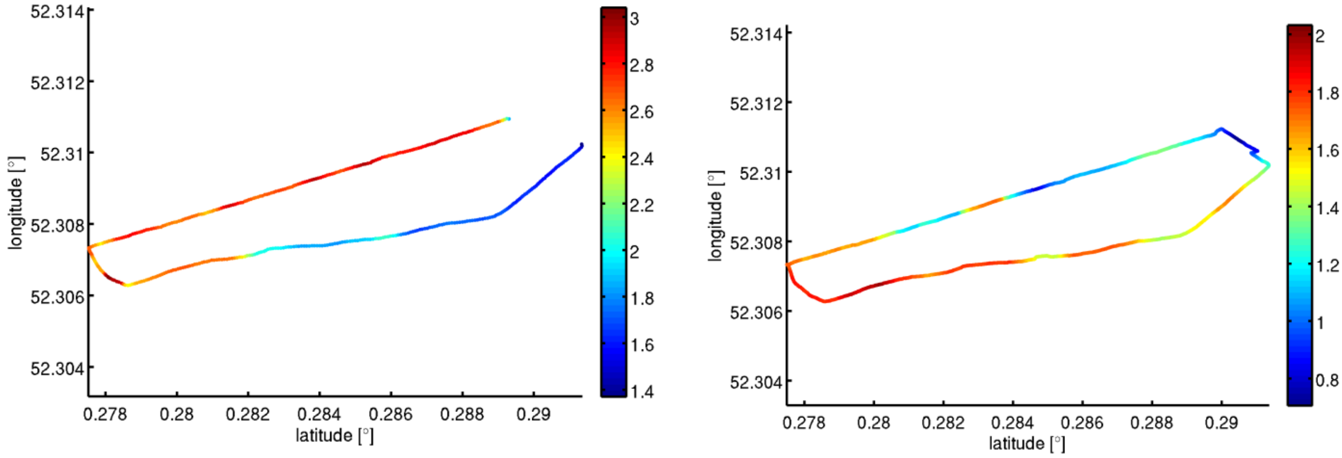

Figure 8. 100/250 MHz surveys thresholded depth predictions (m)

Conclusions

Several possibilities are worth exploring to improve the technique and apply it to measuring total carbon content in Indonesian tropical rainforest peat. We have demonstrated that low-frequency waves and improved data analysis allow depth measurements in peat of high conductivity and low contrast. Further possibilities are to employ electromagnetic dispersion at several frequencies to determine the conversion factor and unambiguously measure total carbon content.

We have shown that GPR peat depth measurements are possible, even when the dominant frequencies are completely attenuated by the high electrical conductivity. Side emissions around 10 – 20MHz provided information through the peat. A second challenge of the lack of a clear lower boundary was overcome by applying rectification and smoothing, then setting an intensity threshold corresponding to the lower boundary.

Our study shows that skill in data analysis and GPR know-how is essential to adapting the technique to inevitable new challenges caused by local peat conditions. We recommend a GPR peat depth survey in Kalimantan. This should start with a pilot feasibility study, to customise the method by investigating a range of frequencies and data analysis techniques, and establish accuracy.

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SOIL CHEMICAL PROPERTIES AT HEATH FOREST AND LOW LAND FOREST IN KALIMANTAN

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This research was aimed to compare soil chemical properties at heath forest and low land forest in Central Kapuas, Kalimantan island, Indonesia, for establishing the policy of restoring and rehabilitation activity at degraded forest. The research was conducted at June up to July 2012. Sampling sites were made at both forest type. Each sampling site was divided into 4 observation strips and each observation strips contain 4 observation plots. Each observation plot was collected 5 (five) soil samples at depth 0 cm, 25 cm, 50 cm, 75 cm, and 100 cm. Research result show that soil chemical in the low land forest better than in the heath forest, especially macro nutrient of C organic, N total dan P available, although both content are low to very low with soil pH are acid category. Kation exchange capacity in the low land forest is low and in the heath forest is very low. Humus thickness is 9,2 cm in heath forest and 12,33 cm in low land forest.

Keywords: Low land forest, heath forest, soil chemical

Introduction

Background

Heath forest in Kalimantan, that also known as kerangas forest, is divided between Brunei, Indonesia, and Malaysia, as well as on the Indonesian islands of Belitung and Bangka, which lie to the west of Borneo. The heath forests have a low and uniform canopy, with thick underbrush and rich growth of moss and epiphytes. Proctor (1999) propose that these forests are growing on soils which are highly acidic, such that hydrogen ion toxicity prevents the growth of non-adapted species. Many tree and plant species in the nutrient-deprived heath forests have developed unconventional ways to get their nutrients. For examples, *Gymnostoma nobile* utilise rhizobia (nitrogen fixing bacteria) in their root nodules. Myrmecophytes, including *Myrmecodia* spp. and *Hydnophytum* spp., are tree species that develop symbiotic associations with ants to get their nutrients. Other plants, including pitcher plants *(Nepenthes* spp.), sundews *(Drosera* ssp.), and bladderwort *(Utricularia* ssp.), are carnivorous, trapping and digesting insects. The heath forests are characterized by many plants of Australasian origin, including trees of families Myrtaceae and Casuarinaceae and the southern hemisphere conifers *Agathis*, *Podocarpus*, and *Dacrydium* (Wong *et al*, 2003).

Low land forests have the some layers of canopy. First, the upper layer towers at between 30 to 40 m, with occasional giants of 60 m. For examples are *Koompassia exelca*, *K.malaccensis*, *Shorea* spp., *Dipterocarpus* spp., *Dryobalanops* spp, etc. The second layer is between 23 to 30 m, for examples are *Campnospermum* spp., *Lophopetalum* spp., *Calophyllum inophyllum*, *Diallium* sp., *Syzigium* sp., *Cinnanomum* sp., etc. The lower level is made up of poles and saplings of a number of species. The ground vegetation is often sparse and comprises mainly small trees and herbs. The forest floor, the bottom-most layer, receives only 2% of the sunlight. Only plants adapted to low light can grow in this region. The layers of the lowland forest vegetation create a variety of different specialized habitats, or niches, to be occupied by a variety of different plant and animal species. This allows the rainforest to be among the most biologically diverse areas.

Most tropical soils in Kalimantan are characterized by significant leaching and poor nutrients; however there are some areas that contain fertile soils. Soils throughout the tropical rainforests fall into two classifications which include the ultisols and oxisols. Ultisols are known as well weathered, acidic red clay soils, deficient in major nutrients such as calcium and potassium. Similarly, oxisols are acidic, old, typically reddish, highly weathered and leached, however are well drained compared to ultisols. The clay content of ultisols is high, making it difficult for water to penetrate and flow through. The reddish color of both soils is the result of heavy heat and moisture forming oxides of iron and aluminum, which are insoluble in water and not taken up readily by plants.

Heath forests are the result of the area's siliceous parent rocks. Permanently waterlogged heath forests are known as *kerapah* forests. The sandy soil of the heath forest are often lacking in nutrients; it is generally considered that nitrogen is the nutrient which is most lacking for plant growth in these forests. This is in contrast to many other lowland forests where phosphorus is considered to be lacking. The physical properties of soil control the tree turnover rates whereas chemical properties such as available nitrogen and phosphorus control forest growth rates.

Purpose

This research was aimed to compare soil chemical properties at heath forest and low land forest in Central Kapuas, Kalimantan island, Indonesia, for establishing the policy of restoring and rehabilitation activity.

Method

Research plots

This research is administratively located in Kapuas Regency, Central Kalimantan Province (Borneo), Indonesia. The center of heath forest research plot is geographically located at 114^{o}13’34” East Longitude and 01^{o}46’11” South Latitute, whereas the center low land forest research plot is geographically located at 114^{o}59’07” East Longitude and 01^{o}51’23” South Latitute. The size of heath forest and low land forest research plots each were 1000 m × 1000 m.

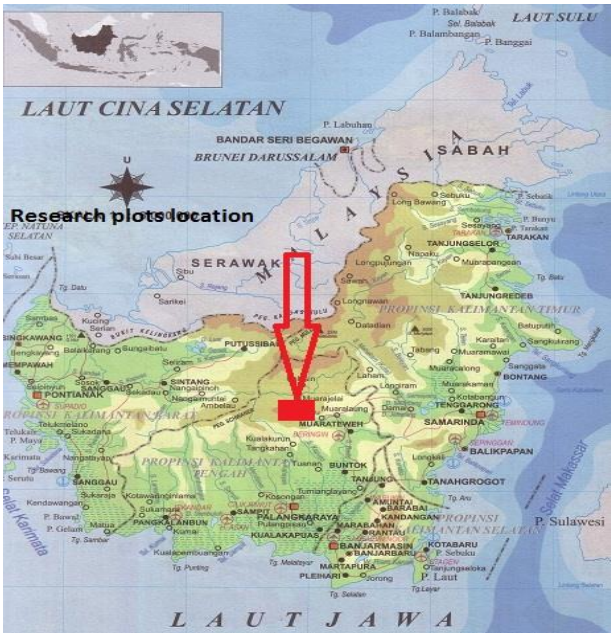

Figure 1. Research plot location in Kalimantan Island

Sampling sites of soil analysis were made at both forest type which were placed in such a manner so that represent their soils chemical properties. Each sampling site was divided into 4 observation strips and each observation strips contain 4 observation plots. Each observation plot was collected 5 (five) soil samples at depth 0 cm, 25 cm, 50 cm, 75 cm, and 100 cm (Figure 2). The research was done in 17 days in the field, starting from 5 up to 22 June 2012. Data processing of soil chemical until compiling final report were conducted at July 2012.

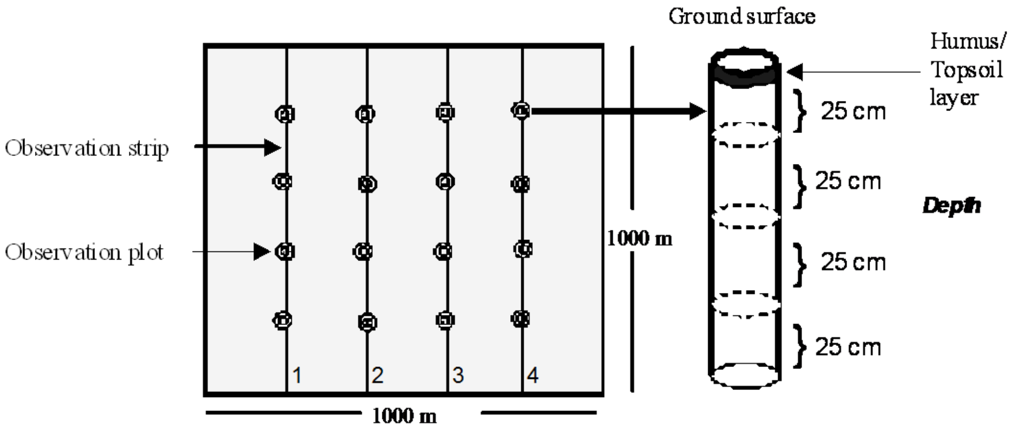

Figure 2. Layout of research plot

Analysis of soil chemical properties

Sample soils that be analysed in the soil laboratory in the form of soil compound according their depth each its strip. Laboratory data analysis using SL-MU-TT-10 (Hydrometer) methods, that were needed for determining the chemical and physical properties of soil could be seen in Table 2.

Table 1. Soil physical and soil chemical analysis methods

Number	Variable	Analysis method
1.	pH *)	SNI 03-6787-2002
2.	C Organik *)	SNI 13-4720-1998 (Walkey & Black)
3.	N Total *)	SNI 13-4720-1998 (Kjeldahl)
4.	P Tersedia *)	SL-MU-TT-05 (Bray I/II)
	Cations exchange	
5.	Ca *)	
6.	Mg *)	
7.	K *)	SL-MU-TT-07 a-e
8.	Na *)	(Ekstrak Penyangga
9.	KTK	NH_4OAc 1 N, pH 7)
10.	KB	
	Al-H_{dd}	
11.	Al^{3+}	SL-MU-TT-09 (Ekstrak KCl lN)
12.	H^+	
13.	Sulfida Total	SL-MU-TT-13 (HNO3-HClO4;
14.	CaO Total	Turbidimetri)
15.	MgO Total	

Number	Variable	Analysis method
16.	Cu Total	SL-MU-TT-13 (HNO3-HClO4; AAS)
17.	Zn Total	
18.	Mn Total	
19.	Fe2O3 Total	

**) Accredited by National Accreditation Committe of Indonesia - Number: LP-221-IDN*

Result and Discussion

Topography of research plots

Topography in the research plots are flat to steep (0% to 30%) and their altitute are between 140 to 273 m above sea level. Topography related to wide of basal area and erodibility level. More and more of slope caused more wide of basal area and its more sensitive for erosion. Therefore land management in the steep area is needed handling carefully. In the generally, the soil colour in the all sampling plots were varying, strarting from dark chocolate to yellow in the low land forest research plot and yellow to reduce colour of grey in the heath forest research plot.

Top soil condition

The top soil layer in the tropical forest was relatively thin, whereas in this zone, it was placed the soil nutrients acumulation and taken place of the close nutrient cycle mechanism in the forest (Mc Kinnon *et a.l*, 2000; Whitmore, 1976), therefore its existence was very important to forest ecosystem balancing, consist of regeneration and growth of vegetations over there. Measurement of topsoil or humus thickness in forest floor was necessary to get the data of fertility level and organic material stocks.

The top soil was containing much organic materials that its more higher pH than its underlayer (Mc Kinnon *et al.,* 2000). In these zone, the weathering and decomposition of organic material by microorganism was going on fastly. Microorganism decompose the organic material become more simple element so that was available for plant. Many "decomposer" microorganism in active at the more or less of 7 of pH, whereas the pH in the topsoil of heath forest between 4,3 to 5,4 and in top soil of low land forest between 4,2 to 6,0 (less than 7), as be seen at Table 3.

Table 2. Top soil thickness and acidity in both research plots based on manual measurement

Research plot	Observation strip	Humus thickness	pH of top soil
Heath forest	1	15,3	5,4
	2	7,4	4,2
	3	10,8	5,0
	4	3,3	4,3
	Average	9,2	4,75
Low land forest	1	7,2	4,2
	2	11,1	6,0
	3	9,5	5,4
	4	21,5	4,9
	Average	12,33	5,13

The humus thickness in the heath forest was from 3,3 cm to 15,3 cm, and in the low land forest was from 7,2 to 21,5 cm. There are still many organic materials in the heath forest floor. In the its topsoil or humus layer, there were much the nutrients that was leached by surface run off or it be infiltrated into the ground, because many sands fraction in the its soils composition that it was caused the nutrients could not be trussed in the soils. It was colouring water in this area so that it causing the colour of water in heath forest's river was brown to blackish. These was also causing the fertility of heath forest's soils was low.

General condition of vegetations

Structure and composition of low land forest is more complex than heath forest. There are five layer that arranged according their vegetations. Vegetations in the upper layer towers are *Koompassia exelca*, *K. malaccensis*, *Shorea* spp., *Dipterocarpus* spp., *Dryobalanops* spp, *Sindora* sp., *Scapium podocarpum* etc. In the second layer are *Campnospermum* spp., *Lophopetalum* spp., *Calophyllum inophyllum*, *Diallium* sp., *Syzigium* sp., *Cinnanomum* sp., etc. The lower level is made up of poles and saplings of a number of species. Dominant trees in this layer are *Diospyros* spp., *Drypetes kikier*, *Canarium* spp. etc. The ground vegetation is often sparse and comprises mainly small trees and herbs. The forest floor, the bottom-most layer, receives only 2% of the sunlight. Only plants adapted to low light can grow well in this region. The layers of the low land forest forest vegetation create a variety of different specialized habitats, or niches, to be occupied by a variety of different plant and animal species. This allows the rainforest to be among the most biologically diverse areas.

Many tree and plant species in the nutrient-deprived heath forests have developed unconventional ways to get their nutrients. For examples, *Gymnostoma nobile* utilise rhizobia (nitrogen fixing bacteria) in their root nodules. Myrmecophytes, including *Myrmecodia* spp. and *Hydnophytum* spp., are tree species that develop symbiotic associations with ants to get their nutrients. Other plants, including pitcher plants *(Nepenthes* spp.), sundews *(Drosera* ssp.), and bladderwort *(Utricularia* ssp.), are carnivorous, trapping and digesting insects. The heath forests are characterized by many plants of Australasian origin, including trees of families Myrtaceae and Casuarinaceae and the southern hemisphere conifers *Agathis*, *Podocarpus*, and *Dacrydium*.

Soil Chemical

Soil Chemical related with the soils nutrient and its availability to be absorbed by plant and trees. Sometimes, there were enough of the nutrients content in the soils but in the form of not available for trees that were caused by some limited factors, like more of acidity of soils and more of Fe and Al elements content in the soils, for example in the podsolik yellow-red (ultisol) soils.

Pursuant to the laboratory data analysis, the nutrients content in the sampling neither in the heath forest and low land forest were low to moderate. The soils conditions in the all of sampling plots were acid or their pH were under 7. The result of laboratory analysis of soils chemical in the low land forest and heath forest could be seen at Table 4.

Table 3. The soil nutrients content in both research plots based on laboratory analysis

No	Parameters	Unit	Heath forest	Low land forest
1	C organic	%	0,79	1,6
2	N total	%	0,03	0,4
3	C/N		20,1	11,2
4	P *available*	ppm	5,0	8,9
6	Ca	cmol/kg	0,54	0,10
7	Mg	cmol/kg	0,08	0,04
8	K	cmol/kg	0,03	0,06
9	Na	cmol/kg	0,12	0,17

No	Parameters	Unit	Heath forest	Low land forest
11	KTK	cmol/kg	4,01	7,21
12	KB	%	16,8	4,89
13	Al3+	me/100gr	0,51	1,62
14	H+	me/100gr	0,64	0,20
15	Sulfida total	me/100gr	98	241
18	Cu	ppm	0,70	1,43
19	Zn	ppm	6,99	39,21
20	Mn	ppm	3,8	1,22
21	Fe2O3	%	1,10	1,78

According to the result of laboratory data analysis at above, could be seen that most of nutrients that were needed by trees was just very low to moderate only. Phosphorus (P) as macro nutrient that needed for growth of trees was available in very low in the all forest type. The cation exchange capasity was just very low to moderate only. The heath forest's soil texture that was dominated by sand fraction could not save many nutrients correctly that were yielded from decomposition and weathering process favourably, so it would cause the leaching of nutrients were happened in the higher level. This condition become worse at former drilling or mining because it done in open area.

Table 4. Condition of soil chemicals in both research plots

No	Parameters	Unit	Heath forest	Low land forest
1	pH		Acid	Acid
2	C organic	%	Low	Low
3	N total	%	Lowest	Low
4	C/N		High	Moderate
5	P *available*	ppm	Very low	Low
6	Ca	cmol/kg	Very low	Very low
7	Mg	cmol/kg	Very low	Very low
8	K	cmol/kg	Very low	Very low
9	Na	cmol/kg	Low	Low
11	KTK	cmol/kg	Lowest	Low
12	KB	%	Very low	Very low
13	Al3+	me/100gr	Very low	Low

In tropical forest, mostly the organic material content resided in the trees whereas its remainder resided in the ground, on the contrary in the sub tropical area. Thereby fertility level of soils in tropical forest was low than in the sub tropical. Therefore, soil management in tropical area was more careful in order to is not happened higher damage of forest and land.

Tropical Forest area was which always warm and humid, it caused the decomposition and weathering process of organic material happened quickly. On the other side of it, the higher precipitation in these area was caused higher soil erosion, additionally in the soil (which contain more sand fraction) that was not managed correctly.

Cultivation activity that conducted at degraded forest areal must be joined with additional input of fertilizer or an organic matter as humus or organic manure. Some nutrients which were added in the following:

1. Heightening pH of land those given in the calcify agriculture or dolomite

2. Addition of nutrient of N, P, K, and others (according to the laboratories analysis of soils chemical) those given in organic manure (like organic NPK, compost, humus ect.) and also the inorganic manure.

Many nutrient elements was becoming not available for plant in the acid or more alkali condition. The best condition was in the pH of thereabouts 7. At the Figure 3, seen that absorbtion of N, Ca, Mg, P, K, S, Mo, and Bo elements were needed pH condition in neutral or thereabouts 7. Several fuctions of nutrients element which were needed for growth of trees in the following:

a. The macro elements of C, H, and O were needed to forming of the body plant through metabolism process.

b. The elements of Fe, Mg, Mn, Zn, Cu, Bo And Mo were needed to forming of enzyme

c. Nitrogen (N) in the form of NH3 (ammonia/nitrate) was need to growth improvement of plants,chlorophyll, protein forming, improving the quality of plant and improving the microorganism activity on the ground.

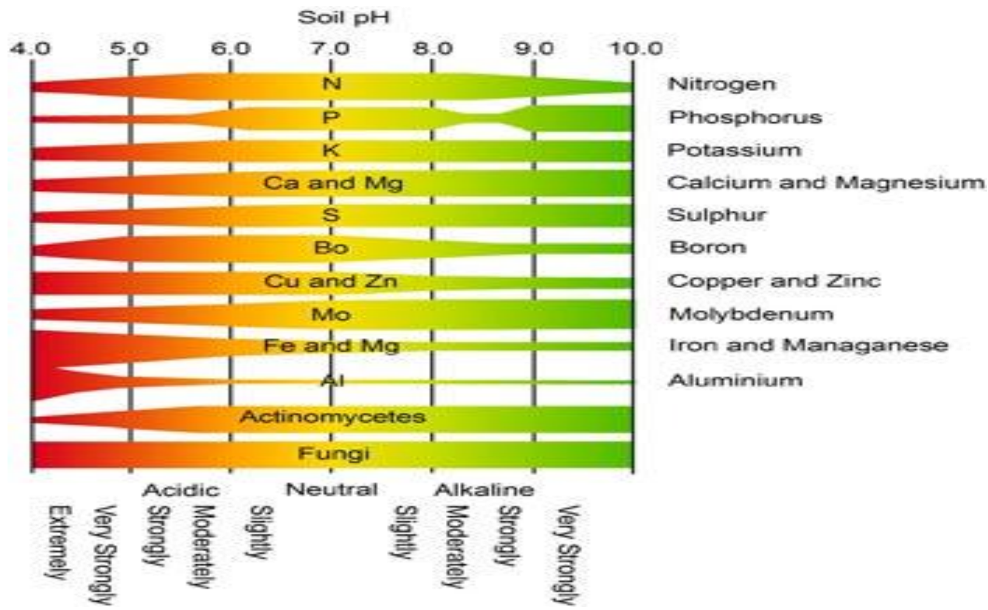

Figure 3. Absorbed nutrient elements effectiveness pursuant the soil pH conditions (Foth, 1990)

d. Pospor (P) was needed for quickening growth of plant root, strengthening of plants and to improve of seed forming process. Element of P is also used to cell nucleus forming and assisting bisection of cell and growth of young cell network. At the soil condition is acid and more of Fe and Al, the element of P is in the form of trussed in soils accordingly could not be used by plants. Availability of P in the ground is obtained from mineral phosphate in the form of limestone and also from organic material.

e. Potassium was needed for quickening carbohydrate forming, strengthening the plants and its stamina to against pest and disease and and also to improve seed quality. Potassium more easy to react with other elements, like chloride, oxygen and others. Availability of Potassium in the ground is obtained from soils, rest of crop to orhanic and anorganic manure (NPK, KCl etc)

f. Calcium (Ca) was neede to repair acidity of soils and also plant body, for growth of root and leaf of plant, antidote, and to forming of new bud

g. Magnesium (Mg) was needed for forming of chlorophyll, arranging P and carbohydrate circulation and to assist enzyme activity.

h. Sulphurus (S) was needed for forming of protein and chlorophyll and growth of root Sulphurus (S) is used to forming of protein and chlorophyll and growth of root

i. Manganese (Mn) was used to forming of protein and vitamine (especially vitamine of C), taking care of consistency kloropil, assisting process of enzyme and catalyst.

j. Iron (Fe) was needed to forming of chlorophyll, carbohydrate, fat, protein, and enzyme processes. Lacking of element of Fe could cause the conglomeration of nitrate and sulphate.

k. Copper (Cu) was needed as enzyme to assist reaction of oxidize and growth of plant in the early stage

l. Zinc (Zn) was needed to forming of the leaf and make healthy crop

m. Molybdenium (Mo) was needed to improving of ammonia role (NH_3), but excess if Mo could be poison.

n. Borium (Bo) was needed to bisection of cell, especially in the initial growh, to forming stamen, flower and root. Bo was not available to plant in the alkali condition.

Conclusion

Soil chemical in the low land forest better than in the heath forest, especially macro nutrient of C organic, N total dan P available, although both content are low to very low with soil pH are acid category. Kation exchange capacity in the low land forest is low and in the heath forest is very low. Humus thickness is 9,1 cm in heath forest and 12,7 cm in low land forest.

Suggestion

Restoring and rehabilitation activity at degraded forest area should be conducted by heightening pH of soils using calcify agriculture or dolomite (calcifying) and addition of nutrients that are needed for growth of plant or forest using the organic manure (like organic NPK, compost, humus) and also the anorganic manure (NPK, TSP, Urea, KCl).

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THE SPECIFIC SPECTRAL DATA OF DOMINANT TREES IN PEAT-FOREST IN CENTRAL KALIMANTAN, INDONESIA
~ Preliminary Results ~

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This paper reports about the compilation of the spectral library of dominant trees in peat-forest in Central Kalimantan, Indonesia supported under JST-JICA Project: "Wild Fire and Carbon Management in Peat Forest in Indonesia". Spectral libraries are commonly established as a means to archive representative signatures of natural materials. Such signatures can then be used to train feature extraction and classification algorithms applied to remote sensing data imagery. Spectral analyses were performed to the 33 dominant species in peat-forest in Central Kalimantan, Indonesia obtained during the field survey measurement (in-situ measurements) in July 2011, July 2012 and September 2013. We found, each vegetation type has unique spectral signature or characteristics. The shapes of reflectance spectra can be used for identification of vegetation types combine with remote sensing data.

Keywords: Spectral library/signature, Peat-Forest, Spectroradiometer, Vegetation, and Kalimantan

Introduction

Remote sensing applications in precision identification of agriculture and forest vegetation have been steadily increasing in recent years due to improvements in spatial and spectral resolutions of remotely sensed imagery. There is a rapidly growing interest in methods for automatic plant identification, especially in agricultural and forestry researches. Innovations in sensors are permitting the connection of remote sensing with methods of laboratory spectroscopy (Raymond *et al*., 2003; Andres Kuusk*et al*., 2004). The Spectral library is "a set of class or endmember spectrum to be referred during feature extraction process from hyperspectral data". It can be further explained as a collection of spectral plots which is being compiled so that it can be used as a reference in information extraction from hyperspectral data. The reflection of radiation from the forest under-storey and ground vegetation, in particular, plays a significant role in the forming of total forest reflectance (Satterwhite and Henley 1990; Danson and Curran, 1993).

Field campaign is the most common and easiest way to collect object spectra of different land cover types or vegetations, and this method produces results which can be easily compiled into spectral library (Andres Kuusk*et al*., 2004; Alvin Lau and MazlanHashim, 2007). To carry out a field campaign, a spectroradiometer is needed to record the spectra received from the objects found especially tropical forest vegetations (tree species) in the study area.

Materials and Methods

Study Area

The study area is located in a tropical peat swamp forest area around Palangka Raya, the capital city of Central Kalimantan Province, Indonesia (Fig. 1) and approximately 120 km from the Java sea with the elevation between 15-20 m above sea level (Shimada *et al*., 2001;

Weiss et al., 2002). Peat swamps cover extensive areas of lowland Kalimantan, with estimates varying between 8% and 11% (McKinnon *et al*., 1996).Area of Central Kalimantan is 153,564 km^2, comprising mostly jungle (ca. 126,200 km^2, 82.18%), swamps (11.80%), rivers and lakes (2.97%), and agricultural land (3.05%). Central Kalimantan contains about three million hectares of peatland which is one of the largest unbroken peatland in the worldand located between 0º 45’ N and 3º 3’ S, between 111ºand 116º E. Ground surveys and field investigations were carried out in the study area in July 2011.

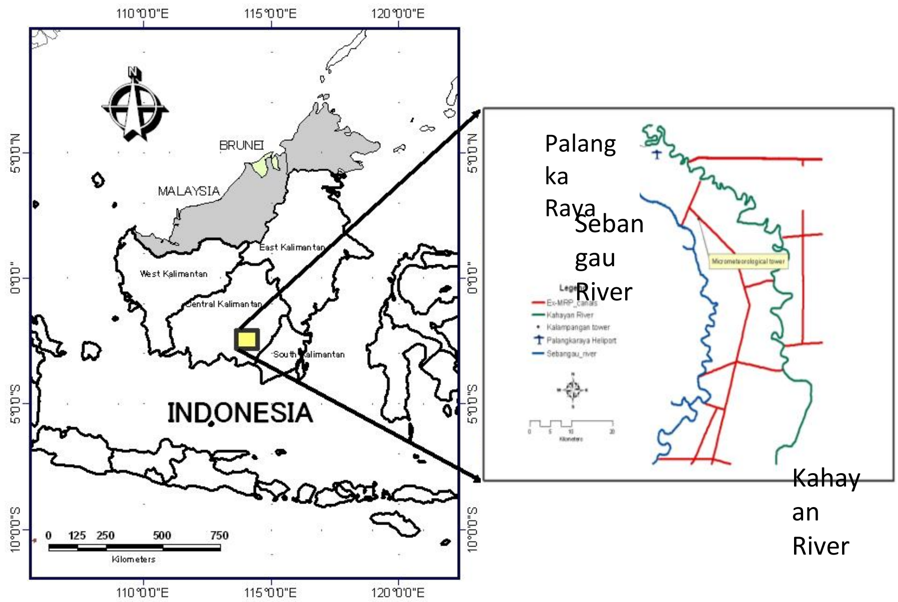

Figure 1. Map of study area in Central Kalimantan Province, Indonesia

Methods

The measurements of the reflectance spectra of ground vegetation were performed by an Analytical Spectral Devices (ASD) FieldSpecPro-FR Spectroradiometer(FieldSpec 3 FR) with a spectral range of 350-2500 nm and a rapid data collection time of 0.1 second per spectrum. The main purpose of this study is to develop the spectral library of individual tree of peat-forest using a ground-based spectroradiometer.The instrument uses three detectors spanning the visible and near infrared (VNIR) and shortwave infrared (SWIR1 and SWIR2). The FieldSpecspectroradiometer is specifically designed for field environment remote sensing to acquire visible near-infrared (VNIR) and short-wave infrared (SWIR) spectra.

The sensor, with a field of view of 25°, waspositioned 30-40 cm above the samples at nadir position. Prior to each three measurements, a white reference panel with approximately 100% reflectance was used as a referencestandard. The measurements were conducted under clear and cloudless sky between 10:00 and 14:00 at local time (West Indonesian Time). A contact probe fore optic was used to minimise BRDF effects from shiny surfaces. Measurements were made with a standard laboratory setup (Pfitzner *et al*., 2006) using the high intensity contact probe at 30° of nadir. The ASD contact probe used is equipped with an internal light source (a halogen bulb light source 6.5 W, with colour temperature 2901 ± 10% K). Spot size of the Contact Probe has the diameter of 22 mm as shown in Figure 2.

The contact probe is an alternative method for collection of laboratory spectra because SWIR spectra collected are found to exhibit improved signal to noise (S:N) ratios, lower standard deviation and less intrinsic uncertainty than spectra collected using more traditional laboratory techniques(Mac Arthur, 2007). The spectrometer and contact probe were warmed prior to use for 90 minutes and 30 minutes, respectively. A white reference measurement was undertaken prior to each material (tree leaves) being sampled. Spectral measurements were made using 30 averages.

Figure 2. Spectral library data collection activities (field survey and sample measurements)

Results

The samples of the library spectra measurements from 10 dominant trees species in peat-forest in Central Kalimantan are shown in Figure 3 from the total of 33 species during field survey and measurements in full-range wavelength (350 – 2500 nm). The definition of dominant trees are trees (or shrubs) with crowns receiving full light from above and partly from the side; usually larger than the average trees or shrubs in the stand, with crowns that extend above the general level of the canopy and that are well developed but possibly somewhat crowded on the sides. A dominant tree is one which generally stands head and shoulders above all other trees in its vicinity. However, there may be a young, vigorous tree nearby, but not overtopped by a dominant tree. This smaller tree may be considerably shorter than the dominant, but still be receiving full light from above and partly from the sides. In its own immediate environment, it is dominant and should be recorded as such. Only understory trees immediately adjacent to the overstory tree will be assigned subordinate crown classes (Frederic Raulier*et al*., 2003; Miles *et al*., 2003).

The spectra demonstrate the basic varieties in the spectral shapes across the visible toshortwave infrared (350–2500 nm) wavelength ranges. These are examples from 33 species measured from various locations in study areas. Figure 4 also presents examples of spectral reflectance's from 10 dominant tree species of peat-forest in SWIR wavelength (1000-1800 nm) with special characteristic of Tumeh (*Combretocarpusrotundatus*) which was always in lowest reflectance values than other tree species such as Belangeran (*Shoreabelangeran*), Gerunggang(*Cratoxylon* sp.), Jelutung (*Dyeracostulata*), KayuHitam (*Dyospiros* sp.), ManggisHutan (*Garcinia* sp.), Ramin (*Gonystilusbancanus*), Mahang (*Macaranga* sp.), Nyatoh (*Palaquium* sp.), and KayuPelawan (*Tristaniamaingayi*).

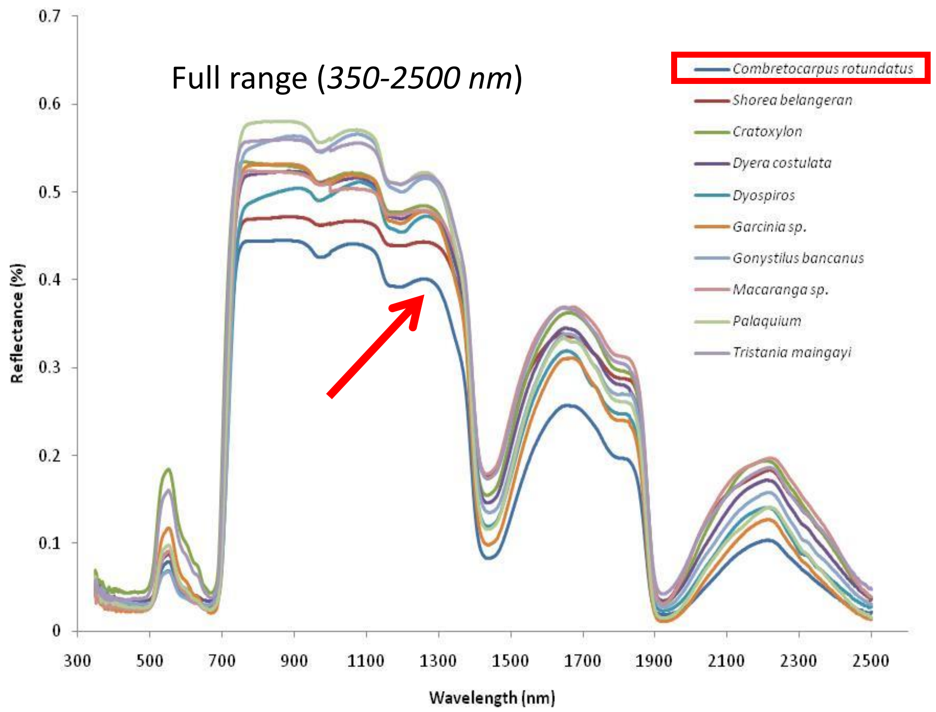

Figure 3. Spectral reflectance's from 10 species of peat-forest in full-range wavelength (350 – 2500 nm)

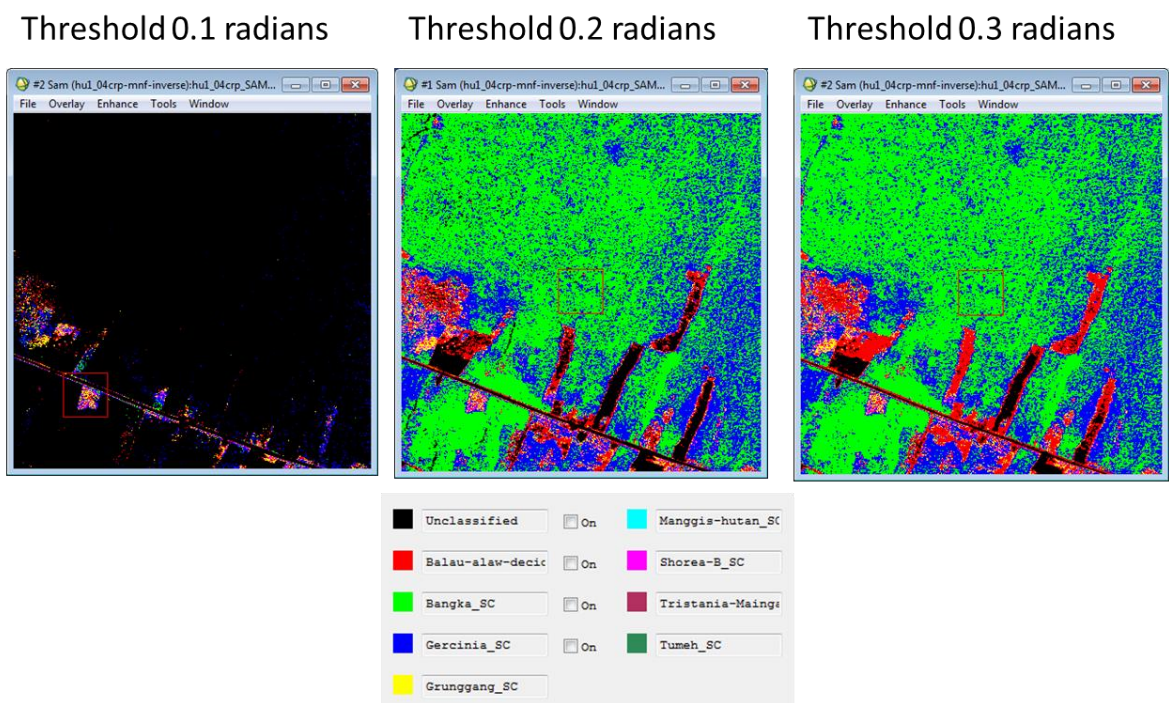

Figure 4. Statistic result of classification image using Spectral Angle Mapper (SAM) using Hymap sensor at Hampangen Educational Forest of UNPAR
(*Source: LadjuGandarum, BPPT*)

As shown in Fig. 3, the variability's are caused mainly by the spatial in-homogeneities of canopies and species. If we made a series of measurements without moving the spectrometer, the variability (caused by noise and possible changes in illumination) was several times less (Andres Kuusk*et al*., 2004; Abbasia*et al*., 2008). As shown in Fig. 4, statistic result of classification image using Spectral Angle Mapper (SAM) using Hymap sensor at Hampangen Educational Forest of UNPAR also gave the interesting results (source: LadjuGandarum, BPPT). This method using SAM is a classification image showing the best SAM match at each pixel and a rule image for each end-member.

However, even though very important, leaf optical properties alone are not adequate to explicitly spectrally distinguish tree species such as in peat-forest ecosystem in Central Kalimantan. Also other canopy components such as bark branches, twigs and understory must to be considered.

Conclusion/Discussion

Spectral analysis and measurements were performed during the field campaign to 33 vegetation species spectra and found that the vegetation spectra are very sensitive to environmental parameters such as leaf condition, vigorous and other physiological and biochemical parameters.Spectral libraries are data archives that consist of spectral signatures measured on selected natural and/or man-made materials. These libraries should also include the corresponding meta-information on the records. There are in principle two potential purposes: the use of the data in remote sensing as in-situ radiance/reflectance measurements for the calibration and/or end-members selection for further data processing (Selige*et al*. 2006).

The knowledge gained from laboratory and field studies of vegetation spectra and laboratory spectral analysis methods are directly applicable to remote sensing data.This analyses highlights the possible integration of in-situ hyperspectral measurements with airborne/space-borne hyperspectral remote sensing data for automatic identification and discrimination of various species/vegetation on the study areas.

The continually updated of spectral library in peatland forest provides initial collections of spectra covering the wavelength range 350–2500 nm that allows for the modeling of basic vegetation and land-cover properties by statistical inference.This study has produced the first preliminary spectral library of the dominant forest tree species of the peat-forest in Central Kalimantan (Indonesia) taking intoaccount the range of spectral variability expected for the species measured under natural illumination conditions.

Meanwhile, spectral libraries from ground measurements and hyperspectral sensors (Hymap) can collect continuous spectral reflectance data with narrow that enable classification of peat-forest types, discrimination of plant/tree species (through biophysical parameters), forest degradation, soil types and so on could support the integrated Measurement, Reporting and Verification (MRV) of Reducing Emissions from Deforestation and ForestDegradation (REDD) programs in Indonesia. Monitoring systems that allow for credible measurement, reporting and verification of REDD+ activities are among the most critical elements for the successful implementation of any REDD+ mechanism.

Acknowledgement

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ANALYSIS OF REGIONAL GROUNDWATER MOVEMENT IN THE BLOCK-C NORTH AREA: PRESENT, PAST AND FUTURE

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Block-C team in Carbon Management 1-1 group (CM-1-1) have continued investigating hydrological environment for Block-C North area. The main objectives of Block-C team are 1) to clarify the hydrological and hydrogeological characteristics of peatland in this area, 2) to evaluate the change of groundwater condition after the Mega Rice Project, and 3) to estimate the dam efficiency to keep the shallow groundwater level high in peat layer through numerical study. There is an aquitard between the upper peat layer and the lower sand layer, which separates the shallow aquifer from the deep aquifer. The drilling data in this area supports the existence of the aquitard. Shallow groundwater in peat layer is recharged by rain and horizontally moves along ground surface to the rivers or drainage canals, and penetrates through silt layer to recharge deep groundwater. Meanwhile, deep groundwater in sand layer flows horizontally toward the rivers affected by river and drainage canal water level. The model could recreate the present groundwater condition very well. According to the calibrated model, groundwater level in peat layer decreased more than 2m below surface near Kalampangan Canal during the 2009 drought period when the severe wild fire occurred. Before the Mega Rice Project, the groundwater potentials were higher than the present. Calculated past groundwater level in peat layer was shown at least 1m higher than the present water level near the Kalampangan Canal even in 2009 drought period. In case that several proposed dams are constructed along the Kalampangan Canal, the dam efficiency to keep high water level in peat layer was estimated more than 10cm within 400m from the canal even in the 2009 drought period.

Keywords: peatland, groundwater model, simulation, dam efficiency

Introduction

A major problem facing Southeast Asian countries is the issue of peatland fires. Peatlands in their natural condition do not burn, unless a very severe drought occurs. Burning occurs when peatlands are indiscriminately and excessively drained for agriculture or forestry activities. Excessive drainage in peat results in the loss of water and irreversible drying up of peat. Dry peat materials are extremely susceptible to fire especially in the dry season. To prevent fires in peatlands it is necessary to reverse the drying of peatlands through rehabilitation of degraded peatlands and blocking of canals that drain the peat area (APFP, 2011; Wöstem *et al.*, 2008).

Block-C team in Carbon Management 1-1 group have continued investigating hydrological environment for Block-C North area (Ishii *et al.*, 2011). Block-C North Area is located about 20km toward the southeast from Palangka Raya in Central Kalimantan. Study area is situated between Kahayan River and Sebangau River and the area is mainly composed of peatland. There are two main drainage canals in Block-C North area constructed with the Mega Rice Project: the Kalampangan Canal and the Taruna Canal. The Kalampangan Canal connects with shortest line between Kahayan River and Sebangau River. On the other hand the Taruna Canal starts at the junction with the Kalampangan Canal to the southeast direction.

Peatlands in Block-C is dome shaped, with an elevation that increases from sea level at the coast to only some 30m above sea level 200 km inland. Sand, gravel and clay deposits of fluvial origin underlie these peatlands (Sieffermann *et al.*, 1988).

The main objectives of Block-C team are 1) to clarify the hydrological and hydrogeological characteristics of peatland in this area, 2) to evaluate the change of groundwater condition after the Mega Rice Project, and 3) to estimate the dam efficiency to keep the shallow groundwater level high in peat layer through numerical study.

Regional groundwater movement

Groundwater and canal water level monitoring

To know the present groundwater condition, 32 observation wells for the shallow groundwater (5m in depth), 6 wells for the deep groundwater (around 20m in depth) and 12 canal water level measuring sites were constructed and installed water level data loggers to the all sites in 2010. These observation sites are shown in *Figure 1*. The weather station is located at the Base Camp of the University of Palangka Raya adjacent the bridge of Trans-Kalimantan Road across the Kalampangan Canal. The coordinates and altitude for all sites are determined by the static GPS survey in 2010 and 2011 (Yamamoto *et al.*, 2011).

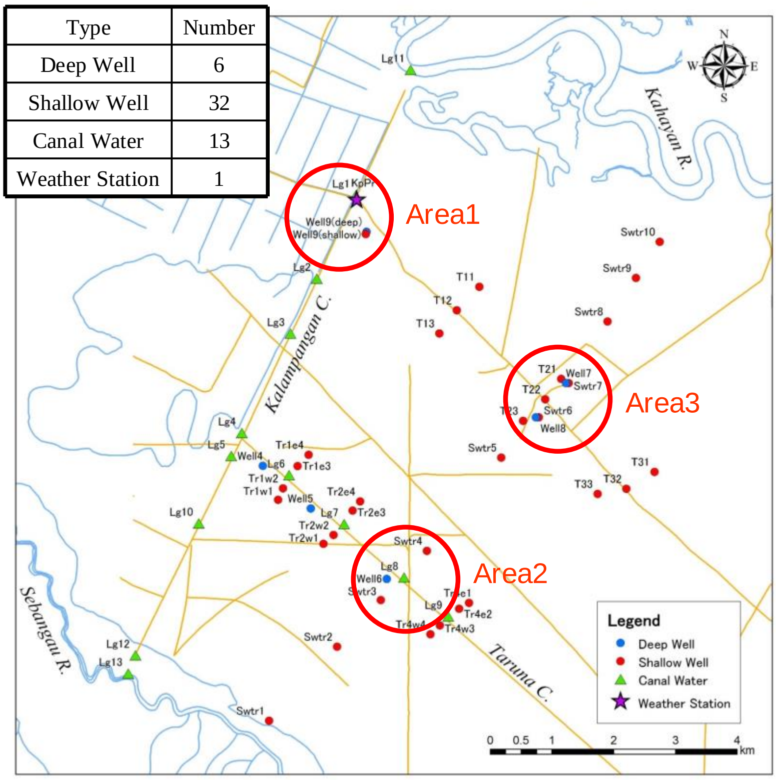


Figure 1. Observation sites in Block-C North Area

Field observation data show the water levels in shallow and deep wells have different seasonal variation patterns. *Figure 2* is the time series of water level changes in Well9 (Shallow and Deep) and Lg1 (almost the same water level as Lg11 adjacent Kahayan River) with rainfall data from July 2010 to May 2012 at the Base Camp.

The water level in Well9 shallow clearly increases in response to significant rainfall events. Meanwhile, the water level in Well9 deep shows slower changes, similar to the Lg1 (Kahayan River) water level. This tendency can be recognized in almost all study area means that there is an aquitard between the upper peat layer and the lower sand layer, which separates the shallow aquifer from the deep aquifer. The drilling data in this area supports the existence of the aquitard.

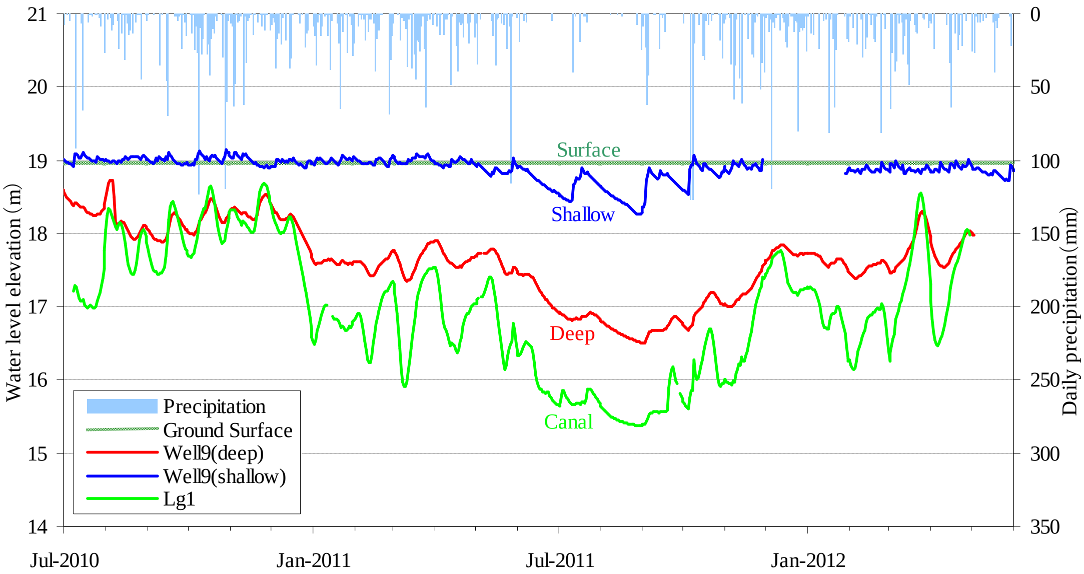


Figure 2. Water level changes in Well9 (Shallow and Deep) and Lg1 with rainfall data

Hydrogeology in study area

Based on analysis of field survey and previous studies, hydrogeological model was constructed for this area. The typical hydrogeological structure in study area is schematized in *Figure 3*.

There are 2 aquifers (shallow and Deep) and 1 aquitard up to 50m in depth. Shallow aquifer composed of Peat I/Alluvial (Peat II) and deep aquifer composed of Sand are separated by aquitard of silt. Deep aquifer has sufficient capacity of groundwater and local people depend on the water in this aquifer for their consumption both as domestic and firefighting purpose.

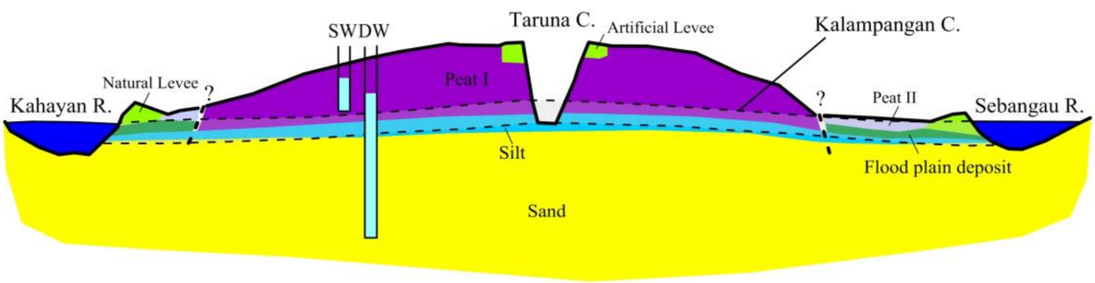


Figure 3. Schematic diagram of hydrogeology in study area

Numerical simulation

Groundwater model and calibration of present condition

The code selected to simulate the regional groundwater flow condition in study area is MODFLOW; a saturated modular three-dimensional finite difference groundwater flow model developed by the U.S.Geological Survey. The application for pre-/post-processing is Visual MODFLOW (Waterloo Hydrogeologic, Inc.).

The unsaturated zone is of considerable importance to wetland hydrology because it provides the link between net surface flux and water table response (Boswell and Olyphant, 2007). However, unsaturated zone dynamics is simplified by tank model, and the result from tank model input to the groundwater model as recharge, because the information for the unsaturated zone in study area is limited and main objective is to estimate the dam efficiency keeping the shallow groundwater level high in peat layer.

Tank model for the study area is composed of two vertical tanks (*Figure 4*). First tank represents surface and unsaturated layers. Second tank represents shallow aquifer and can simulate water level in shallow aquifer. Daily recharge can be estimated vertical outlet from first tank. Input rainfall used is the data at the Base Camp and daily evapotranspiration in peatland is assumed constant value of 4.0mm/d based on previous studies (Hooijer *et al.*, 2008) and empirical formula. Tank model structure shown in *Figure 4* could sufficiently recreate water level change in Well9 shallow very well.

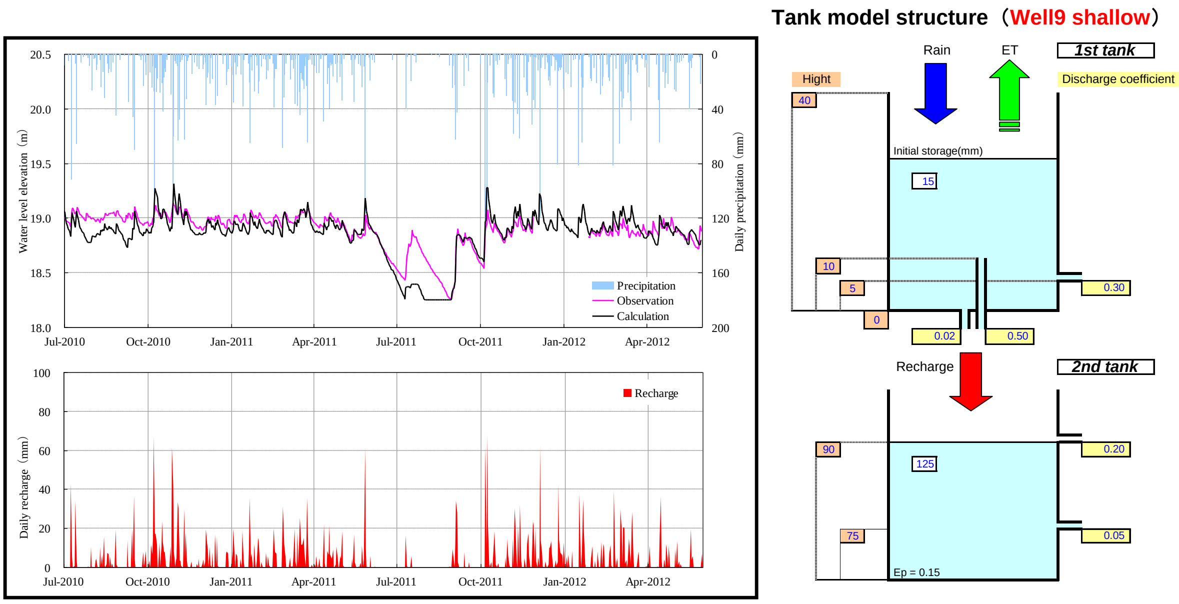


Figure 4. Tank model structure and the results of the tank model calculation

The area selected for the groundwater model is shown in *Figure 5*. The horizontal range contains the whole region of the study area along 21.4km in X direction, 18.2km in Y direction and 389.48km^2 in area, respectively. The model domain was discretized with a uniform 100m x 100m square grid. The developed groundwater model consists of 2 aquifers and 1 aquitard. The model grid is formed of 116,844 cells (214 columns x 182 rows x 3 layers), including the inactive area.

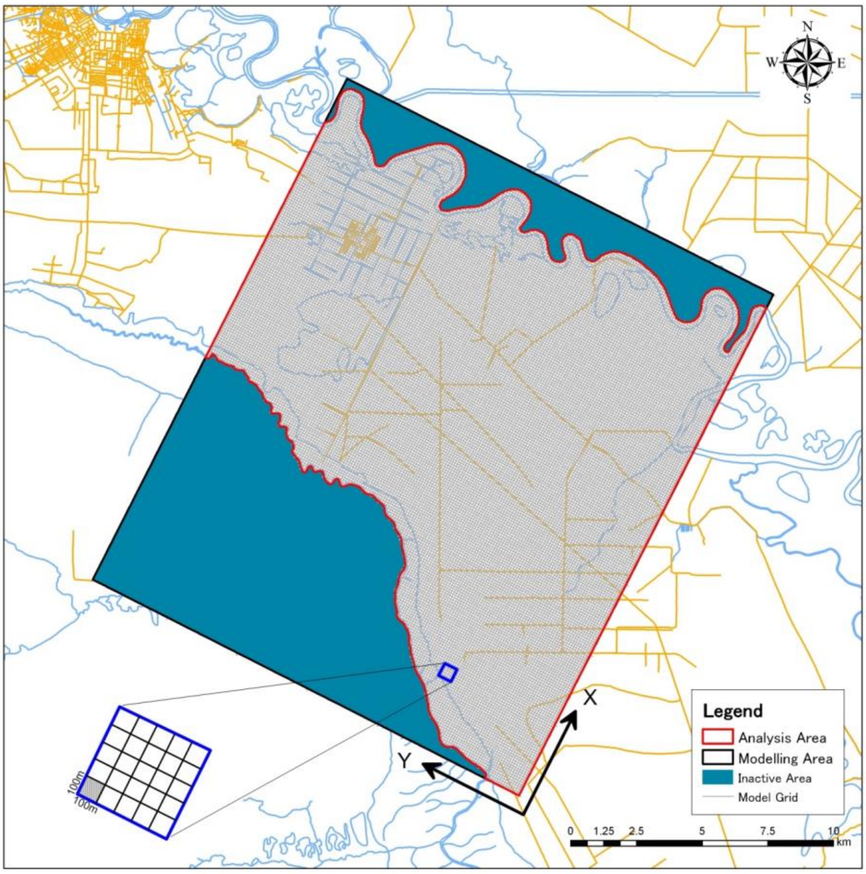


Figure 5. Modelling area and analysis area with model grids

The interpolated elevation data from static GPS survey, Airborne Laser Scan (Kalteng Consultants, 2009) and SRTM were imported to the top layer of the model. Basement of the model sets -200m above sea level so as to have sufficient thickness for minimizing the impact to the model calculation and to be able to evaluate the regional groundwater movement in deep aquifer. It is assumed that the silt layer is 3m below surface from survey data and distribute over the whole area in the model, and the bottom of the silt layer is flat because the information for the thin silt layer act as aquitard is limited. Hence the thickness of the silt layer becomes thinner in accordance with lowering of the surface elevation.

Analytical area is bounded to the north-east by Kahayan River and to the south-west by Sebangau River. The model simulations employed time-variant specified head boundary conditions for these two river boundaries. However, there is no hydrologic divide such as rivers or canals in the south-east and north-west boundaries and the groundwater can flow into/out through them. General Head Boundaries (GHB) is head-dependent flux boundary, provides a way to simulate the effects of a far-away boundary in a small model domain. The water level at the GHB of the model cell has to be specified, but this water level is actually representative of the head at a defined distance. For the south-east and north-west boundaries, the GHBs are introduced. The constant values as hydraulic heads at the boundaries extrapolated from the results of field survey were specified in this case.

A three-dimensional visualization of the model grid with boundary conditions is shown in *Figure 6*.

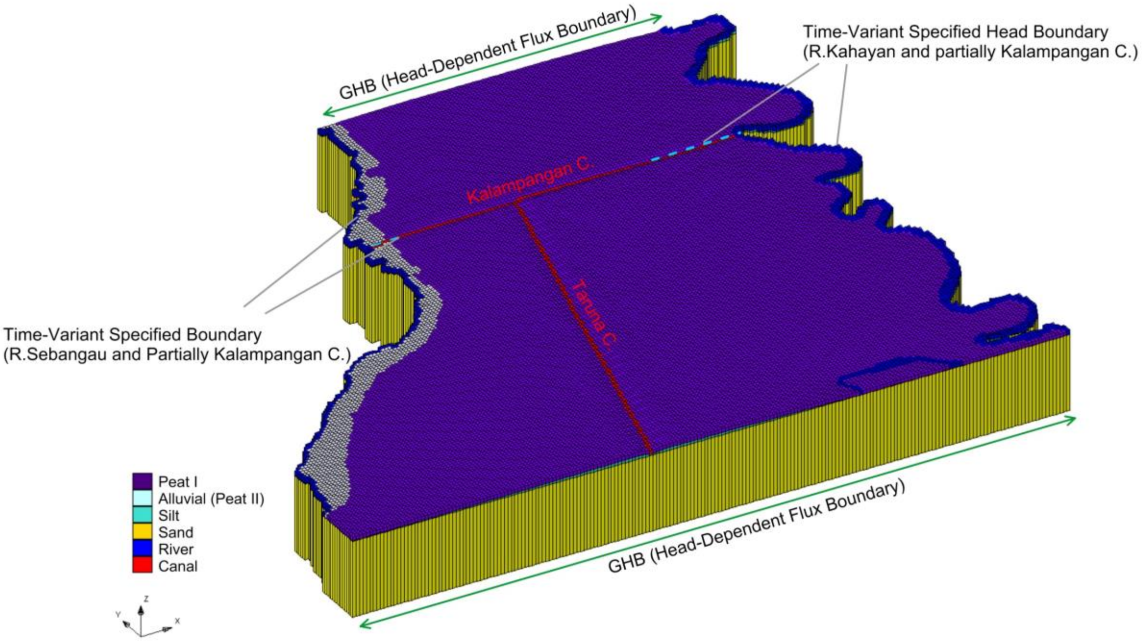


Figure 6. Three-dimensional visualization of the model grid with boundary conditions

Analytical condition for model calibration is summarized in *Table 1*. Transient simulation was carried out from July 2010 to May 2012. The groundwater model was calibrated to fit measured water levels in observation wells to improve the precision of the model.

Table 1. Analytical condition for model calibration

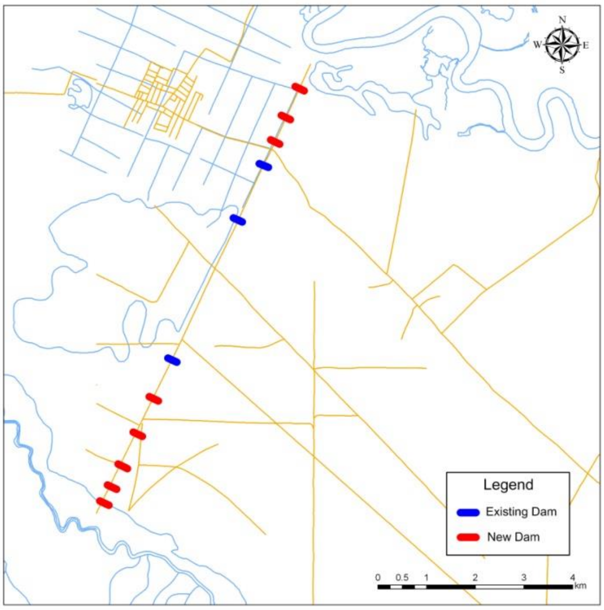
Application (Code)	Visual MODFLOW (Schlumberger Water Services) (MODFLOW: Finite Difference Method)
Simulation Method	Transient Simulation
Analysis Period	2010.7 - 2012.5
Time Step	1day
Boundary Conditions	Canal and River Water Level, GHB
Recharge	Estimated Value from Tank Model
Initial Condition	Steady State Groundwater Potential Distribution
Calibration Target	Water Level Changes in Observation Wells

Using the calibrated model, predictive numerical studies for groundwater situation in severe drought condition are carried out as following three cases: (1) before the Mega Rice Project (MRP); (2) present canal and dam conditions; and (3) after proposed dams construction.

"(1) Before the MRP", both of the Kalampangan and Taruna canals did not exist. Groundwater movement had been dominated by shape of ground surface and natural boundary conditions. To calculate this case, grid cell elevations correspond to canals in the groundwater model were modified so as to represent the ground surface before digging canals.

After MRP, two main canals were dug and many dams were constructed along the canals to prevent peatland water from draining. However, plenty of dams were destroyed by flood and only three effective dams are remaining. "(2) Present canals and dams conditions" is the case for evaluating the change of groundwater condition after the Mega Rice Project. CM-1-1 is planning new 8 dams along Kalampangan canal (*Figure 7*). "(3) After proposed dams construction" is the case for estimating the dam efficiency to keep the shallow groundwater level high in peat layer.

The predictive studies were carried out on Jan 2009 to Mar 2010 including 2009 drought period when severe wild fire occurred.



Case No.	Condition
1	Before the Mega Rice Project
2	Present Canal and Dams Condition
3	After Proposed Dam Construction

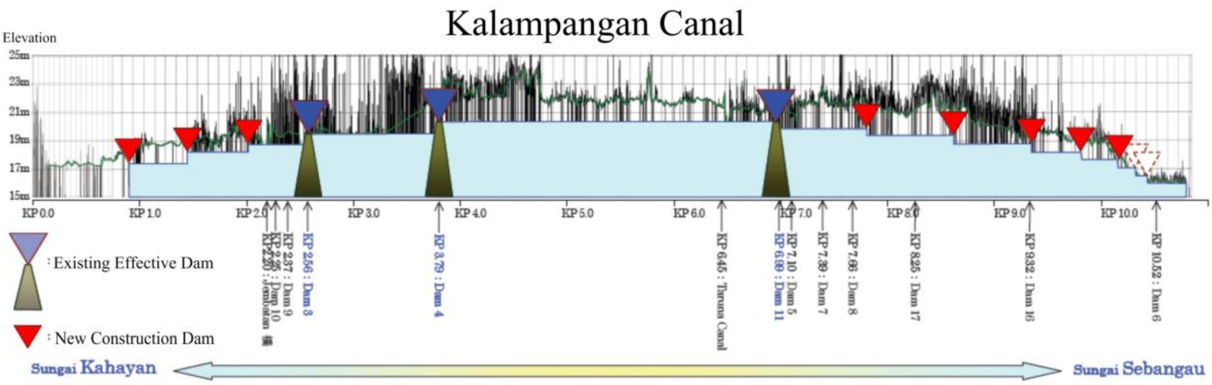


Figure 7. Predictive numerical cases and proposed dams location

Results and discussion

1) Validation of present groundwater movement

Based on previous studies as reported by Susilo and Yamamoto (2010) and Wöstem *et al.* (2008), initial hydraulic conductivity was assigned to each layer. Final hydraulic parameters, after calibration, are listed in *Table 2*. Hydraulic conductivity in sand layer resulted in one order higher than Peat I layer. Vertical conductivities set 1/10 of horizontal conductivities to all layers.

Table 2. Final hydraulic parameters

Layer	Horizontal Conductivity kx,ky (m/s)	Vertical Conductivity kz (m/s)	Specific Yield Sy (-)	Specific Storage Ss (1/m)
Peat I	1×10^{-5}	1×10^{-6}	0.2	1×10^{-5}
Alluvial (Peat II)	5×10^{-4}	5×10^{-5}	0.35	1×10^{-5}
Silt	1.5×10^{-7}	1.5×10^{-8}	0.2	1×10^{-5}
Sand	7×10^{-4}	7×10^{-5}	0.15	5×10^{-5}

The results of the repeatability in time series for each aquifer in three different areas are shown in *Figure 8 - 10*. The observed groundwater level for each aquifer shows a seasonal variation from July 2010 to June 2011 and decline during drought period until Sep 2011. Water levels gradually recover to almost the same level before declining. Model can represent these seasonal variations and long-term tendency very well. The depressing of groundwater level in drought period can be recreated by the appropriate recharge and boundary conditions.

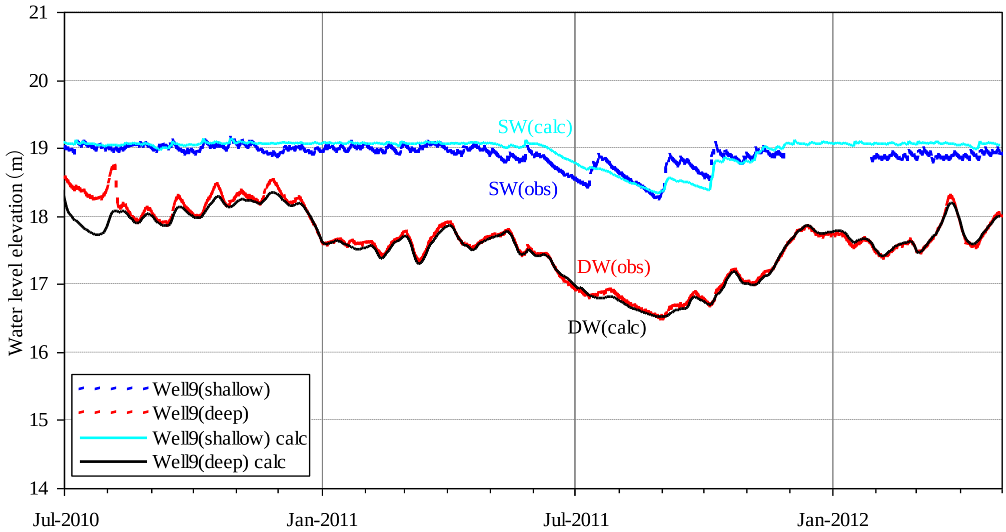


Figure 8. Results of the repeatability in time series for each aquifer in Area1

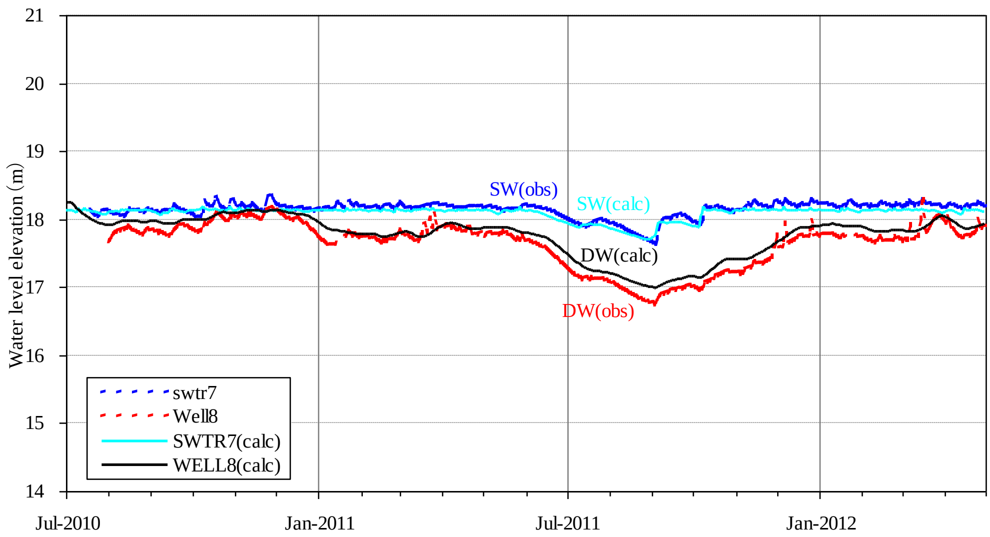


Figure 9. Results of the repeatability in time series for each aquifer in Area2

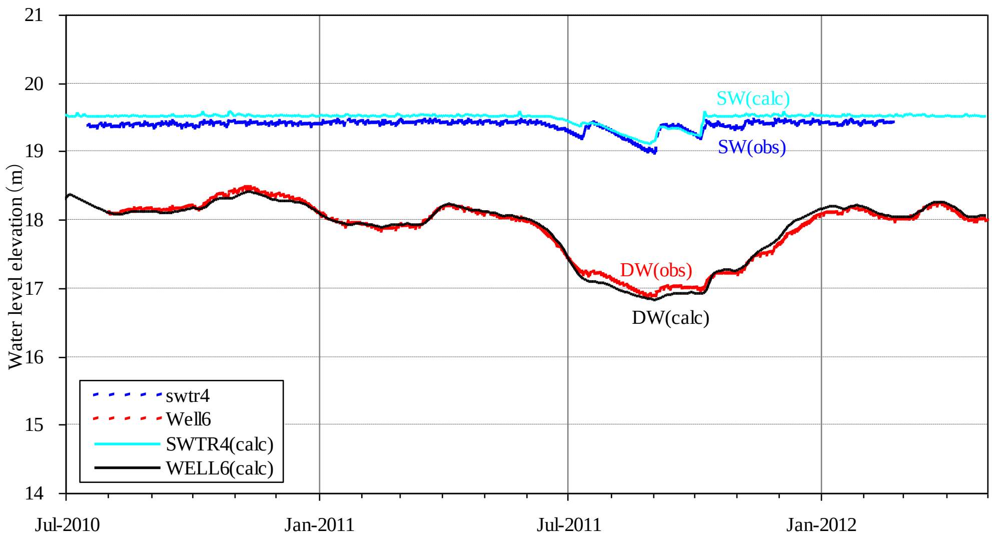


Figure 10. Results of the repeatability in time series for each aquifer in Area3

Planar distributions of groundwater potentials in each layer for rainy period and draught period are summarised in *Figure 11*. Groundwater potentials in both aquifers are generally affected by shape of ground surface.

Calculated data shows groundwater potential in shallow aquifer is always higher than that of in deep aquifer and gradually degreases to the rivers or the canals. That is, shallow groundwater in peat layer is recharged by rain, horizontally moves along ground surface to the rivers or drainage canals and vertically penetrates through silt layer to recharge deep groundwater. Meanwhile, ground water in deep aquifer flows toward the rivers affected by rivers and drainage canals water levels.

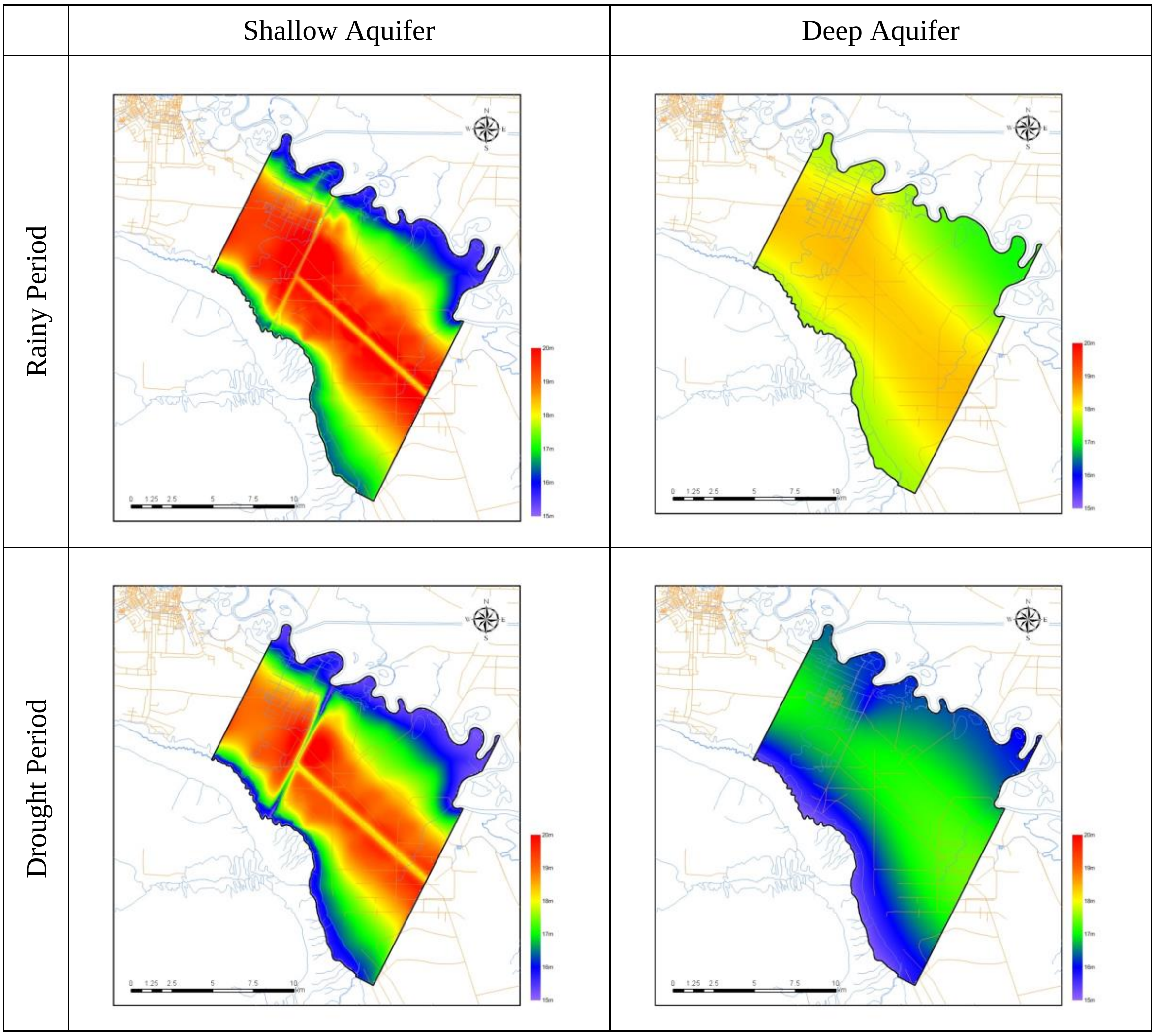


Figure 11. Planar distributions of groundwater potentials in each layer for rainy period and draught period

2) MRP Impact and dam efficiency after proposed dam construction plan

In 2009, severe wild fires occurred in central Kalimantan including Block-C area. To know the shallow groundwater condition on such circumstance, the time series for three cases at Well9 (located in wild fire area) are compared in *Figure 12*. Model prediction shows the groundwater in shallow aquifer might drawdown more than 1m below surface (case2). On the other hand, if there are no canals, water level might keep just only 40cm below surface even in severe drought period. After the proposed dam construction, water level might drawdown around 90cm below surface. However, the well9 located more than 400m apart from Kalampangan Canal, it is difficult to evaluate the dam efficiency.

Figure 13 shows the planar distributions of groundwater potential in three cases at evaluating time. The lowest water level is Case2. Case1 and Case2, 3 have clearly different distribution of groundwater potentials especially the area in the vicinity of drainage canals. Groundwater potentials of Case1 were higher than those of Case2 and Case3 and eventually near the Kalampangan Canal, heads keep near the surface. The heads decreased in Case2 and Case3 more than 2m below surface near Kalampangan Canal. Head distribution of Case2 and Case3 considerably resembles except for the area in the vicinity of Kalampangan Canal. Case3 heads were higher than Case2 near the Kalampangan Canal causing dam efficiency.

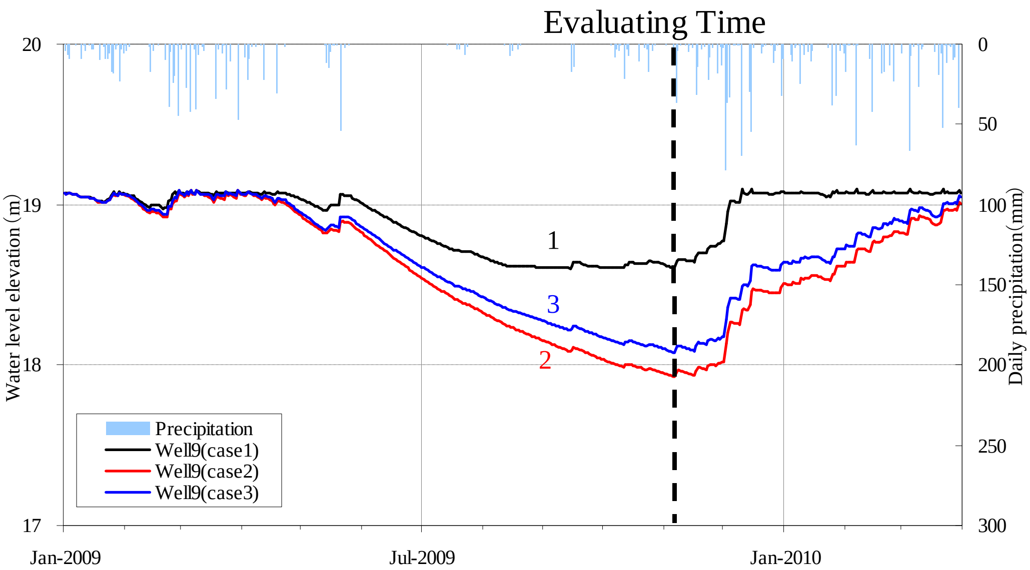


Figure 12. Time series for three cases at Well9

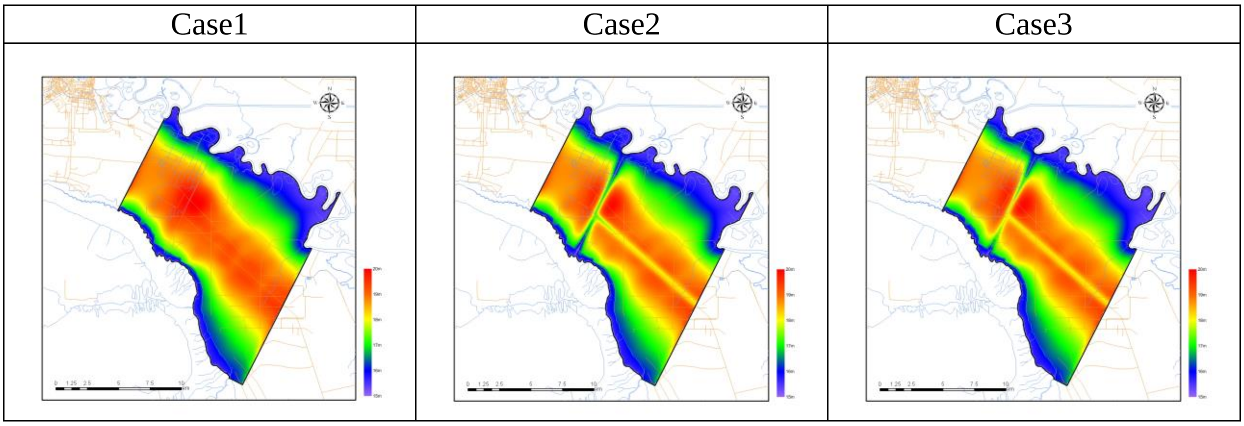


Figure 13. Planar distributions of groundwater potential in three cases at evaluating time

To confirm the detail of dam efficiency, heads difference map between Case3 and Case2 were drawn at evaluating time (*Figure 14*). X-X' is the cross section passing Well9. The dam efficiency to keep high water level in peat layer was estimated more than 10cm within 400m from the Kalampangan Canal even in the 2009 drought period.

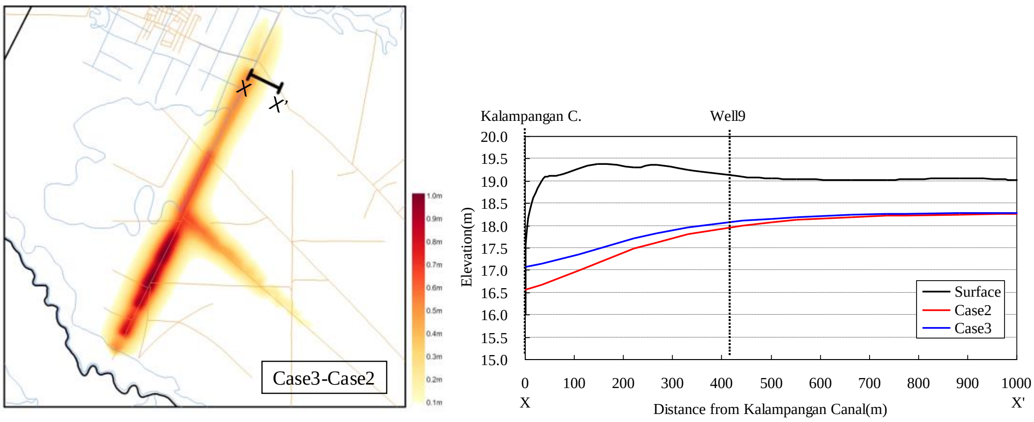


Figure 14. Heads difference map between Case3 and Case2 at evaluating time (left) and cross sectional diagram at X-X'

Summary

CM-1-1 team could clarify the hydrological and hydrogeological characteristics of peatland in this area. Hydrogeology and groundwater movement are as follows:

1. There is an aquitard between the upper peat layer and the lower sand layer, which separates the shallow aquifer from the deep aquifer. The drilling data in this area supports the existence of the aquitard.
2. Shallow groundwater in peat layer is recharged by rain and horizontally moves along ground surface to the rivers or drainage canals. Deep groundwater in sand layer flows horizontally toward the rivers affected by river and drainage canal water level.
3. Shallow groundwater penetrates through silt layer and recharges deep groundwater.

The change of groundwater condition after the Mega Rice Project was evaluated and the dam efficiency to keep the shallow groundwater level high in peat layer was estimated through numerical study. The results of simulation are summarized as follows:

1. The model could recreate the present groundwater condition very well. This means the hydrogeological assumptions are correct.
2. According to the calibrated model, groundwater level in peat layer decreased more than 2m below surface near Kalampangan Canal during the 2009 drought period when the severe wild fire occurred.
3. Before the Mega Rice Project, the groundwater potentials were higher than the present. Calculated past groundwater level in peat layer was shown at least 1m higher than the present near the Kalampangan Canal even in 2009 drought period.
4. In case that several proposed dams are constructed along the Kalampangan Canal, the dam efficiency to keep high water level in peat layer was estimated more than 10cm within 400m from the canal even in the 2009 drought period.

Acknowledgement

This study was carried out as a part of the research project, "*Wild Fire and Carbon Management in Peat-Forest in Indonesia*" supported by the JST-JICA. The authors would like to express their sincere thanks to the editors for their constructive comments, which were very helpful in improving the quality of the report.

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Appendix

Translating MRV Ideas into Implementation on the Ground: SAPPORO Initiative's Proposal

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Content

List of Abbreviations

C	Carbon
CDM	Clean Development Mechanism
COP	Conference of the Parties of the United Nations Framework Convention on Climate Change
DNPI	National Council on Climate Change – Indonesia
EB	Executive Board
GIS	Geographic Information System
GPG	Good Practice Guidelines
HR	High resolution
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MRV	Monitoring, Reporting and Verification
PDD	Project Design Document
QA	Quality Assurance
QC	Quality Control
REDD+	Reduction of Emissions from Deforestation and Forest Degradation including sustainable forest management
REL	Reference Emission Level
UAV	Unmanned Airborne Vehicle
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VER	Verified Emission Reduction
VHR	very high resolution

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The authors express great thanks for foundation by JSPS Core University Program between Hokkaido University, Japan and Research Center for Biology (LIPI), Indonesia on " Environmental Conservation and Land Use Management of Wetland Ecosystem in Southeast Asia" from 1997 to 2006, and by JST-JICA program on "Wild fire and Carbon Management in Peat-Forest in Indonesia" from 2008 to 2014, for which more than 200 scientists and also 200 students have been jointing. This book based mainly on results of these two long term projects. The authors express also great thanks for main contributors in these projects: G. Inoue (Research Institute for Humanity and Nature (RIHN), Japan), B. Setiadi (National Standardization Agency of Indonesia, (BSN), Indonesia), H. Takahashi (Nonprofit Organization Hokkaido Institute of Hydro-climate, Japan), T. Hirano (Hokkaido University, Japan), T. Honma (Hokkaido University, Japan), W. Takeuchi (University of Tokyo, Japan), T. Kohyama (Hokkaido University, Japan), H. Simbolon (The Indonesian Institute of Sciences, Research Center for Biology (LIPI), Indonesia), S. H. Limin (CIMTROP of The University of Palangka Raya, Indonesia), A. Ito (National Institute for Environmental Studies, Japan), and H. Sekine (Mitsubishi Research Institute, Inc., Japan).

Executive Summary

The sustainable reduction of carbon emissions of Indonesia will produce positive and negative impacts which are not well understood today. However, a general change of behavior based on a better understanding of the pros and cons among the citizens and stakeholders is required. How this can be achieved (legally enforced, incentives, public advertisement, etc.), what the impacts of economically and politically may be and how the change of public perception will impact on the long term the political stability and economic welfare requires interdisciplinary research on many levels.

A challenge for tropical countries is an adopted forest management approach, linked to the key drivers of deforestation and forest degradation (e.g. agriculture, plantations, fuel demands, fires, settlements …) which can efficiently reduce the carbon emissions. Here, man-made drivers like low impact logging, fire prevention, agro-forestry, oil palm plantations, agriculture, settlements, infrastructure, etc. need to be addressed. This leads to the issue of improved **national spatial planning** efforts, as the focal point of all related issues.

In order to be fully compliant with the COP 16 Decision one of the key elements for REDD+ implementation is the development of a national **Monitoring, Reporting and Verification (MRV)** system for the carbon stocks and their development. This system is the guarantee that Parties will effectively meet their respective mitigation commitments under a new UNFCCC mechanism including REDD+. But it has to be fully integrated in the national spatial planning efforts to assure coherence across the provinces and sustainable development on all levels.

The three major components “Monitoring”, “Reporting” and “Verification” of the national MRV system require different measures and will need to be implemented in a phased approach.

First comes the “**Monitoring**” element which requires concrete measurements of past and recent carbon stocks based on a reliable measuring and monitoring system. For Indonesia an integrated Monitoring System is proposed based on a combination of repetitive field survey and multi-sensor (optical, SAR, LIDAR) / multi-scale (satellite & airborne) data, adapted to the main ecosystems (with emphasis on Peat-Land and Dry Land Forest). Such approaches can be combined in so-called multi-stage inventory concepts which can be applied at national, sub-national Level and on project level.

The **Reporting** and **Verification** elements rely on the results of the **Monitoring** component. In the present set-up they are addressed by the national **VER (Verified Emission Reduction) Registry Scheme**.

The **VER sector of Government** plays the role as the manager of the entire scheme, and the

responsibilities and structures of the operational committee are comparable to the United Nations Executive Board of the CDM and the VER Executive Body for certification. It is also responsible to enable the **rural communities** to participate in the REDD-plus project, to assure from the beginning:

1) their participation for project planning, MRV installation and implementation,
2) safeguards for their economical benefit,
3) their contribution for the sustainable rural development in the country.

PREFACE

This Draft was submitted to DNPI as a key manuscript of **" POLICY MEMO: Translating MRV Ideas into Implementation on the Ground: SAPPORO Initiative Proposal "**.

1. Introduction

The Draft decision [-/CP.16] of COP16 in paragraph 70 "Encourages developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following activities, as deemed appropriate by each Party and in accordance with their respective capabilities and national circumstances:

(a) Reducing emissions from deforestation;
(b) Reducing emissions from forest degradation;
(c) Conservation of forest carbon stocks;
(d) Sustainable management of forest;
(e) Enhancement of forest carbon stocks"

This decision paves the floor on world-wide level for the implementation of the so-called "Reducing Emissions from Deforestation and Forest Degradation (REDD+)". It is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development and including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

However, the interaction between land use/land cover dynamics and their impacts to the carbon flux is poorly understood. This is due to the lack of appropriate information baselines on the dynamics and impacts and missing of comprehensive means linking socioeconomic and institutional drivers of these changes. Here, a number of challenges that can influence land use changes include energy production, forestry land conversion, sustainable patterns of production systems, risk and vulnerability assessment, urban governance, and technology innovation within the overall perspective of climate change. Of particular importance is the need for extensive and dependable monitoring of the extent of avoided land use/land cover changes across space and time.

Achieving truly climate-compatible development will require substantial changes to Indonesia's economic structure, its land-use planning, and its government policy. It will also require a new mindset focused on long-term, environmentally-sustainable development taking hold within the government, the business community, and the non-profit sector.

A principal goal of the low carbon growth strategy is to ensure that the people of Indonesia do not achieve reduced emissions at the cost of reduced growth. Additional financing will be needed to underwrite the considerable investments associated with the transition to a climate-compatible development path. Some of that financing will likely be provided by the domestic government, some by international donor agencies covering opportunity cost of stakeholders, some by future carbon trading and some by the private sector as companies see the potential to generate positive returns.

A number of challenges may influence the success of the implementation of a low carbon economy including policy design, data acquisition and management, technology and technical capacities as well as institutional mechanisms among key agencies operated at different level of governance. Therefore, there is a need to establish further strategic efforts to mobilize expertise and resources of interested countries in the area of science, policy and implementation of the broader issues of low-carbon development.

The National Council on Climate Change – Indonesia (DNPI), Hokkaido University, University of Freiburg and potential affiliated partners initiated the “SAPPORO Initiative”. This initiative aims to create a comprehensive information baseline on existing condition and trends (covering social, economic and environmental aspects) in Indonesia utilizing GIS and spatial/remote sensing data, especially for the assessment of land use and land cover changes. This shall assure that adaptation and mitigation activities are implemented considering scientifically sound, technically feasible and economically efficient MRV means. This baseline will be substantiated by field survey and - at the micro level - by observations and contributions from local communities. A process of stakeholder engagement for consensus building and acceptance will also be part of the Initiative.

2. Framework Conditions

2.1. International Framework

In response to the COP 16 decision Indonesia’s Government is encouraged to contribute to mitigation actions in the forest sector. Hence, Paragraph 71 of the COP 16 decision requests developing country Parties to develop the following elements:

(a) A national strategy or action plan;
(b) A national forest reference emission level and/or forest reference level
(c) A robust and transparent national forest monitoring system for the monitoring and reporting of the activities referred to in paragraph 70 above,
(d) A system for providing information on how the safeguards are being addressed and respected throughout the implementation of the activities

In order to translate the COP 16 Decision into national actions one of the key elements for REDD+ implementation is the development of a national Monitoring, Reporting and Verification (MRV) system for the carbon stocks and their development. This system is the guarantee that Parties will effectively meet their respective mitigation commitments under a new UNFCCC mechanism including REDD+.

Any MRV system has to be compliant with the requirements of the Intergovernmental Panel on Climate Change (IPCC), developed on the request of the United Nations Framework Convention on Climate Change (UNFCCC), reflecting the most common and robust approaches currently available (UN REDD Newsletter 8). Summarizing these requirements, the MRV needs to address the following 5 principles:

a) **Consistency**: Information on carbon stocks shall be provided based on consistent data sources. However, in most cases in developing countries the use of heterogeneous data sources (especially looking into the past to establish base lines) will be the only technical feasible possibility rather than a systematic and consistent monitoring approach. The latter is only possible looking into the future once a national MRV is installed.

b) **Transparency**: Expert opinions, independent assessments or model estimations are commonly used as data. But it should be the goal of the country to establish a technically feasible and scientifically sound basis for national reporting with the involvement of science, public and policy.

c) **Comparability**: few countries have experience in using the IPCC Good Practice Guidelines (GPG) as common estimation and reporting format. However, setting up a national MRV in Indonesia most recent technology should be applied to achieve comparable results in the future.

d) **Completeness**: lack of suitable forest data is evident in Indonesia for both area change and changes in carbon stocks. The latter requires carbon emission factors at least for the main Indonesian forest types Peat Land and Dry Land Forests.

e) **Accuracy**: Although in the past limited information on the uncertainty and error sources of estimates could be provided by countries, there are well established approaches to analyze, reduce, and deal with comprehensive error budgets in order to facilitate international reporting.

2.2. Key Drivers for a national MRV for Indonesia

A national MRV system based on IPCC guidelines shall comprise the following elements (Table 2-1)

Table 2-1: The three basic carbon-related MRV components and their relation to the IPCC Good Practice Guidelines

IPCC Elements	**Activity Data** (land representation)	**Emission factors** carbon stock changes	**Emission estimates** greenhouse gas emissions and removals
MRV System Elements	Satellite based land monitoring system	National forest inventory	National greenhouse gas inventory

Translating these international requirements into a national low carbon policy REDD+ will call at least for the following services

1. to establish "baselines" or Reference Emission Levels (REL) derived from historical information of land use, land use change and forestry (LULUCF), with an emphasis on forest area historical changes. This information has to be documented in benchmark forest maps and needs to be translated into carbon stocks of current and historical CO2 emissions.

   For the latter most critical for many tropical countries is the availability of emission factors which translate the area of a certain land use category (i.e. peat forests or Dry Land forests in different growth conditions, various species compositions, ages, forest cover densities, and affected by many external man-made impacts) into carbon stock equivalents. As in many cases this information can only be obtained by national forest inventories (as depicted in Table 2-1) a technically feasible and economically efficient sampling design needs to be established (see Annex II).

2. To manage land tenure and to set out a national « environmental cadastre ». This is key element of an integrated national spatial planning approach towards long-term sustainability of any national REDD+ implementation.

3. To control through the MRV that deforestation and degradation reduction objectives as well as carbon stock enhancement by reforestation and afforestation have been achieved.

Thus, in order to control all REDD+ related measures, to mitigate wrong developments once detected and to assure that financial compensation and benefits will reach all beneficiaries implementing the national MRV is a key element for the overall REDD+ implementation in Indonesia.

However, it has to be fully embedded in the national spatial planning activities based on state-of-the-art methods and economically feasible means to implement the necessary REDD+ mechanisms. It is the only way to allow the direct accounting of responsibilities and benefits to the local stakeholders involved. It is as well the focal point to integrate the various activities and to manage the various impacts and interactions on all levels.

2.3. Carbon stock information

The IPCC guidelines recommend that carbon stock information can be obtained at **three different Tier** levels which can use (1) IPCC default factors, (2) country specific data for key factors, and (3) detailed national inventory of key C stocks, including repeated measurements of key stocks through time or modeling. For each Tier a range of methods is available which differ significantly with respect to effort and operationality under tropical conditions. However, for any Tier IPCC expects that estimates should be accurate and uncertainties should be quantified and reduced as far as practicable. It is recommended that carbon stocks of key categories and pools should be estimated with higher tiers. The balance between accuracy/precision and effort should be guided by the principle of conservativeness i.e. a tier lower than required can be used – or a carbon pool can be ignored if the overall estimate of emission reduction is likely to be underestimated.

2.4. Reference Emission Levels (RELs)

An open issue in the international political discussion on REDD+ is the question of **Reference Emission Levels (RELs)** which can become a main cost driver for a MRV. RELs (including carbon sequestration) are needed as benchmarks to identify if national carbon reduction goals have been achieved and how they can be rewarded by the carbon market or international policy. They can be applied on different national scales, with different scopes and varying conceptual approaches. But they are needed for all accounting purposes and to fulfill voluntary of compulsory commitments. Hence, they need to address historic, recent and future carbon stock developments (dynamics). At the same time RELs have to be pragmatic and technically feasible to be accepted. As the negotiations on international level are still ongoing the recommendations or rules to follow have to be carefully monitored in order to assure compliancy and to avoid wrong investments.

In general, in developing countries a cost-effective monitoring and evaluation system for REDD+ requires a balanced approach of remote sensing (for activity data) and ground measurements (for the estimation of emission factors; see Table 2-1). Hence, key elements for an MRV system will incorporate satellite data, airborne/UAV measurements, and ground observations in an efficient and transparent way.

While activity data monitoring (i.e. land use, land use change and forestry- LULUCF) is relatively easy by remote sensing means, the assessment of forest degradation (i.e. forest remains forest but undergoes a certain reduction of biomass) and carbon stocks (especially in Peat Land Forests) is more challenging, and largely relies on ground measurements, complemented by very high resolution (VHR) remote sensing.

2.5. Carbon-offset Credit Systems

The credit used for carbon offset is referred to as VER (Verified Emission Reduction), differentiating it from the credits of the Clean Development Mechanism (CDM) of the Kyoto Protocol. Although the idea of carbon-offset is historically common in projects related to forests, it has penetrated into a wide range of fields such as clean energy including biomass energy. Particularly, the purchasing of carbon-offset credits of projects related to forests is an effort to prevent global warming which is familiar with citizens and companies in many countries.

The effort of carbon-offset which Future Forests Co. in Britain made in 1997 is known as the first example for such a project. Since then, efforts have multiplied and the size of the transactions in the carbon market has expanded (see ANNEX I – Japan's VER System).

3. The MRV system and Issuance Credits to REDD+ Projects

3.1. Key Ecosystems for applying the Issuance Credits to REDD+ Projects

Indonesia has several main forest ecosystems: (a) Peatland Forest, (b) Mangrove Forest, (c) Mid-Low land Forest, and (d) High land Forest. They can be classified into two Ecotypes: "Peat Land Forest" and "Dry Land Forest", according to water statue and organic matter accumulation. To establish the Issuance Credits to REDD+ Projects the methodology protocols of MRV and management of REDD+ projects need to be adapted to the specific conditions of these main Indonesian Forest Ecotypes.

Therefore, it is proposed that the Model of Issuance Credits to REDD+ Projects should be mainly established on Peat Land Forest and Dry Land Forest. In a later stage other forest types can develop their Model of Issuance Credit to REDD+ Projects by a modification of Peat Land Forest and Dry Land Forest, respectively.

3.2. Integrated Measuring/Monitoring System for MRV

The integrated Measuring/Monitoring System for the MRV is quite different between Peat Land and Dry Land Forests in a way that for each key ecosystem adaptations are required (see similarities and differences of MRV approaches for both Ecotypes in Table 3-1).

Table 3-1: Similarities and differences of MRV means for Peat Land and Dry Land Forests

	Peat Land Forest & Dry Land Forest
Similarities	• Deforestation monitoring • Forest Degradation monitoring • Afforestation/Reforestation monitoring
Differences	• Carbon stock monitoring • Carbon flux monitoring • Modeling and simulation on carbon budget

Especially Peat Land Forest is a very complex ecosystem highly regulated by water statue, and characterized by low resilience and high vulnerability. Hence, the Indonesian MRV needs to assure that sustainable forestry and land management, the afforestation and reforestation methods, and the rehabilitation and conservation methods take into account these issues.

In contrast, Dry Land Forest is ecologically totally different (e.g. in water statue, soil carbon content, in its land resilience (relatively high) and its land vulnerability (relatively low). Thus, for this ecotype an Integrated Measuring/Monitoring System will be less complex and the Measuring/Monitoring elements will be less expensive.

According to more than 10 years of field investigations from the **Hokkaido University, Japan** to characterize carbon fluxes in Peat Land Forests 8 key parameters are needed: (1) CO_2 Flux and CO_2 concentration, (2) Wild fire detection and Hotspot, (3) Forest degradation and Species mapping, (4) Deforestation and Forest biomass changes, (5) Peat-subsidence, (6) Water level and soil moisture, (7) Peat dome detection and Peat thickness, and (8) Water soluble organic carbon (Fig. 3-1).

For the measurement of these parameters and to monitor their development a complex combination of different sensors and field measurements is required. The installation of such a Peat Land Forest Monitoring System in the main Peat Land Forests of Indonesia will definitely require certain investments in a phased approach.

For the Dry Land Forest ecotype key parameters for the MRV system are: (1) CO_2 Flux and CO_2 concentration, (2) Wild fires detection and Hotspot, (3) Forest degradation and Species mapping, (4) Deforestation and Forest biomass changes, (5) soil characteristics (depths, soil moisture, and mineral content).

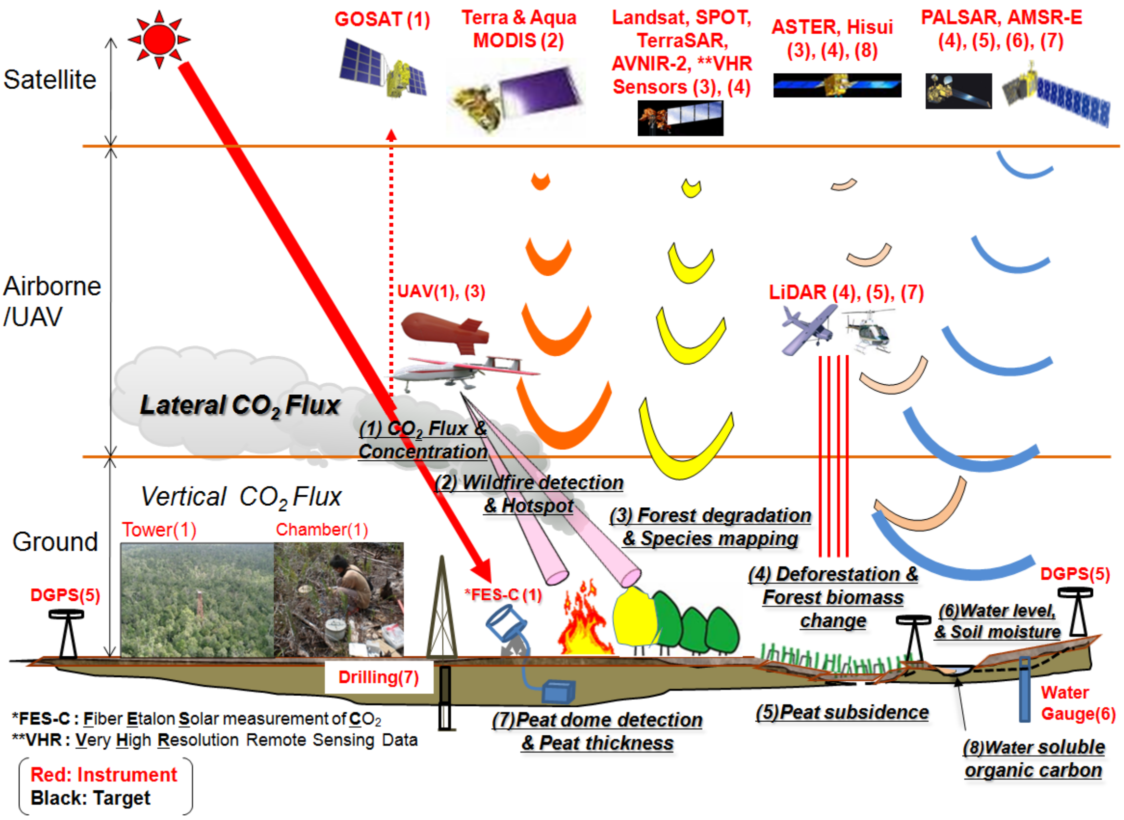

Fig. 3-1. Key Elements of the proposed MRV system for Peat Land Forests.

3.3. Functions of the MRV Institute

3.3.1. The Spatial Data and Service Infrastructure for the National MRV Centre

For the establishment of an Indonesian REDD+ Spatial Data and Service Infrastructure Centre which can fulfill the complex requirements of the national MRV system the following architectural components need to be considered (Figure 3-2):

(1) Technical Infrastructure

The technical infrastructure comprises all technical hardware and software components to assure data flow from various sources, data storage and retrieval, data analysis and reporting and the link to users via intranet and the Internet.

(2) Activity Data (e.g. deforestation / afforestation and forest degradation monitoring, peat specific information, etc.)

This aims to monitor the whole land of Indonesia by means of remote sensing combined with in-situ measurements in the framework of an integrated multi-stage inventory approach.

(3) Carbon stock modeling

The link between LULUCF information from remote sensing to carbon stock is achieved by Carbon Accounting models which combine spatially explicit information from remote sensing with carbon emission factors for the different land cover / use classes.

(4) Quality Assurance and Quality Control (Verification System)

For internal and external verification (e.g. for a reliable error budget estimation) of carbon stock estimates, as requested by IPCC, international donor organizations and the future REDD+ carbon stock market.

(5) Dissemination of Results

The results obtained by the above mentioned components need to be analysed and disseminated to various interest groups, such as the international climate change community (IPCC, Donors), the international stock market to allow the trading of carbon equivalents estimated by the monitoring system, the citizens interested in the progress of forest protection and the national efforts to reduce the overall carbon emission reduction rates the forest service to support / enforce the control of sustainable forest management across the country.

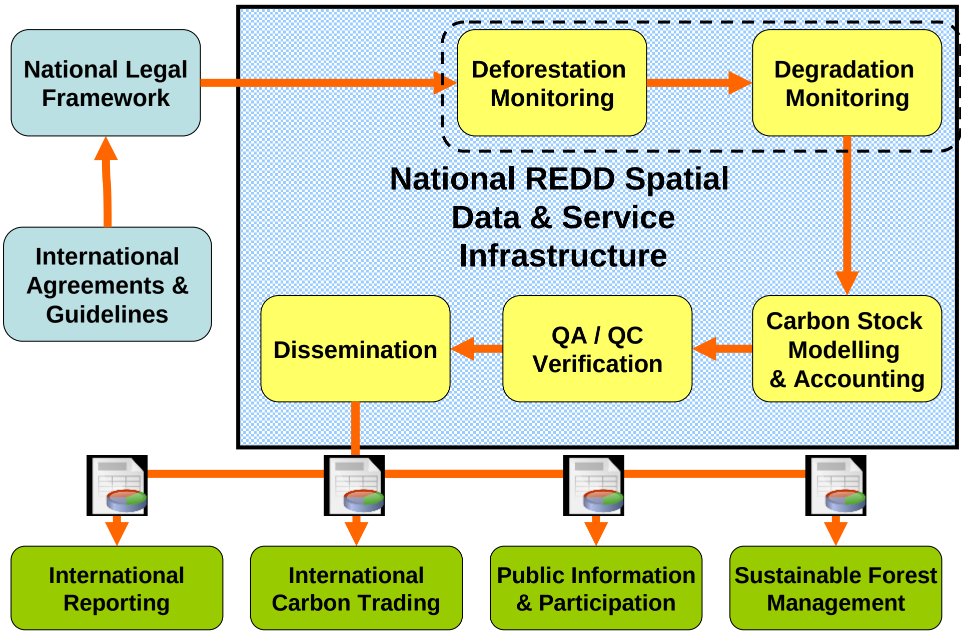

Figure 3-2: Main architecture elements for a national MRV Centre

3.3.2. Reference Emission Levels

One of the critical and crucial issues in establishing a robust MRV system is setting up **Reference Emission Levels (REL)**. REL are significantly important as the basis to measure the success of any intervention on actions to overcome the avoided emission of carbon from the terrestrial system as well as increasing sequestration of carbon from the atmosphere into the terrestrial system. The level of detail (scale) of an REL has to be defined at national and/or sub-national level, using results from wall-to-wall monitoring, statistical field sampling, and model-based simulations.

To estimate conversion rates of land cover categories (such as forests, agriculture, grasslands, settlements, etc.) the approach is straight forward. It is mainly based on time series of land cover change derived from optical satellite imagery. However, in regions frequently covered by clouds recent SAR imagery can support such approaches assuring data availability whenever needed (Fig. 3-4).

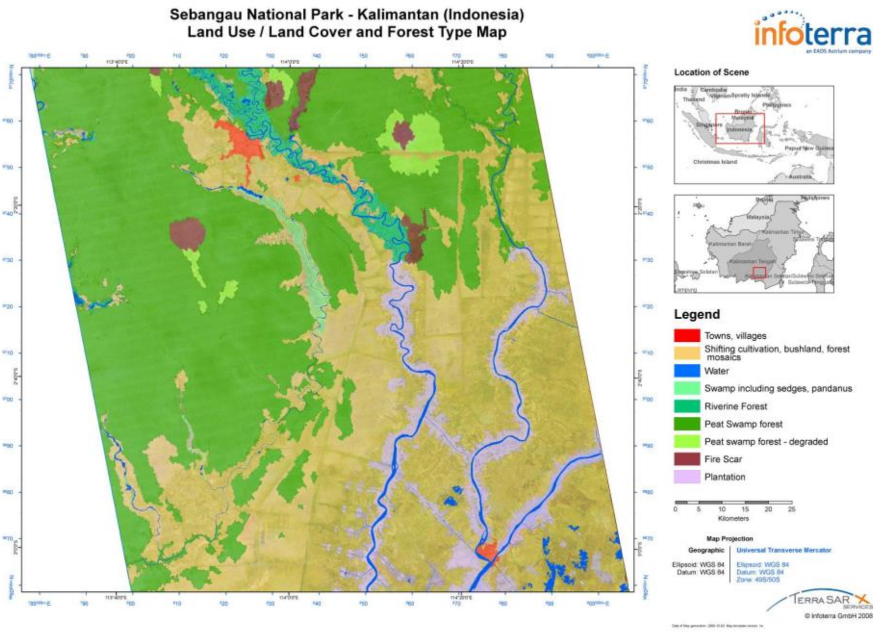

Figure 3-4: Forest type mapping in Sebangau National Park based on 3-m StripMap data from TerraSAR-X; © Astrium GEO-Information Services

For Peat Land Forests the REL estimation is more complex. According to results from long term monitoring of Carbon Flux in peat forests, CO_2 is emitted even in natural peat forest (CO_2 loss by peat decomposition). Once peat land is drained the forest and peat degradation accelerates, and large amounts of CO_2 are emitted from peat by microorganism respiration and subsequent peat fires. Hence, any change in the forest cover (e.g. by selective logging or conversion) will have direct CO_2 emission affects potentially accelerated by seasonal and climate factors (e.g. El Nino events). Hence, as shown in Fig. 3-5, it is necessary to establish well distributed monitoring sites for CO_2 flux from Peat Land Forests at sub-national level to be fully integrated into the national REDD+ REL and its monitoring approach.

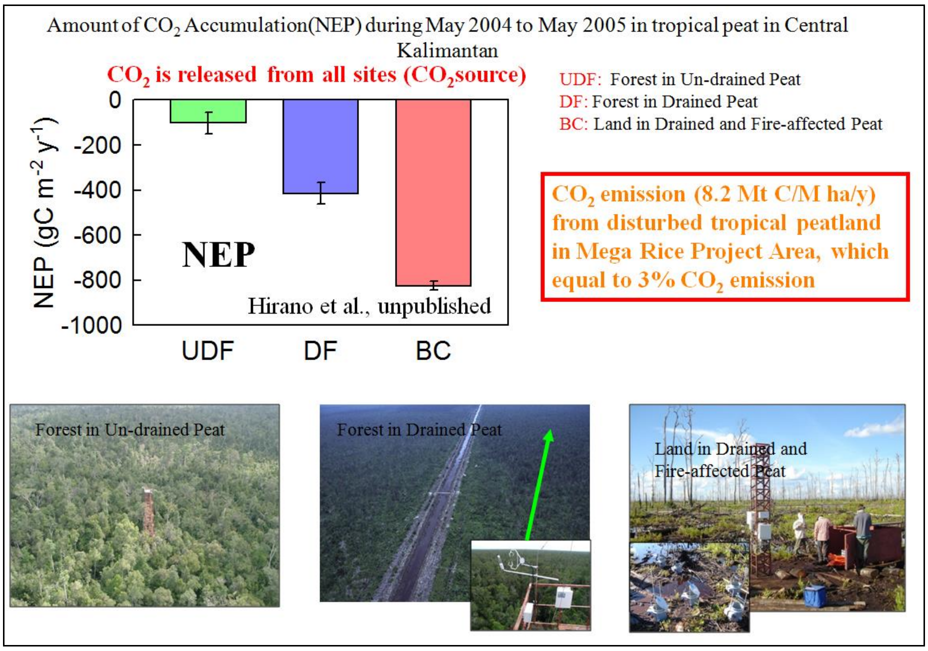

Figure 3-5: Amount of CO_2 Accumulation (NEP) from May 2004 to May 2005 in tropical peat in Central Kalimantan (Original data cited from Hirano et al. 2007 and 2009)

To estimate Reference Emission Levels (REL) in REDD+ context, deforestation and forest degradation must be monitored as follows.

1) Deforestation mapping and biomass estimation:

Deforestation mapping is essential to evaluate forest biomass change. In tropical countries, Synthetic Aperture Radar (SAR) is useful than optical sensor because SAR penetrates cloud and can acquire image in day and night and in all weather conditions. Thus, combining data from SAR, optical sensor and ground observations is most promising technique for deforestation mapping. While estimation of above-ground biomass density is also necessary for estimating productivity, carbon cycle, nutrient allocation, and fuel accumulation in terrestrial ecosystems (Brown et al., 1999). Some researchers have conducted direct biomass estimation using SAR data. Luckman et al. (1998) estimated biomass density of regenerating tropical forest using backscatter from JERS-1/L-band SAR. And ALOS/PALSAR, a successor to JERS-1/SAR, has an advanced function of multi-polarization and it is expected to improve the backscatter saturation limit and to provide more useful data for forest biomass density and forest types.

2) Forest degradation and species mapping:

Hyperspectral sensors can collect continuous spectral reflectance data with narrow wavelength bands that enable forest degradation classes, discrimination of tree species (through biophysical parameters), detection of minerals, soil types and so on. Using HyMap data, leaf area index (LAI), Chlorophyll contents (SPAD), Yield and growth stage of paddy rice were analyzed for West Java area (Fig.3-6, Fig.3-7 and Fig.3-8). This also makes possible to evaluate the capability of hyperspectral data for forest degradation and species mapping.

Fig. 3-6 shows distribution maps derived from HyMap (airborne hyperspectral sensor) data represents distribution of crop biophysical parameter such as LAI, chlorophyll content (SPAD value) and yield estimation of paddy rice. LAI and SPAD indicate the current status of the health and vigor of crop facing to harvest time.

Fig 3-7 shows a distribution map derived from HyMap (airborne hyperspectral sensor) data represents classification of growth stages of paddy rice into 3 primary stages as shown in legend. Detailed discrimination of crop status in the field has potential to monitor the rice health status facing to harvest time.

Fig 3-8 shows a distribution map derived from HyMap (airborne hyperspectral sensor) data represents classification of growth stages of paddy rice into several stages in detail as shown in legend. Detail discrimination of crop status in the field is potential to monitor the existing condition (healthy) of rice status facing to harvest time.

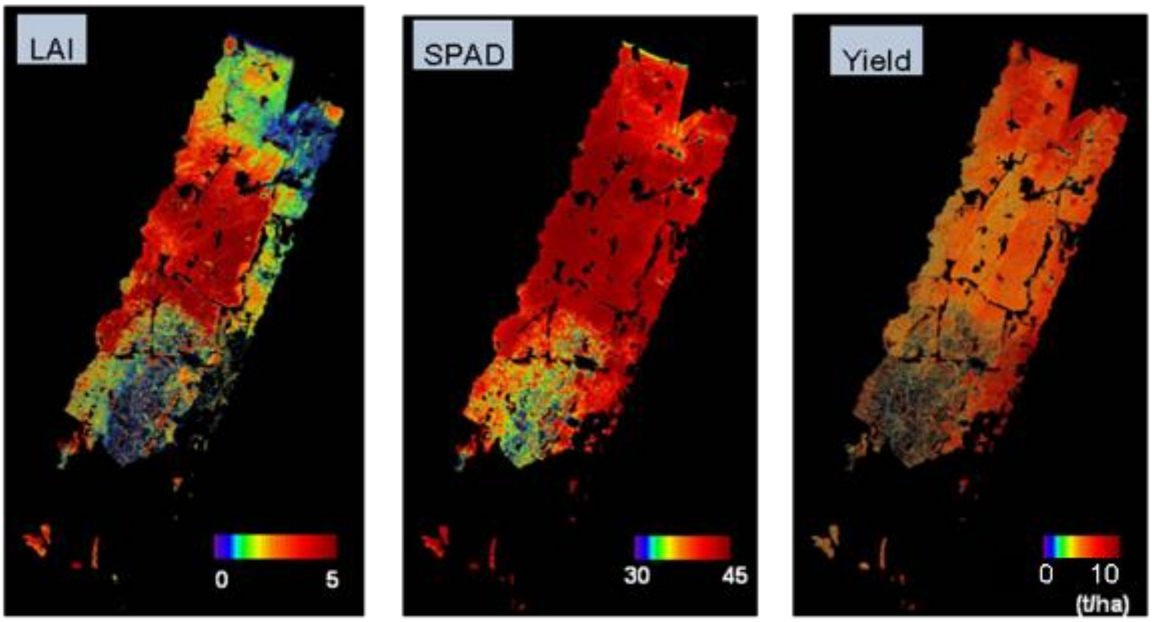

Figure 3-6: Distribution maps of crop biophysical parameter
(LAI, SPAD and Yield) of paddy rice

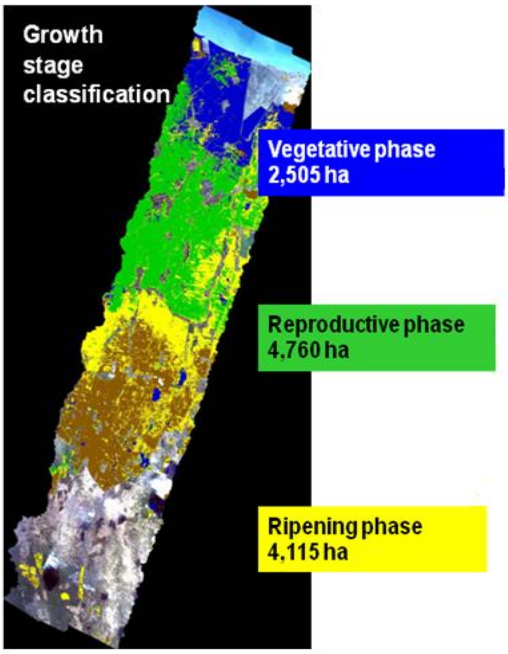

Figure 3-7: Distribution map of classification of growth stages of paddy rice

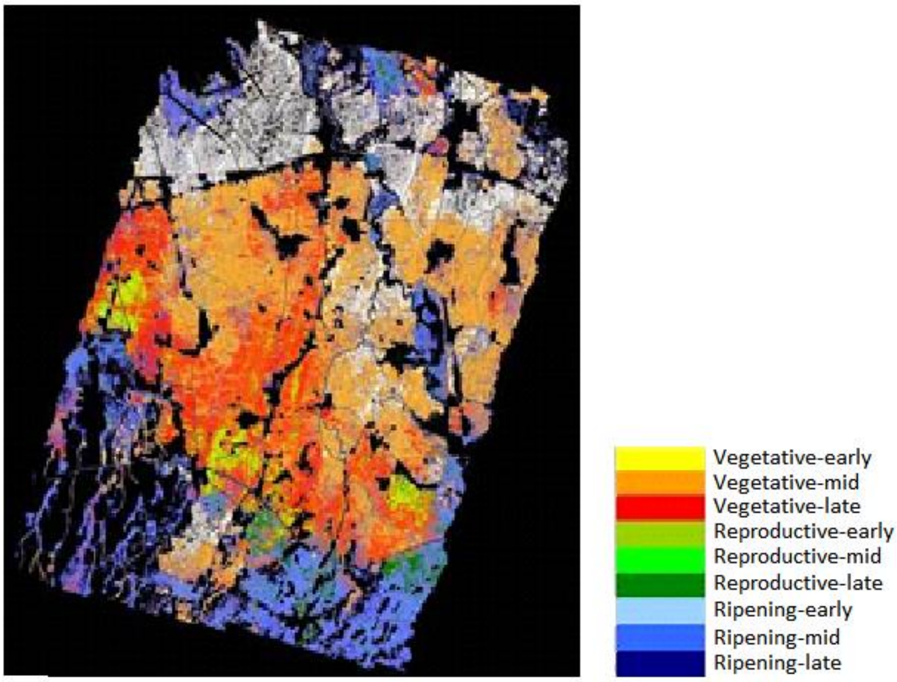

Figure 3-8: Distribution map of classification of growth stages of paddy rice (Cooperation program between BPPT and Earth Remote Sensing Data Analysis Center of Japan)

4. The Indonesian Carbon-offset Credit (VER) System for REDD-plus

The prevention of global warming will require wide ranging efforts in daily life both by the Indonesian government as well as by various national and international entities and the citizens, and carbon offset is one of the important measures that are to be taken.

Efforts towards a REDD+ on national level in Indonesia have rapidly advanced through the promotion of more than 50 model projects by the government. However, efforts at a Global level would require more time to finalize modalities and procedures for the operation with regards to REDD+.

In the model projects presently in progress in Indonesia, those involved in REDD+ (including project-implementing bodies, investors and local government bodies) do have a high demand for the creation of a financial mechanism at the international and at the provincial level, respectively. To establish a Carbon Credit System for REDD+ in Indonesia the **Carbon-offset credit system** is a useful reference. The credit used for carbon offset is referred to as **VER (Verified Emission Reduction)**, differentiating it from the credits of the Clean Development Mechanism (CDM) of the Kyoto Protocol.

The VER System in Indonesia is proposed as one of the reliable examples of a Carbon Credit System, demonstrating the feasibility of translating a carbon-offset scheme for REDD+ into the national and provincial level projects in Indonesia. The Indonesia VER System shall be verified by the MRV system, to be implemented.

Figure 4-1 shows the framework of the Indonesian VER registry scheme for carbon-offset, which is compliant with the Clean Development Mechanism (CDM) and ISO14064.

Indonesia's VER Registry System is basically applied with modifications to 1) REDD+ Credit authorized by International agreement, 2) Voluntary Credit, and 3) Carbon-offset. Indonesia's VER Registry System is composed of 1) the Project Implementation Body, 2) the VER Executive Body for Certification, 3) the Project Implementation Body. In this VER Registry process the MRV center supports all activities by providing several information such as Earth observation and field data, REL, carbon flux modeling, access to GIS data, simulation results, and so on.

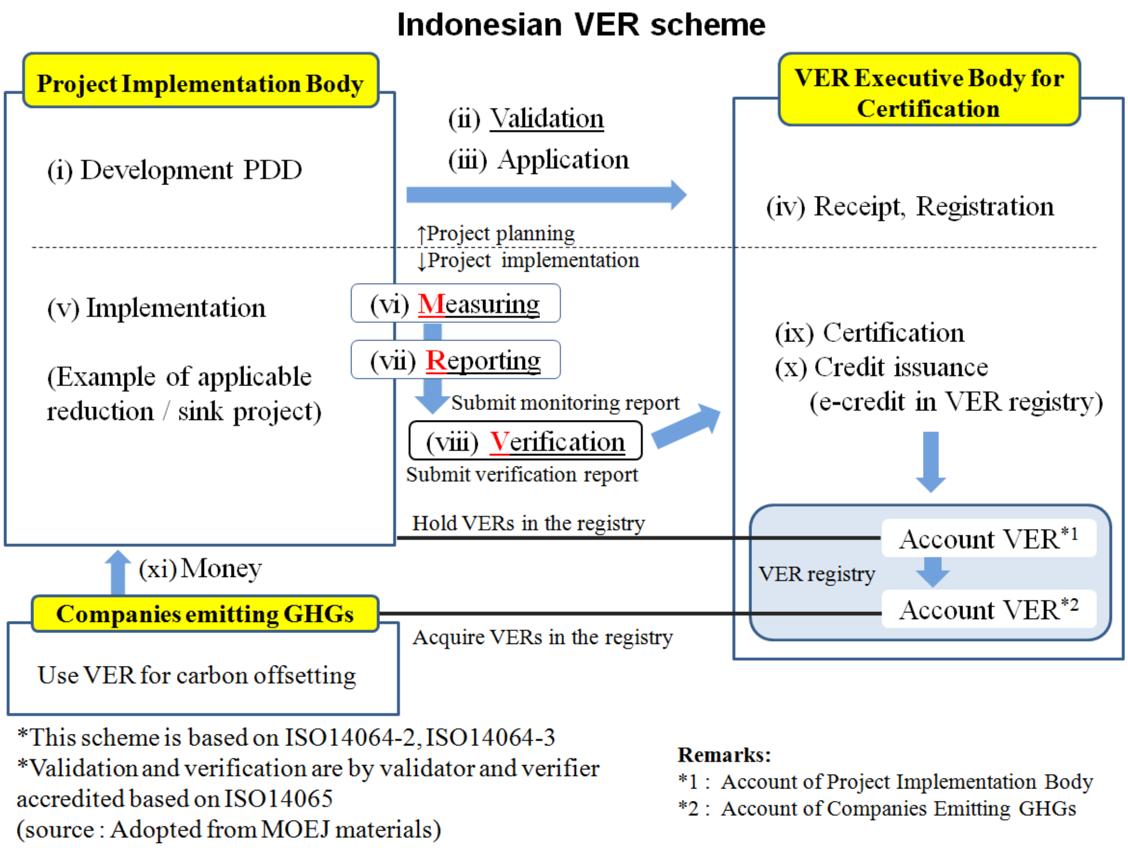

Figure 4-1: Indonesian VER scheme
(Underlines show the measurement elements in the MRV system)

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Authors

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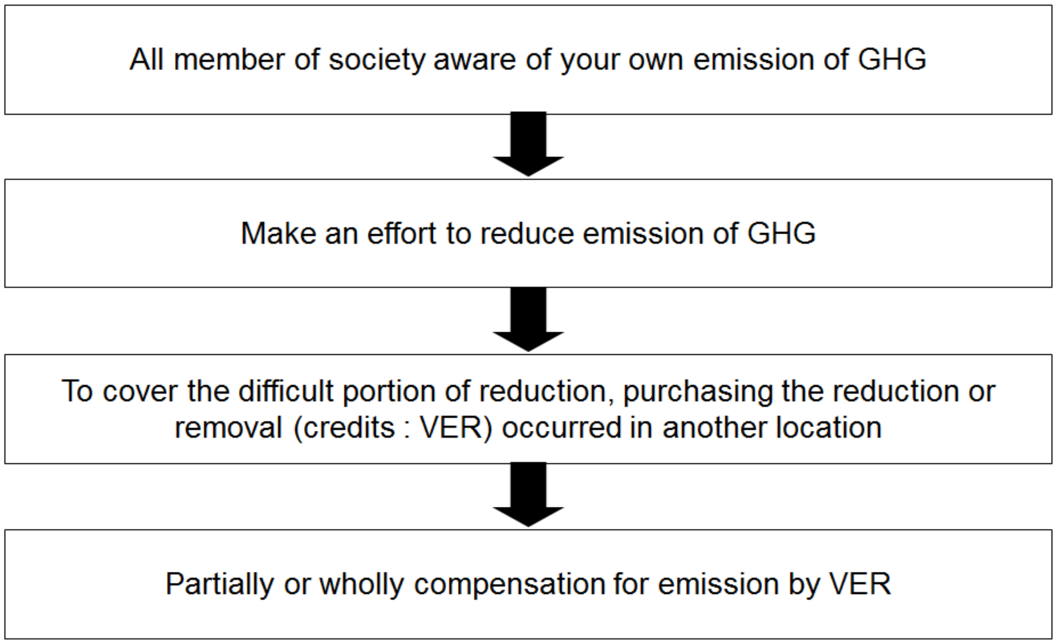
ANNEX-I: Concept of the Japanese VER system



VER : Verified Emission Reduction

The ANNEX-I simply illustrates a representative definition of carbon-offset, following "a system whereby all members of society; citizens, businesses, NPOs/ NGOs, local government, national government, etc., are aware of their own emissions of greenhouse gases and make an effort to reduce them autonomously by purchasing the reduction or capture of emissions occurring in another location to cover the portion which is difficult to reduce (known as credits) or, partially or wholly compensating for emissions by establishing activities or projects to reduce or absorb emissions in another location." (Ministry of the Environment of Japan, 2008).

In order to promote the spread of carbon offsetting, the Ministry of the Environment set up the “The Commission for the status of Carbon Offsetting” in September 2007 and in February released the results as “The guideline for carbon-offset in Japan”. Furthermore, in March 2008, “Commission for certification criteria for VER using carbon offsetting” (hereinafter the “VER commission”) was set up. They considered the system design regarding issues of VER and third party verification, and in November 2008 released “The carbon-offset J-VER guideline”. The implementation rules stipulated highly transparent monitoring, reporting, validation and verification rules and a framework for issue and management of carbon offsetting credits (J-VER: Japan Verified Emission Reduction). Further, “The Forest J-VER Guideline” was established to include projects related to forests in the J-VER framework in March, 2009. In February, 2010 “The prefectural J-VER program scheme ”started to further the J-VER framework.

ANNEX-II: National Multi-stage Forest Inventory Concept

Carbon stock estimates are necessary to determine net forest emissions, and are derived by combining the area extent of deforestation and/or forest degradation with carbon density measurements. For large area degradation monitoring it has been recently demonstrated (e.g. in Brazil; by IMAZON) that HR optical data are relevant and provide valuable information in various cases of degradation. However, for Peat Land Forest and for less degraded forests the REDD Sourcebook (2009) recommends the use of very high resolution (VHR) imagery or field survey for low intensity degradation, to allow for instance the identification of selective or reduced impact logging activities (i.e. removal of single trees. Hence, multi-resolution/ multi-stage sampling approach today can provide a good trade-off between need to routinely monitor large areas and need to characterize small pattern of low-intensity degradation.

The following figure shows an example for a multistage cluster sampling approach for REDD (Kuntz et al., 2010, modified). Based on wall-to-wall forest mapping from remote sensing - the forest cover is assessed. This allows a stratification of the 1st stage units. In the second stage a further sampling grid with a spacing of 4x4km and a buffer of 1km will be implemented in the above selected sampling areas resulting in 9 clusters. Each cluster consists of 6 sample plots (3. stage), which are surveyed on ground and where dendrometric measurements are carried out to estimate carbon stock.

As VHR imagery for large areas is expensive and still has limitations in acquisition capabilities in very large area acquisitions campaigns it is recommended to use a sampling approach instead and combine this with the mandatory ground survey required to estimate carbon emissions factors.

DEFINING UNCERTAIN PEATLAND DEFINITION IN BRIDGING SCIENCE TO POLICY

Draft of: 12 April 2012

Novotel Bogor, West Java INDONESIA
13-14 September 2012

EXECUTIVE SUMARY

The importance of peat as a source of carbon emissions has gained greater acceptance globally. The carbon release from tropical peatland represents a unique and predominantly Indonesian challenge as Indonesia holds approximately 50 percent of the total tropical peat area. Currently emissions from peatland represent 38 percent of Indonesia's total emissions and will continue to remain a dominant portion in 2030 (at 30 percent) if there is no major action uncertaken. Under the business-as-usual scenario, emissions from peatland are expected to increase by 20 percent from 772 MtCO 2e in 2005 to 972 MtCO 2e in 2030. Indonesia's tropical peatland covers only 5% of the global peatland area, but it contributes more than 50% of the world emission, originated from tropical peatland. Peatlands are threatened all over the world by drainage and uncontrolled fires. According to available data and information, in Indonesia more than 300,000 hectares of peatland is being degraded annually, resulting in degraded peat area of approximately 10 million hectares.

Tropical peat ecosystems consider as a key roles not only in the storage of carbon in forests and peat, but also in controlling water resources and in preserving bio-resources and biodiversity. Once the tropical peatland is disturbed by deforestation or degradation and the canals digging, then the water table in the peat soil and water content at the peat surface will decrease. These will lead the carbon contained in peat soil are lost through peat fires, respiration of the microbial fauna contained in peat, and the run-off of black carbon (Dissolved Organic Carbon, DOC) into rivers.

The problem of deforestation and forest degradation of peatland which occurs at the local level is counted to be national problem which needs attention from the Indonesian government. Government needs to adopt policies due to the problems in peatland, and to determine a policy which will lead to the better regulation, better governance and better management to achieve peatland sustainability.

The certainty of policy, regulation and action can be used as a tool to convince the international level about the Indonesian target in reducing the emissions by 26% until 2020. However, here are important steps to overcome the problems related to the climate change: 1) Define the peatland; 2) Support the Indonesia Climate Change Center by the 'One Map' initiative; 3) Broadening peatland assessment to capture existing institutional dynamics; 4) Conducting research and development; 5) Developing capacity building; 6) Building the research network on peatland and peatland mapping; and 7) Bringing-up peatland issues to international communities

PREFACE

This Draft was submitted to DNPI as a key manuscript of **" POLICY MEMO: PEATLAND DEFINITION FROM UNCERTAINTY TO CERTAINTY ".**

This assessment on peatland definition and mapping is intended to adjust existing definition of peatland and further work to improve the existing peatland map that will help identify the gaps amongst various peatland definition, and propose a comprehensive peatland mapping under one-map initiative organize by BIG and related agencies. The collation of data presented here is from secondary sources – project documents and reports of a number of organizations funding or working on issues related to peatland as well as a series of intensive technical discussions among scientists and resource persons facilitated by Indonesia Climate Change Center (ICCC).

This report consists of four parts. Part 1 provides an overview of the importance of peatland both at global and national context, including variety of assessment of peatland contribution to GHG emission. Part 2 outlines the current definition of peatland both scientific and authoritative definition in Indonesian context. Part 3 summarizes a proposed “safe definition” of peatland and possible improvement in the future. A list of references used is also provided in the end.

The data presented below will be substantiated and added to/confirmed by the scientific committee of the ICCC. The final report will be used primarily for three purposes: (1). to help identify key components peatland and peatland mapping (2). to identify the gaps and discrepancies in peatland data. (3). to develop a comprehensive proposal of peatland mapping improvement based on this assessment.

Most of the data available is based on work done by international, and bilateral organizations on the ground. Of particular relevance are the data collected by national and international agencies including Ministry of Agriculture, Ministry of Forestry, Wetland International, Hokkaido University (though very little, if any, of that data has actually been released to the public – most of it in the form of aggregate figures only), etc. Further, very little efforts have been made to systematically collect data on peatland as well as very few formal systems of systematic data collection and aggregation/reporting existed.

CONTENT

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Glossary

DNPI	Dewan Nasional Perubahan Iklim (National Council on Climate Change)
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD plus (REDD+)	REDD-plus calls for activities with serious implications directed towards the local communities, indigenous people and forests which relate to reducing emission from deforestation and forest degradation
USFS	United States Forest Services
UKP4	Unit Kerja Presiden
MRV	Measuring, Reporting, Verifying
GHG	Green House Gas
RAN-GRK	Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca
RAD-GRK	Rencana Aksi Daerah Penurunan Emisi Gas Rumah Kaca

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Mitsuru Osaki, is a Professor of Research Faculty of Agriculture, Hokkaido University and Professor of Graduate School of Agriculture, Hokkaido University from 2006. He was trained as a plant physiologist and soil scientist, and obtained his doctorate degree in from the Faculty of Agriculture, Hokkaido University, in Japan in 1981. He worked as Associate Scientist in Maize Unit of CIMMYT in Mexico from 1982 to 1984. He has been carried out many collaborative researches and teaching projects on tropical peatland management and rehabilitation of tropical peat-forest. He is now a leader of JST-JICA Project on "*Wild Fire and Carbon Management in Peat-Forest in Indonesia*".

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1. BACKGROUND

The better management of peatland forests, in particular, can make a substantial contribution to reducing atmospheric greenhouse gas concentrations in countries with significant peat forest carbon stocks. At the global level, in total peatland covering about 3,8 million km2; about 3% of the global land surface. Peatland store more carbon than any other forest types, and their degradation results in larger emissions than from any other ecosystem. About 30 countries are responsible for the largest greenhouse gas emissions from peatland (Joosten, 2009), including many non-Annex I countries. The majority of the 130 million hectares of peatland in non-Annex I countries are naturally forested, and contain about 100 billion tonnes of carbon - most of which is in their soils. When the peatland are drained the carbon is released and emissions are ongoing until rehabilitation takes place.

Since 1990 peatland emissions have increased in 45 countries of which 40 are non-Annex I countries. Indonesia, Malaysia and China are some of the countries with the highest emissions from drained peatland among non-annex 1 countries. The emissions from peatland in non-Annex I countries through drainage and peat fires causes an annual of estimated 1.2 billion tonnes of carbon dioxide. In Southeast Asia for example in the last 20 years, more than 12 million ha has been drained; and more than 3 million ha has been burnt (especially during el-nino droughts. The recent decline of peatland forests in the region is twice the rate of decline of other forests. Under LULUCF of the Kyoto Protocol a new accounting activity is proposed for the second commitment period to provide incentives to reduce emissions from drained peatland in Annex-I countries. For non-Annex I countries REDD should provide such incentives.

At least three critical functions of peatland why peatland is so important:

<u>First</u>, is peatland and carbon regulation. Peatland are areas with a thick organic soil layer: peat, an accumulation of partially decayed vegetation matter. Peatland are critical for carbon regulation. They sequester and store atmospheric carbon for thousands of years. Globally they contain nearly 30 percent of all land-based carbon (550 GT carbon); this is 75% of all atmospheric carbon, and twice the carbon stock in the forest biomass of the world (Parish et al, 2008). Their huge carbon stock is attributable to the thick layers of peat (up to 25 meters) that are conserved by the wetness of the substrate. This peat largely consists of organic material with a carbon content of over 50%.

When drained however, the carbon is no longer safely stored in the peatland. Currently, this mainly results from the drainage of peatland from activities like logging, agriculture and plantations. As a result of peat drainage, the organic carbon that was built up over thousands of years and is normally saturated with water, is suddenly exposed to the air. It decomposes and releases carbon dioxide (CO_2). The degradation of peatland through drainage and peat fires causes annual emissions of an estimated 2 billion tonnes of carbon dioxide. Peat fires occur mostly there where peatland have been drained making them extremely vulnerable to fires. This amount can increase in times of extreme drought. Altogether, the loss of peatland is responsible for emitting nearly 6% of all anthropogenic emissions into the atmosphere (Joosten, 2009).

<u>Second</u>, is hotspots for biodiversity and ecosystem services**.** Besides being hotspots for climate mitigation, peatland are for biodiversity and home to many rare and specialized species that are found nowhere else, including the endangered Orangutan in Borneo. In addition peatland play a key role in water resource management, storing a significant

proportion of global freshwater resources and providing ecosystem services such as water supply and flood control.

Third, is reducing further emissions from peatland**.** Emissions from peatland can be reduced by protecting remaining peatland, better management and by restoration of drained peatsoils (rewetting and revegetation). Rewetting the drained peatland can stop a significant amount of these emissions. There are lots of lands available for such rewetting programmes. Besides protection of peatland, the activity of rewetting drained peatland is a cost effective climate change mitigation. Reducing peat fires is another priority, but is also closely linked to peatland restoration as these areas are most vulnerable for fires.

2. DEFINING INDONESIA'S PEATLAND: AUTHORITATIVE AND SCIENTIFIC DEFINITION

2.1 Uncertainty on Peatland Definition and Consequences of GHG Emission Estimates

While in the past emissions from deforestation and forest degradation have received the vast proportion of climate-focused attention, both domestically and internationally, carbon emission from Indonesian peat reserves is even more significant. Only very recently there been a broad recognition of the importance of peatland emissions, and while the science is still at a relatively early stage it has improved significantly in recent years. The importance of peat as a source of carbon emissions has gained greater acceptance globally. Figure 1 captures the difference between this DNPI report and various estimates published by other government agencies, multilateral organizations, and non-governmental organizations. The differences may stems from the different data, methods, assumption as well as techniques used.

Peatland store a massive amount of carbon in the form of organic matter accumulated in waterlogged soils. The release of carbon from tropical peatland represents a unique and predominantly Indonesian challenge as Indonesia holds approximately 50 percent of the total tropical peat area. Emissions from peatland today represent 38 percent of Indonesia's total emissions and will continue to remain a dominant portion in 2030 (at 30 percent) if no major action is taken. Under the business-as-usual scenario, emissions from peatland are expected to increase by 20 percent from 772 MtCO 2e in 2005 to 972 MtCO 2e in 2030.

Fires are the main sources of peat related emissions. In 2005, fires accounted for 472 MtCO 2e, more than 60 percent of all peatland related emissions. Decomposition of peatland as a consequence of drainage is the second largest source of peat related emissions, accounting for another 300 MtCO 2e. As peatland forest are converted to other land uses, the removal of the above ground biomass during land clearing and timber extraction during logging of concession forests (HPH) result in further CO 2e emissions; to avoid double counting, these emissions are accounted for in the LULUCF sector.

Peat fires. Emissions related to peat fires will increase from approximately 470 MtCO 2e per year at present to nearly 580 MtCO 2e in 2030, as the total share of degraded peatland at high risk to fire increases if peatland conversions are not stopped and if fire is continued to be used as the main tool for land preparation and fertilization by smallholders. It should be noted that the year-to-year emissions from peat fires tend to fluctuate significantly, as they are heavily correlated with annual rainfall, the groundwater table, and the extent of the dry season.

The estimates for peatland fires are based on an analysis of 2000–2006 emissions from peat fires by Van der Werf et al. (2008) as well as the future projected development of degraded land areas and the share of different land types as described by Hooijer et al. (2006). The estimates are based on the same publication from Van der Werf as used by Indonesia's Ministry of Environment in Indonesia's Second National Communication.

When compared to estimates published by other scientists (e.g., Page et al. (2002)), estimates for peat fire based on the Van der Werf data can be considered to be conservative. There should be no doubt that emissions from fires on degraded peatland will continue to be a major contributor to emissions, pending strong action. Indeed emissions from peat fires could easily range higher than the estimates used here.

Decomposition. Emissions from decomposition will continue to grow by 30 percent from 300 MtCO 2e in 2005 to approximately 395 MtCO 2e in 2030, due to the combination of emissions from already drained peatland and due to the fresh conversion and drainage of peatland for plantations (e.g., pulpwood and oil palm plantations) and smallholder agriculture. Drainage accelerates the rate of soil decomposition, as significantly larger volumes of peat soil are exposed to oxygen and hence made susceptible to further oxidation.

It is only in recent years, as more peatland have been cleared, that land managers and scientists have come to understand how peat soils behave as they dry out. Peat soils subside dramatically due to compaction, shrinkage, and decomposition, and this can result in a loss of the fertile surface layers. At the same time, the drying out of the surface layers results in a growing vulnerability to hard-to-manage peat fires. Our estimates of carbon emissions from peat decomposition are based on an analysis of historically drained peat areas and their expected future conversion into different land uses. Emissions from soil decomposition are assumed to depend on drainage depth. Estimates are derived from measures of decomposition for different levels of drainage (for different land uses) combined with the area of degraded land and the number of years of decomposition after the initial drainage. One key uncertainty is that soil and root respiration make up somewhere between 40 and 60 percent of measured carbon flux between soil and atmospheric carbon, as a result of soil and biomass respiration and carbon uptake during photosynthesis, as recently described in Couwenberg et al. (2009). Measurements of carbon flux from soil decomposition, using changes in soil mass and carbon composition, are not subject to this uncertainty, but few such studies with comparable measurement methods have been published.

The emission levels used here were calculated using Wösten's linear peat drainage emission model (which predicts emission patterns for different drainage depths) and average drainage depths of different land uses provided by Hooijer et al. 2006. Hooijer et al. 2006 synthesizes the direct observations of drained peatland made by different scientists in different areas of Indonesia, Papua New Guinea, Malaysia, and Brunei. It includes estimates for decomposition of peat soils in secondary forests, palm oil plantations, and agricultural areas planted with other crops affected by drainage.

Estimates of emissions from peat decomposition remain subject to revision, as further scientific work is done. Many potentially useful research efforts to tackle open issues were started only recently. The results of these efforts, expected to be published in the coming two to three years, might change the current view of the extent of peat decomposition. Given this uncertainty, estimates used here are conservative relative to other widely cited estimates.

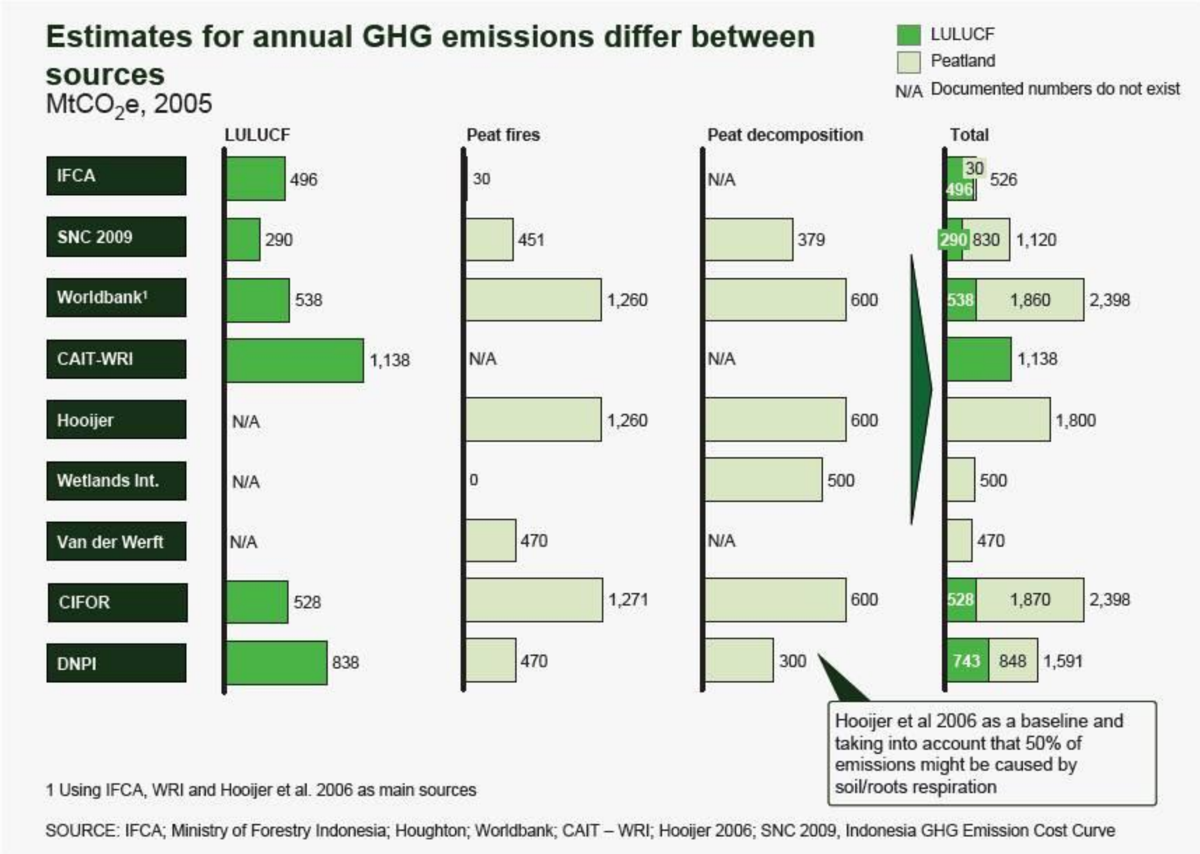


Figure 1. Difference of of GHG Assessment from Peatland (DNPI, 2010)

Despite lack of consensus over what is at stake, consolidation of efforts are underway to precisely define practical definition of peatland and further development to improve existing peatland maps available to be consolidated under the “one map”[1] initiative. These efforts are motivated by a variety of concerns including the desire to improve data quality for better peatland related assessment and management.

There are two broad categories in defining peatland definition that might be used for practical definition: authoritative and scientific definition. These differences have serious legal and practical consequences on the ground (box 2). Following are the detailed description:

2.2 Authoritative and Scientific Definition

Peat is a soil material consisting of partially decomposed organic matter; found in swamps and bogs in various parts of the temperate and tropical zones. It is formed by the slow decay of successive layers of aquatic and semiaquatic plants, e.g., sedges, reeds, rushes, and mosses. One of the principal types of peat is moss peat, derived primarily from sphagnum moss. Peatland, in the context of UNFCCC, is part of the wetland.

[1] “One Map” is an initiative promoted by BIG to consolidate different source of maps into one authoritative common platform.

Definition of peatland and wetland by authoritative and scientific

Peatland		
	Authoritative	**Scientific**
Classification of thickness	• Center for Soil and Agro-climate Research, Indonesia: 1) 0.5-1m (shallow); 2) 1-2m (moderate); 3) 2-3m (deep); and 4) >3m (very deep) • The Land Resource Evaluation Project: 1) ,0.5m; 2) 0.5-2m; and 3) >2m • RePPRot: 1) <0.5m; 2) 0.5-3m; and 3) >2m	• Radjagukguk (1992): 1) <1m; 2) 1-2m; 3) >2m
Material content	• Soil organic matter which is naturally accumulated more than 65%, formed from the vegetation weathering which its decomposition has hampered by anaerobic and wet land (Minister of Agriculture of Indonesia) • An organic soil at least 50cm thick, 1 ha, in aerial extent and containing <35% ash (Second International Congress of Soil Science, 1930) • Organosol in horizon H, with the thick of 50cm or more, or can be 60cm if the materials consists of Sphagnum or moss, or if the weight content is less than 0.1g cm-3 (The Research Center of Land, 1990) • Residual plantations which naturally formed through a long term decomposition processes, and accumulated in swamp areas or un-drained/static water (Ministry of Environment of Indonesia) • Residual organic material accumulated in a long period of time (Ministry of Forestry of Indonesia	• Cumulative layer of 40cm or more containing >30% organic matter and therefore is for toral area of Histosols that includes both nonpeat organic soil and true peat (Jansen *et al*., 1985) • The surface layer of soil, consisting mostly of partially decomposed vegetation, with an organic content of at least 65% in a minimum thickness of 30cm (Andriesse, 1988) • Soil containing high organic material (Wirjodiharjo and Hong, 1950) • Organosol (Dudal and Soepratohardjo, 1961)
Wetland		
	Authoritative	**Scientific**
Definition of wetland	• Areas of marsh, fen, peatland, or water (Ramsar Convention, 1971) • May be natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salty, including areas of marine water, the depth of which at low tide does not exceed 6 meters (Ramsar Convention, 1996)	

Unfortunately, none of the definitions is clearly pointed out in the recent President Instruction Number 10/2011 on the moratorium of new licence permits for utilization of natural forest and peatland areas.

The largest area of tropical peatland at the present time exits in Southeast Asia (Figure 2), moreover they are found largely in Indonesia (predominantly Sumatra, Kalimantan and West Papua), Malaysia (Peninsular Malaysia, Sarawak and Sabah), Brunei and Thailand (Whitmore 1995, Page *et al*. 2004). In Borneo, peat swamp forest is distributed along the coasts of Sarawak, Brunei Darussalam, Sabah and Kalimantan on low-lying, poorly-drained sites and exist further inland than its neighboring beach forest and mangrove forest formation. Over past 4500 years, peat has accumulated as much as 20 m in some areas (Phillips 1998).
The tropical peat swamp forest is important as not only for its wealth of diverse bio-resources but also its huge carbon pool (Tawaraya *et al*. 2003). Tropical peat swamp forests and deforested peatland are important stores of carbon whose release in large quantities through burning can contribute significantly to climate change processes.

Figure 2: Map of peatland in South East Asia. The map *illustrates* that most peatland are distributed on the islands of Sumatra and Borneo (Kalimantan, Sabah, Sarawak and Brunei) and in Peninsular Malaysia (*Source*: Whitmore 1995).

Indonesia is charting a green growth plan which will ensure sustainable economic growth with smaller carbon footprint. Total amount of CO_2 emission in 2005 from Indonesia is 2.1Gt, and 37.5% is from peatland. Ironically, the CO_2 emission in Indonesia is estimated to grow from 2.1 to 3.3 Gt from 2005 to 2030. Therefore, the reduction of CO_2 emission from peat is a key factor to contribute on REDD.

Indonesia has collected many data (such as land cover change, forest management, biomass above ground, biomass below ground, forest types, forest growth), but significant gaps exist to reach national monitoring system. The data of peatland area in Indonesia is also available as presented in the *Figure 3*. The differences of result and data uncertainties may stem from different assumption, methods, and technology used. The different organizations may use different methodologies and sources which contribute the different estimation, such as estimation of carbon emission.

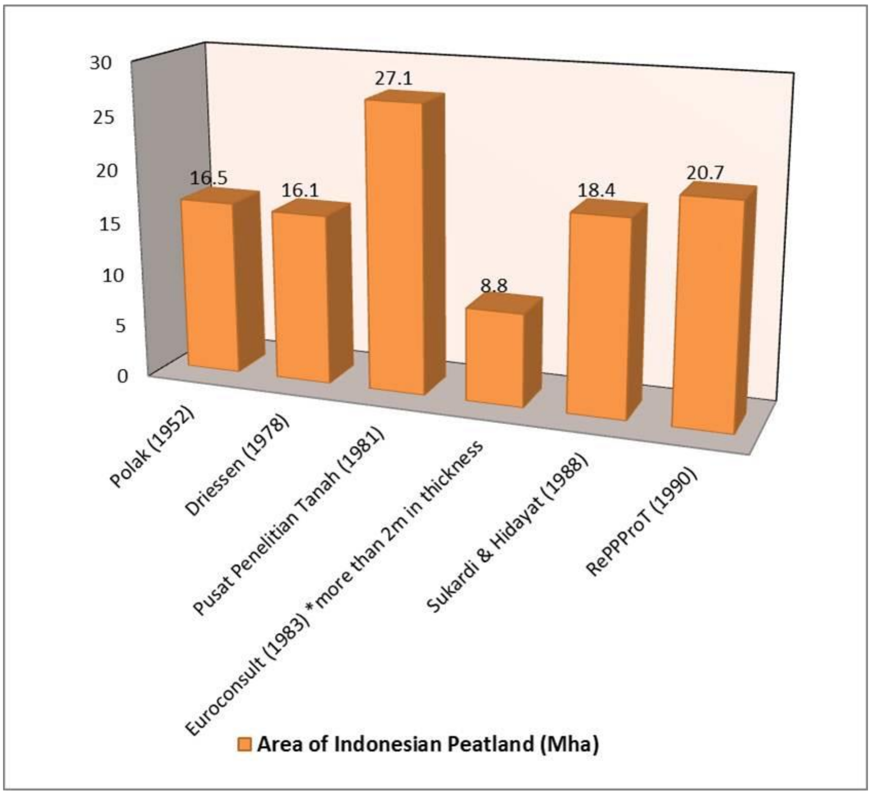


Figure 3: Peatland area in Indonesia (in million ha)

The conservation and restoration of peatland can provide a major contribution to the climate change mitigation. Improving guidance and capacity for reporting of peatland emissions will prove valuable to the current negotiations towards the successful of REDD program. However, to can estimate the CO_2 emission from peatland, and to can make the policy in the national scope for the climate change adaptation and mitigation on peatland, the definition of tropical peatland is very important. This will bring with the same understanding, and will make it easier to get the same view of thinking to problems that occur related to peatland in Indonesia.

What are current existing definition and classification of peatland?

Peat formation is a true carbon sink, the carbon being sequestered out of the system and converted into peat through biological activity (Sorensen 1993). Peat is a heterogeneous mixture of decomposed organic matter and inorganic minerals. There are various classification systems of peat and organic soils based on anted in the *Figure 4 and 5*.

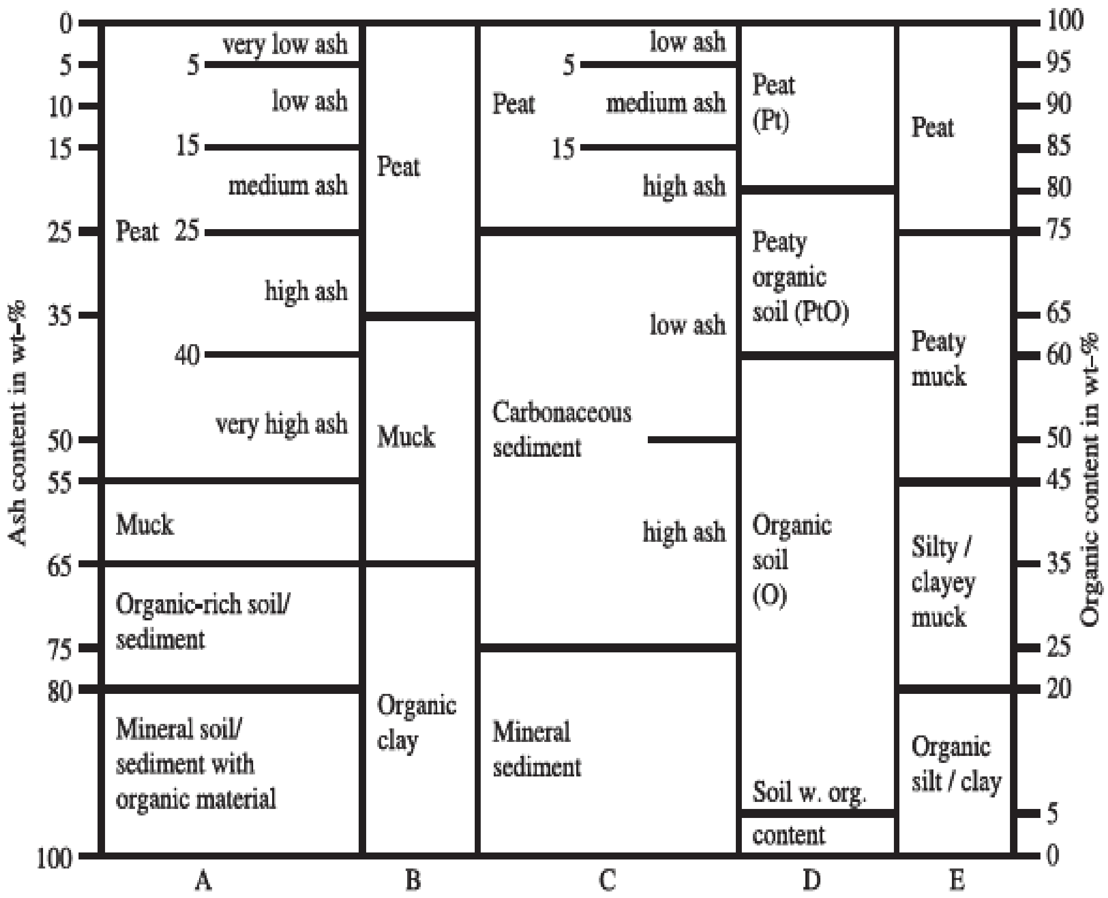


Figure 4: Various classification systems of peat and organic soils

Legend of Figure 4:

(A) The proposed classification of the study of Wust *et al*. (2003)
(B) The classification by Moris (1989)
(C) The classification of the Organic Sediments Research Center of the University of South Carolina (Andrejko *et al*., 1983)
(D) The system of the American Society for Testing and Materials (Landva *et al*., 1983)
(E) The system by Jarrett (1983)

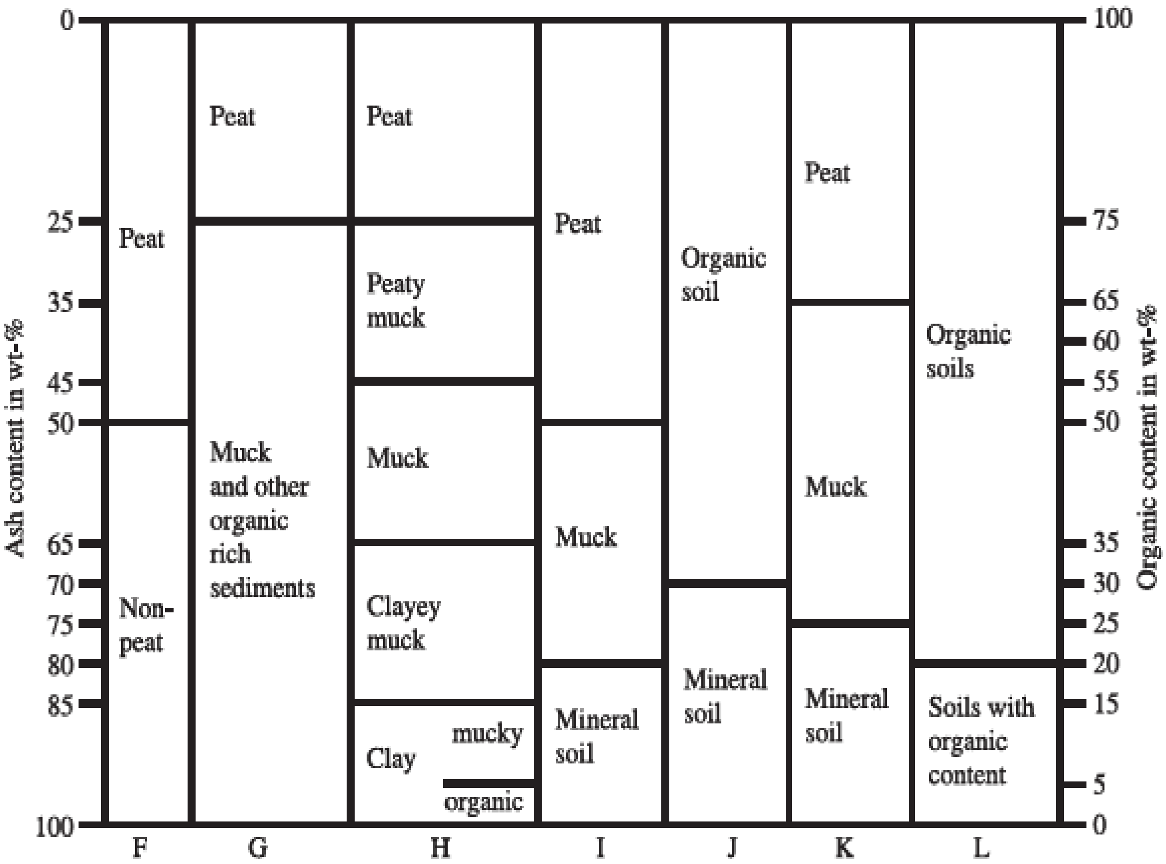


Figure 5: Various classification systems of peat and organic soils

Legend of Figure 5:

(F) The classification by Russian (Mankinen and Gelfer, 1982)

(G) The previous classification of the American Society for Testing and Materials (ASTM) 1982)

(H) The system by Louisiana Geological Survey (Kearns *et al*., 1982)

(I) The classification by the International Peat Society (Kivinen, 1968)

(J) The Canadian System of Soil Classification (CSSC, 1987)

(K) The classification by Davis (1946)

(L) The system by Arman (1923)

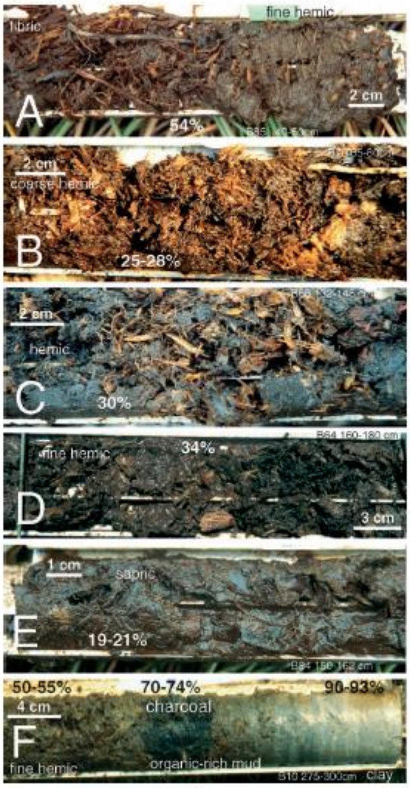
Based on the definition by Ramsar, peatland are ecosystems with a peat deposit that may currently support vegetation that is peat-forming, may not, or may lack vegetation entirely. Peat is dead and partially decomposed plant remains that have accumulated in situ under waterlogged conditions. It is understood in this guidance that the term "peatland" is inclusive of active peatland ("mire"). An active peatland ("mire") is a peatland on which peat is currently forming and accumulating. All active peatland ("mires") are peatland, but peatland that are no longer accumulating peat would not be considered as active peatland ("mires"). The presence of peat or vegetation capable of forming peat is the key characteristic of peatland.

What is the important factor to define the peatland in tropical?

Most of schemes for common use for field and laboratory classification of peats were developed in boreal and humid temperate regions, and these schemes do not recognize the distinctive features and specific uses of tropical peats. Wust et al. (2003) suggested that these schemes failed to fully characterize and classify the tropical organic deposits of of Tasek Bera (Malaysia) peatland (which was chosen as an example of tropical peat deposit to evaluate different classification systems, which is ideal for testing the applicability of peat classification systems for lowland tropical peats), for the following reasons: 1) Temperate and boreal peats are often dominated by bryophytes/moss and shrubs; 2) Existing classification schemes for temperate and boreal peats are based on selected characteristics for specific uses in the fields of agriculture, engineering, energy, etc. rather than having a generic approach; and 3) Classifications of organic soil for agricultural purposes (e.g., CSSC, 1987; Soil Survey Staff, 1990; Paramananthan, 1998) are based on a control section (Figure 4).

And therefore, the important aspects of peat texture (morphology of constituents and their arrangement) and laboratory ash content (residue after ignition) need modification to be valuable for classifying tropical peat deposits. Wust et al. (2003) proposed three-group (fibric, hemic, sapric) field texture classification applicable to tropical organic deposits, which is based on classification by Esterle (1990), which was modified from the US Soil Taxonomy and developed for tropical low-ash, ombrotrophic peat deposits and soils. This field texture classification was made bases on: 1) Visual examination of the morphology of the peat constituents (texture); and 2) Estimates of fiber content and matrix.

Peat is defined as having an ash content of 0-55%, muck 55-65%, organic-rich soil/sediment 65-80% and mineral soil/sediment 80-100%. And the peat class is subdivided into subclasses: 1) Very low ash (0-5%); 2) Low ash (5-15%); 3) Medium ash (15-25%); 4) High ash (25-40%9; and 5) Very high ash (40-55%).



A: Fibric (left) to fine hemic (right); ash contents 54%
B: Coarse hemic peat; ash contents between 25% and 28%
C: Hemic peat; ash contents 30%
D: Fine hemic peat; ash contents 34%
E: Sapric peat; ash contents between 19% and 21%
F: Basal section; (from right to left): typical progression from a kaolinitic clay with quarts grains (ash= 90-93%); an organic-rich mud (ash= 70-74%); to fine hemic; woody peat (ash= 50-55%)

Figure 6: Various peat textures of the tropical lowland mire systemof Tasek Bera (Malaysia) peatland

2.4 Gaps among Two

There are still big gap between Authoritative Definition and Scientific Definition, but also among Authoritative Definition as Box 2(or and Scientific Definition as Box 2, and Figures 4 and 5) themselves. However it is acceptable for peatland definition to use two elements such as carbon content in soil and peat depth. Then it is propose to establish methodology for peatland definition, how to estimate carbon content and to measure peat depth. After getting peat mapping (Scientific Definition) including carbon content and peat depth, it is define what is peat or peatland for practical peatland management (Authoritative Definition), which should be minimize Carbon Emission. Estimation methodologies in detail are described in Session 3 and 4.

3. SYNTHESIS OF PEATLAND DEFINITIONS

3.1 Research Finding from Central Kalimantan

3.1.1. Key Element of Peatland

Tropical peat ecosystems are considered to play key roles not only in the storage of carbon in forests and peat, but also in controlling water resources and in preserving bio-resources and biodiversity. Once tropical peatland have been disturbed by deforestation/degradation and the digging of canals, the water table in the peat soil and the water content at the peat surface both decrease. Then, large amounts of the carbon contained in peat soil are lost through peat fires, respiration of the microbial fauna contained in peat, and the runoff of black carbon (Dissolved Organic Carbon, DOC) into rivers (Fig. 7). Also tree growth decreases and tree mortality increase by lowering water table, which cause seriously to degrade Forest (Unpublished data), and decrease biodiversity.

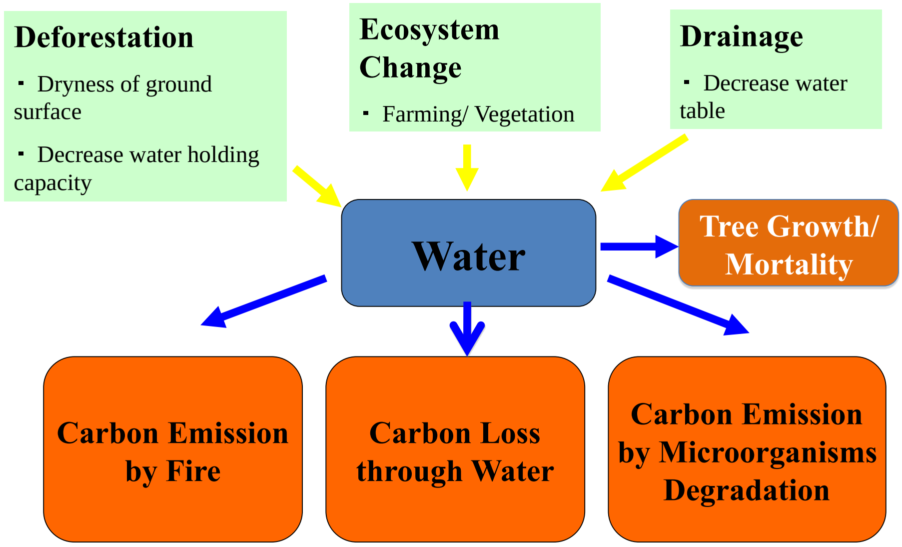


Figure 7: Key element on carbon flux and loss from peatland (cited from Mitsuru Osaki *et al*. Springer, 2012)

Because a strong relationship between deep peat fire and the water table has been confirmed that deep peat fires become more frequent and peat soil respiration increases (H. Takahashi 2003, T. Hirano *et al*. 2007 and 2009). The ratio (RE/GPP) of RE (Respiration in Ecosystem) to GPP (Gross Photosynthetic Product in Ecosystem) against groundwater level is plotted in (Fig. 7). One negative line (r^2 = 0.38) explains the relationship for both the un-drained swamp forest (UDF) and drained forest (DF) sites. Another negative linear relationship (r^2 = 0.69) was found for the burnt forest after drainage (BD) site. RE depends on GPP, because vegetation respiration consumes photosynthates. Thus, the ratio of vegetation respiration to GPP can be assumed to be almost constant. If so, variation in RE/GPP is mainly related to that of microbial respiration. Therefore, the negative linear relationships indicate that microbial respiration or peat decomposition was enhanced as groundwater level decreased.

Therefore, the following two methods were proposed for estimating and predicting carbon fluxes and balances; one is the direct measurement of carbon flux, and the other is simulating the carbon flux using either a water statue such as the water table, the moisture content in peat soil, or evapotranspiration in peatland. In conclusion, the carbon and water model is essential to carry out the MRV system in tropical peat and forest.

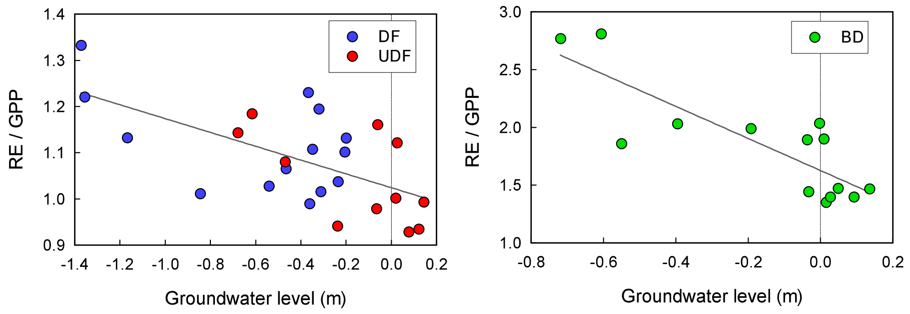


Figure 8: Relationship between the ratio of RE to GPP and groundwater level on a monthly basis from April 2004 to May 2005. UDF: Undrained Forest, DR: Drained Forest, and BD: Burned Forest (cited from Mitsuru Osaki *et al*. Springer, 2012)

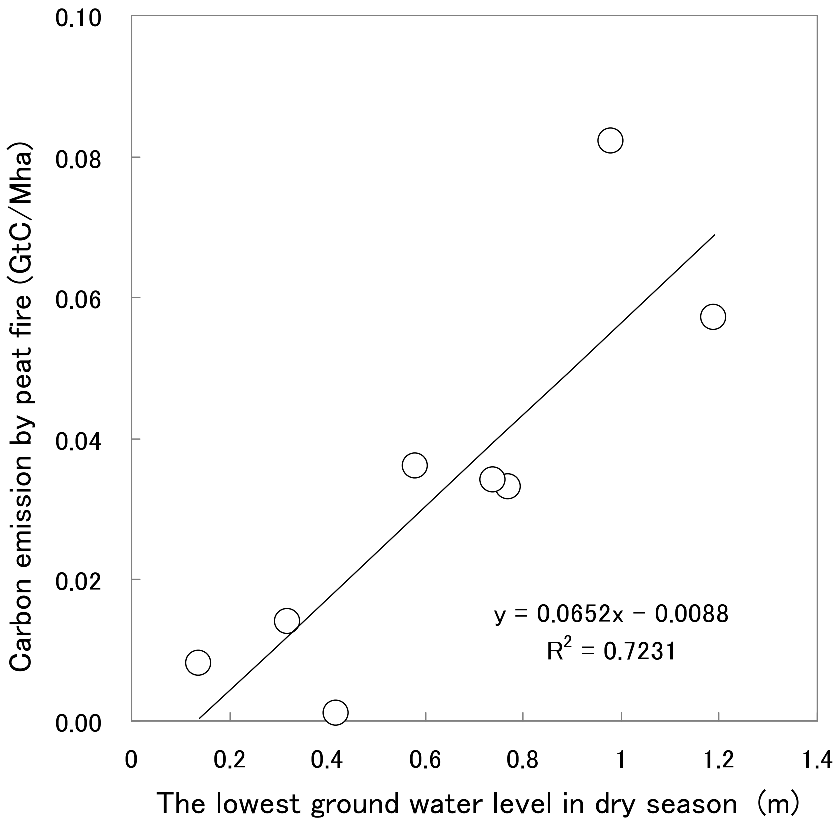
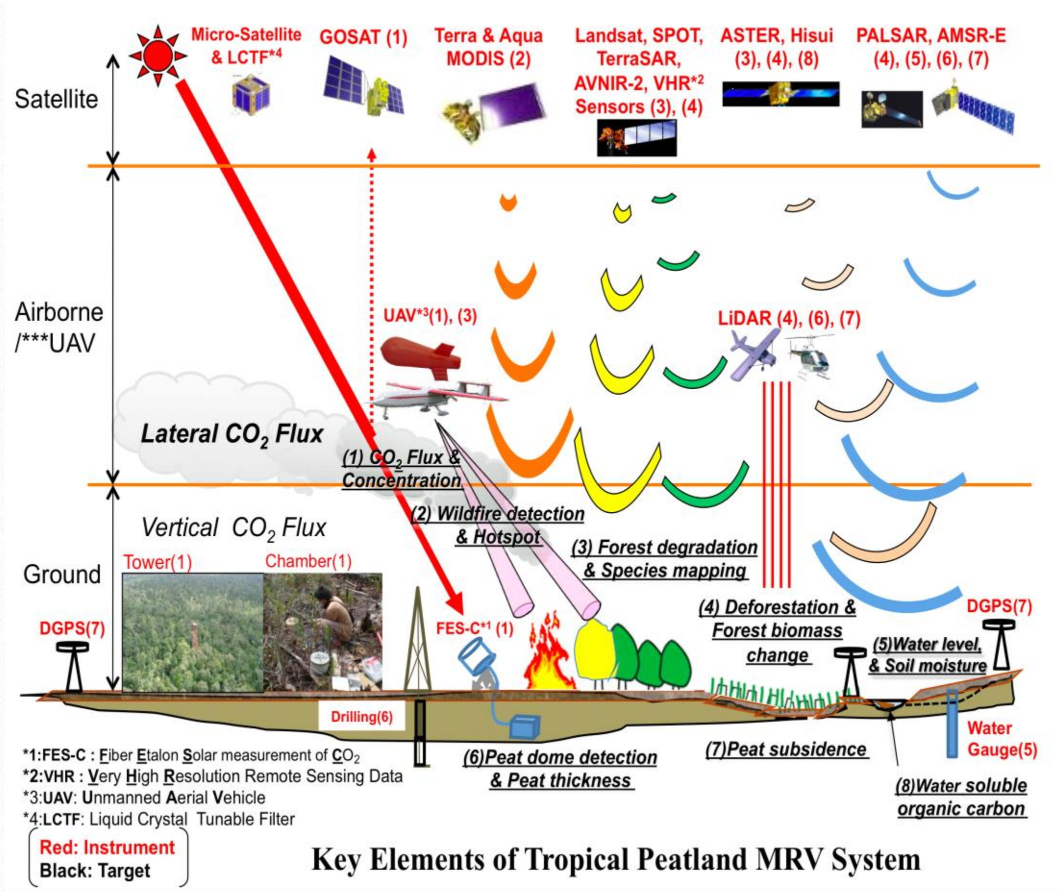


Figure 9: Relationship between the lowest ground water level in peatland and total amount of carbon emission in Mega rice project area (cited from Mitsuru Osaki *et al*. Springer, 2012)

Thus, carbon balance in the ecosystem is estimated as flux/loss of carbon, which is affected by the water level or content in peat soil. Water level has an effect on biodiversity through peat degradation, fire occurrence, and aquatic ecosystem changing. Carbon sensing network is a most important technique; however, as maintenance of the carbon sensing network is very costly, a more simplified model for carbon balance is required. From our long-term monitoring of carbon flux and the water table, it became clear that the water table is most important factor related to carbon loss by fire and respiration. Therefore, the Carbon-Water Model became the final Model for MRV and estimation on biodiversity.

3.1.2 Integrated MRV System using Ground Truth and Satellite Sensing

As carbon balance in peat is strongly affected both by the water statue and the ecosystem (vegetation, farming system and topography), the carbon budget should be estimated as a multifunctional system within the carbon-water-ecosystem. The MRV Unit will manage a Data Sub-Unit and a Training Sub-Unit. To successfully achieve the "Measuring, Reporting and Verification" roles, an MRV system comprised of the following three sections was proposed. The building of a monitoring and sensing system for the carbon-water-ecosystem is urgent and necessary to be able to apply new sensing technologies using different altitude levels such as satellite, aircraft, and ground.. The MRV Section has a final role to store and accumulate data in a standardized GIS format in the Data Sub-Unit. MRV Section is carried out mainly by sensing via satellite and airplane (a) and monitoring by ground tools. Monitoring/Sensing targets are (1) CO2 concentration, (2) Hotspot(s) of peat fire, (3) Forest degradation and species mapping, (4) Forest biomass and biomass loss, (5) Peat-subsidence, (6) Water level and soil moisture, (7) Water soluble organic carbon, and (8) Peat thickness.



3.2 Moratorium Map Assessment and Possible Improvement

3.2.1 Peatland Map Assessment Finding (the case in Central Kalimantan)

On 20th May 2011, Indonesian President signed a decree (No.10/2011?) which aims to protect primary forest and peatland from the newly issued license for two year. In the same time, latest distribution map of primary forest and peatland was produced as the “Moratorium Map” by REDD+ Task force team. Moratorium map (1:250,000 scale) is available and can be downloaded from the website of Ministry of Forestry (Fig. 11 and Fig. 12).

Figure 11: “Moratorium Map” on the website of Ministry of Forestry
(Green: Primary forest, Red: Peatland area)
Source: http://appgis.dephut.go.id/appgis/petamoratorium.html

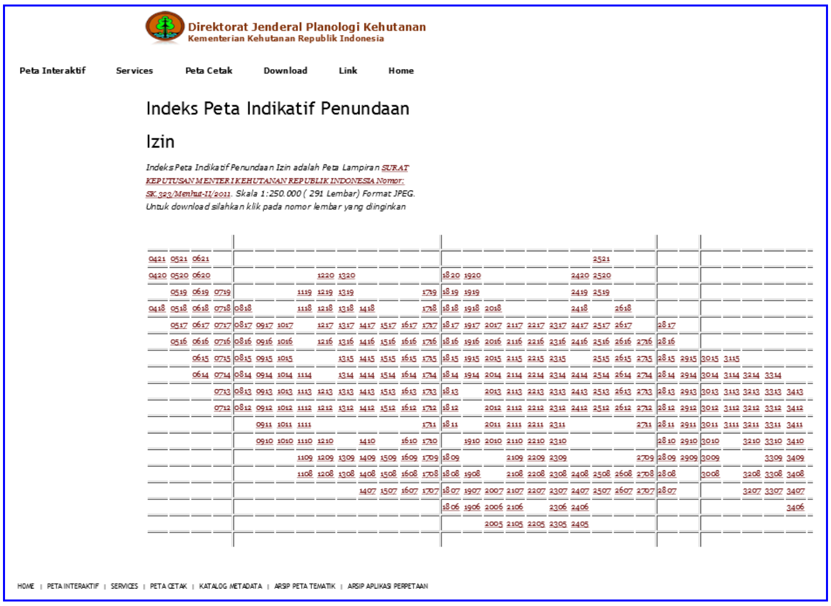


Figure 12: Map Sheet of Moratorium Map (1:250,000 scale)

3.2.2 Moratorium Map Assessment with Existing Peatland Map

Since different extents of peatland have been reported using different sources, Wetlands International compiled existing available peatland data for Sumatra, Kalimantan and Papua to summarize existing survey data from a number of relevant institutions in Indonesia (Wetlands International, 2008).

Moratorium Map was assessed to compare with Wetlands International Peatland map published in 2004 (Hirose et al, 2012). Moratorium Map and Wetlands International peatland map are shown in Figure 13. Differences between both maps are indicated by red and yellow circles on Figure 14. Red circles show a total of about 125,000ha of decreased areas from Wetland International map to Moratorium Map. Yellow circles show a total of about 35,000 ha of increased areas from Wetland International map to Moratorium Map. Those differences might have been considered with existing license and newly issued license areas.

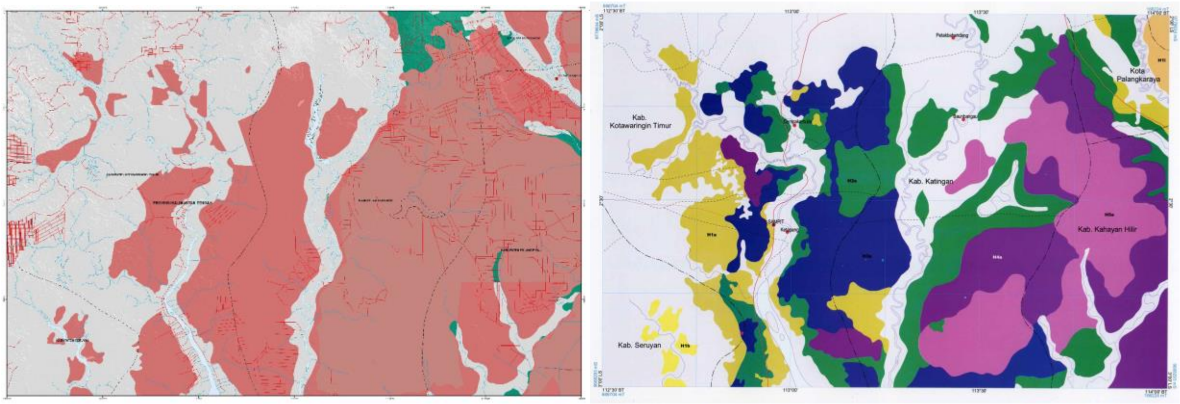


Figure 13: Moratorium Map (left) and Wetlands International peatland map (right) for Central Kalimantan (Map sheet No. 1613, 1:250,000 scale)

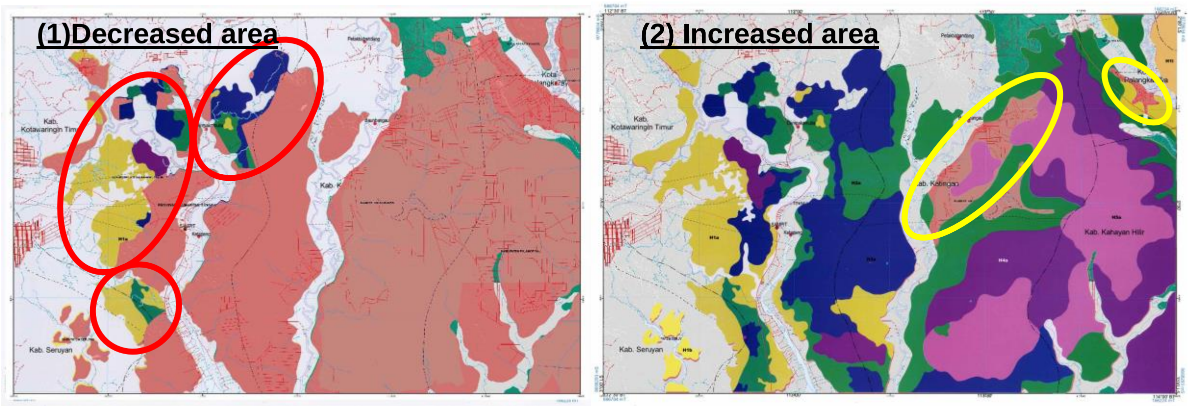


Figure 14. Example of differences between Moratorium Map and Wetlands International peatland map (Left: Decreased area on Moratorium Map, Right: Increased area on Moratorium Map)

3.2.3 Possible Improvement and Challenges of Peatland Mapping

Moratorium Map has to be revised its boundary at every six months (May and November) by presidential decree. Therefore regular improvement is necessary to cooperate with all related institutions such as REDD+ Task Force, BAPPEDA, universities and international donors concerning with 1) reviewing and compiling all available data, and 2) advanced satellite data utillization.

1) Reviewung and compiling all available data by proposed peat definition

Although Wetlands International had compiled existing all data, further presice data review and compiling all available data are necessary by all Indonesian and international experts for applying peat definition which is proposed in this policy brief. For achieving the remarkable improvement of peatland map, short training is necessary for the experts to understand standard methodology.

2) Advanced satellite utillization

Remote sensing is the most useful tool to observe earth seuface and a lot of advanced satellite utillization has been proposed. However, only few methodologies have been proposed for peatland boundary delineation as follows;

Combiation of NDVI and Ts

Shimada (2003) found significant relationship between classified phenology types of peat swamp forest and peat volume in Central Kalimantan based on Normalized Difference Vegetation Index (NDVI) and Surface Radiative Temperature (Ts) of NOAA-AVHRRR data (Fig.15). Therefore, significant improvement of existing peatland maps is expected significantly for entire peatland area in Indonesia within short periods of time.

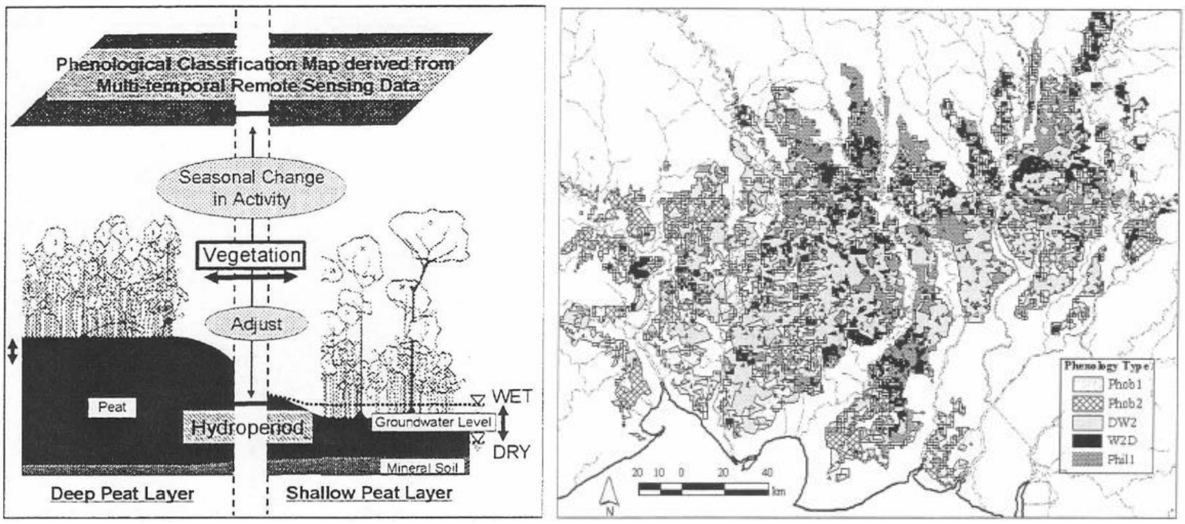


Figure 15: (left)Schematic hypothesis model for detecting the difference between the deep and the shallow peat layered swamp forest, (right) Classified map of phenology types peat swamp forest in Central Kalimantan

Satellite data utilization (Hyper Spectral Data)

Earth Remote Sensing Data Analysis Center (ERSDAC) conducted for peatland forest mapping in Central Kalimantan using Hyper Spectral Data on July 2012. 124 bands data were acquired from 400nm to 2500nm with 10-15nm band resolutions by Airborne Hymap Sensor. Result of data analysis showed different peat swamp forest types and it is expected to discriminate specific forest types which is closely related to different peat swamp condition such as pH, peat depth and elevation. Also data by nallow spectral band resolution (10-15nm) enables to estimate presice water leaf content of peat swamp forest which suggests ground water level and peat depth (Fig. 16).

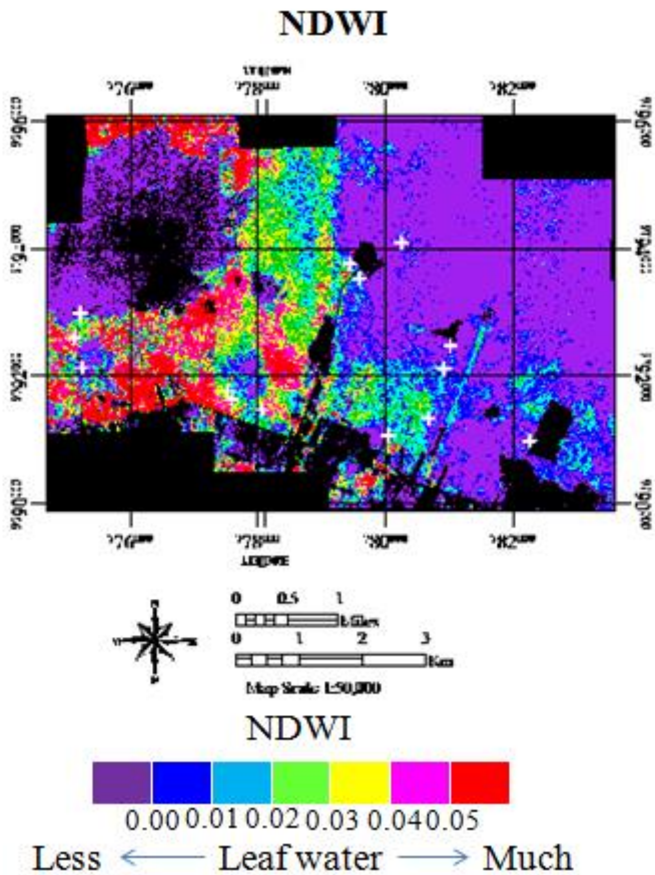


Figure 16: Presice leaf water content map by Normarized Difference Water Index (NDWI) of Hymap data

3.2.4 Adding the Ecology and Social Activity on Peatland Assessment

The Feasibility Study (FS) survey for "Katingan Peatland Restoration and Conservation Project" has conducted in many areas of PT Rimba Makmur Utama (PT RMU). As an output from the FS surveys, the monitoring plan for the future activity of "Katingan Peatland Restoration and Conservation Project" is developed as follows,

1. The Quality Assessment and Quality Control guidelines are need to be proposed;
2. Monitoring the project implementation;
3. The calculation of actual net GHG emissions avoided is based on data obtained from sample plots, regional literature values and methods developed in GPG-LULUCF (Good Practice Guidance for Land-Use, Land-Use Change and Forestry) to estimate carbon stock changes in the carbon pools and peat emissions;
4. Periodically monitoring the stratification of the project area;
5. Monitoring the leakage due to activity displacement and accounting it in order to calculate the net GHG emissions avoided;
6. When a project is undergoing validation and verification, non-permanence risk analysis shall be conducted by both the project developer and the verifier at the time of verification

in accordance with the VCS (Verified Carbon Standard) tool for AFOLU (Agriculture, Forestry and Other Land-Use), Non-Permanence Risk Analysis and Buffer Determination.

Monitoring of project emissions

Emissions in peatland normally occur due to fire, man-made drainage, and through extractive or conversion activities, and occasionally could occur due to extended droughts. The system of monitoring should have built-in checks and take a hierarchical approach starting with satellite imagery, aerial surveys, and then ground patrols. Due to hydrostatic pressure, canals can have impacts on draining peat forest several kilometers away, causing subsidence, oxidation, and the eventual collapse of peat domes. To avoid this issue, the methodology calls for a buffer that excludes man-made canals from the carbon accounting area and monitoring will need to track whether any canals are being built in this buffer. Monitoring should be conducted by a professional team consisting of a coordinator, a field team, and a GIS technician. All monitoring activities should be implemented using Standard Operational Procedures (SOPs) and all personnel should be trained permanently to ensure the data quality.

4. CONCLUSION AND RECOMMENDATION

4.1. Peatland Definition

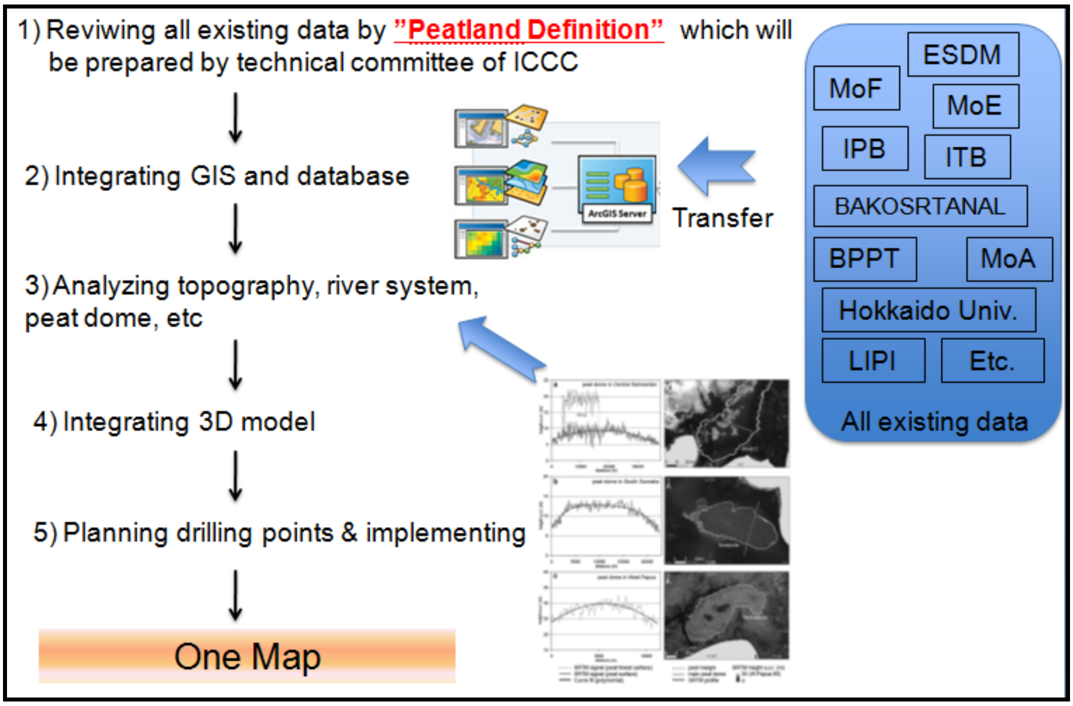


Figure 17: Propose Work Flow to integrate peatland map for "Moratorium Map" and "One Map"

Based on scientific published reports and analysis, we concluded that the proposed of peatland definition as: a heterogeneous mixture of decomposed organic matter and inorganic minerals with texture classification applies to all organic soils with 0-50% ash content, muck 55-65%, organic-rich soil/sediment 65-80% and mineral soil/sediment 80-100%. And the peat class is subdivided into subclasses: 1) Very low ash (0-5%); 2) Low ash (5-15%); 3) Medium ash (15-25%); 4) High ash (25-40%9; and 5) Very high ash (40-55%).

4.2. Indonesia Climate Change Center Support of "One Map" Initiative

The ICCC will facilitate international scientific/research discussions on Peatland and Peatland Mapping and through Bakosurtanal coordination, support the Peatland Map revision process. The ICCC Peatland Cluster Manager will cooperatively help formulate a plan to support the initial ICCC/One Map focus area of Peatland mapping guided by GOI identified, prioritized needs.

A US Government "One Map" Team with representation from the US Geological Survey (USGS), US Forest Service (USFS), and National Aeronautics and Space Administration (NASA), traveled to Indonesia in June, 2011 to assist Bakosurtanal in coordinating an initial "One Map" Workshop in preparation of the initial Indonesian Moratorium Map revision process. A US Study Tour, for the Indonesian "One Map" development team, is planned for April, 2012 as a follow up to the initial Workshop. This Indonesian team will visit and view USGS and USFS data management and remote sensing/mapping facilities with a targeted capacity building approach. The overall goal of the Study Tour is to strengthen the Indonesia

One Map collaboration through consideration of US inter-agency collaborative approaches and supportive technologies and their application to the Indonesia context. The primary focus for immediate USG support will be to assist the GOI in the development of a repeatable map revision process, the acquisition of requested imagery, and the actual revision/ new development of the Peatland map for all of Indonesia, coordinated through Bakosurtanal and supported by the ICCC. Plan development will be guided by the following current situation:

- The current moratorium map (based on 2009 Landsat imagery), which is an integral and instrumental part of the President's Instruction (Inpres) No. 10/2011 for the License Issuance Moratorium on Primary Forest and Peatland, will be updated at least every six months. This moratorium map and its regular updating scheme, has been deemed by the President of Indonesia as the vehicle toward achieving a ONE MAP. Initial US assistance will focus on assessing the methodologies used and accuracy of the revised Peatland Map.
- The regular map updating will have a methodology/strategy (being devise by Bakosurtanal, Lapan, and Ministry of Forestry) including the incorporation of more recent satellite imagery (2010/2011 Landsat). Systematic updating requires a constant supply of new satellite spectral and/or radar imagery. The USG will assist Indonesia in new imagery acquisition.
- The definition of Peatland for the moratorium map has been discussed by its stakeholders and it is agreed that the first thing that needs to be done in support of its next revision is updating the Peatland delineation. The agreed operational definition of Peatland delineation for the moratorium map will encompass the hydrologic area of Peatland (histosol) that supports the existence of Peatland (organosol) and the Peatland (organosol) itself.
- The current moratorium map uses Wetland International Peatland map as its source for the Peatland area delineation. All stakeholders have agreed that this map is needs to be revised using the regular map updating scheme as described in the President's Instruction.
- There has been a formal and agreed upon definition of primary forest for the moratorium map, which is based on the SNI on Land Cover, however, this SNI-based definition needs to be tested on the ground through a series of pilot projects, which eventually will provide feedback for the next moratorium map updating process. Bakosurtanal and the Ministry of Agriculture will devise a Peatland area delineation procedure using satellite and radar image, which will then supported by ground truthing missions.
- The newly delineated Peatland on the revised moratorium map shall be used for the basis of several initiatives: a) Scientific research to back up the Peatland definition as used on the moratorium map (this will be done by the ICCC), this initiative can also lead to the formulation of a SNI on Peatland; b) Pilot of peatland mapping procedure; c) Peatland mapping of Kalimantan, Sumatera and Papua.
- Another related initiative is the building up of the national database of satellite and radar image metadata (being carried out by Lapan under the coordination of Bakosurtanal) as a basis of a SINGLE LICENSE, SINGLE BUYER approach on satellite/radar image provision for ONE MAP.

4.3. Research and Development

Peatland ecosystem is the one of unique and vulunelable ecosystem to climate change. Therefore, comprehensive and long term research and development should be continued to understand its complicated syetem by scientific experts with local stakeholders's assistance. In this context, capacity building for stakeholders is an impotant role to implement peatland mapping research and development. *Table 2* shows proposed work plan for the first stage which is focussing on four Kalimantan provinces including REDD+ pilot province Central Kalimantan.

Peatland area especially in Indonesia which content huge of forest carbon storage and it`s management (including REDD-plus programs, etc.) are part of mitigation responses to the climate change issue. It covers a very wide angle of scientific disciplines. Therefore, there are research and development needs for forest carbon management, such as: (1) Forest carbon accounting, (2) Forest measurements, (3) Carbon management technology, (4) Socioeconomic issues, (5) Decision-support systems, (6) Funding mechanism and benefit distribution, (7) Biodiversity and its conservation and valuation, and (8) Environment services.

Table 3: Propose Work Plan to integrate Kalimantan Peatland Map

Work No.	Work item	Data to be used	2012/ 04	2012/ 06	2012/ 08	2012/ 10	2012/ 12
1	Finalizing "peat definition" and training for experts		→				
2	Reviewing all available data -Core sample -Log sheet -Laboratory analysis data	Drilling core, water well, water gauge, geophysical data, etc	→	→	→		
3	Integrating GIS & database	Hard/soft maps, etc		→	→		
4	Analyzing topography, geology, river system to detect peat dome	DEM, DSM, etc			→	→	
5	Integrating 3D model	Peat depth (drilling) and elevation (DEM) data			→	→	
6	Planning supplement drilling implementing					→	→
6	Preparing basic data for "One Map" initiative			→	→	→	→

In facing the challenges of uncertainty of peatland definitions and peatland mapping, DNPI organized a series of expert meetings by inviting outstanding resource persons from both national and international.

The following are summaries, findings and proposed activities from participants:

- It is important to observe further of why the U.S., Norway, Australia, and Japan are interested in the ICCC development of ICCC;
- It is important to encourage and involve the Master Program and PhD Program Students on peatland study, which is addressed to create an expert on peatland;
- It is recommended to improve the utilization of data on peat which is available in the Ministry of Agriculture (such as the data of peatland of Sumatera, Kalimantan and Papua region) to take an action on climate change adaptation and mitigation;
- It is recommended for ICCC to align the programs with UKP4, as UKP4 has been gathering data from various peatland agencies;
- It is recommended that peatland database of development program can fill in the gaps of the misperceptions about peatland;
- It is important to clearly define the peatland, as it is a fundamental thing of the data set;
- It is recommended for the ICCC to explore the opportunities of CSR of ESRI to develop infrastructure capacity for geospatial technology and access data;
- It is necessary to conduct a study on social dynamic at the micro scale level of the village and to involve rural communities should be involved on the activity, and it is recommended to examine the issue of land tenure, economic potential and social capital in the village;
- It is important to review the basic needs of forest communities related to the carbon trading, as there are 26.000 villages located in forest areas where the forest dependent communities live and actively interact with the forest;

- The framework determination is a key factor to can make a more focus research programs, as it seems that the peatland research plan is not based on a clear research framework;

The proposed program is presented in the **ANNEX 2**.

4.4. Capacity Building

Capacity building is geared toward academicians and technical people as well as the forest community on peatland areas. Training and education should be geared toward academicians and technical people. Only a certain number of people have understood the important of peatland related climate change issue. For example, peatland and REDD-plus program in technical terms are the global effort to reduce deforestation and degradation including credit for the effort to give incentives to developing countries to preserve and conserve their forests with financial incentives from developed countries. The arrangement of the incentive is not definite yet. Few people knew the REDD-plus issue and incentive arrangement, and therefore there is a need for education and training.

Capacity building is a multidimensional process that improves the in-house “ability” to understand & face challenges successfully (effectively and efficiently); this includes human resources, other resources, institutions & structures, policies, procedures, etc. The capacity building in term of objectives and programs divided from 3 (three) categories as Institutional Capacity Building (ICB), Social Capacity Building (SCB), and Research Capacity Building (RCB).

The current climate change global environment issue has put the tropical region in general as a strategic element to eliminate the impact. Indonesian Kalimantan Region is undoubtedly playing very important role in reducing the carbon emission by sustaining its ecosystem function while supporting the need for local and regional social life. The local Universities play a very important to: 1) supervise and execute researches; 2) make coordination in research and collaboration; 3) make socialization; 4) provide a scientific based advice; and 5) engage in various CC related Working Groups. Related to the preservation of tropical rainforest ecosystem, especially peatland, the five universities need to increase their role by enhancing its coordination, communication, and cooperation in executing research, education and community service. The presence of these five core universities in Borneo to meet these expectations is important, and therefore, capacity building is very important. In connection with all of the above, ' Kalimantan University Consortium ' is expected to improve the university's role in addressing Capacity Building of Research/Education for Peatland and mitigation of climate change.

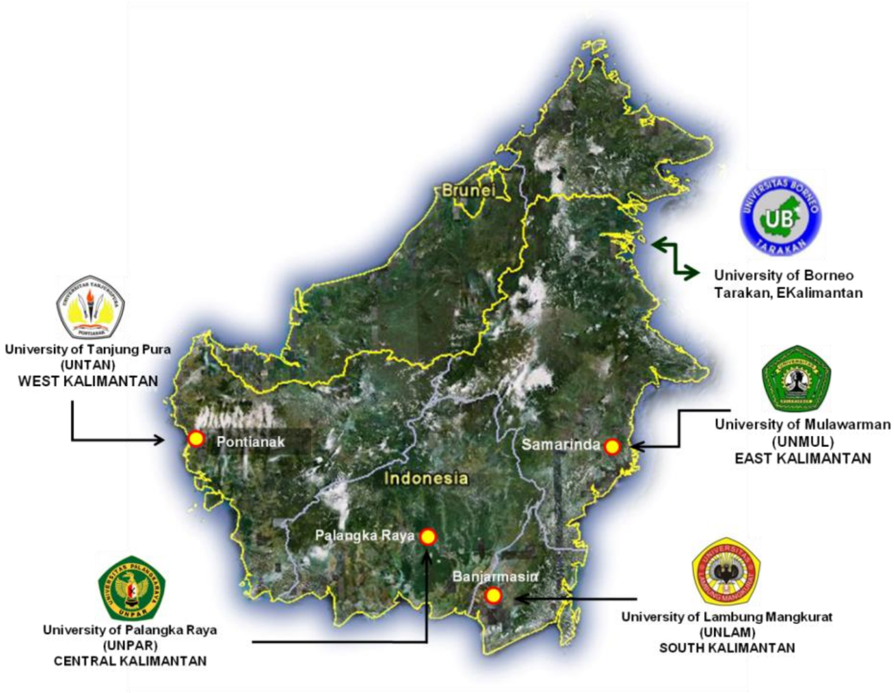


Figure 16: Core Members of Kalimantan University Consortium

The aims of 'Kalimantan University Consortium' are:

1. Facilitating communication and collaboration: among core universities and research institutes related to climate change;
2. Making coordination of internal, external and international research cooperation and collaboration;
3. Exchanging of research outputs, including broader dissemination of information;
4. Facilitating necessary training to improve research workers capacity, uptake and application of research outputs;
5. Establishing the new idea, opportunities and inputs;
6. Facilitating policy makers for scientifically based decision.

The initial participating universities in this network will be those 5 core state universities located in Kalimantan i.e. Tanjungpura University, Palangka Raya University, Lambung Mangkurat University, Mulawarman University and Borneo University (Table 1). Share of research activities and information may also be established with other National Universities and Local Private Universities having climate change related activities.

Tabel 1: Current Status of Core Universities

Region	**Number of Faculties, Leading Faculties**	**Main Scientific Expertise (PIP)**
University of Tanjungpura, West Kalimantan	9 Faculties and, Agriculture, Forestry, Economics	Wetland and Tropical Peat
University of Palangka Raya, Central Kalimantan	6 Faculties and 4 Master Program , Agriculture, Fishery	Development of science, technology and art focusing on watershed and environment of tropical peat land area
University of Lambung Mangkurat, South Kalimantan	11 Faculties and 13 Master Program, Agriculture, Law	Study on wetlands and marginal dry-land
University of Mulawarman, East Kalimantan	14 Faculties , Forestry, Agriculture, Social Politics, Fisheries and Marine Science	Tropical Rain Forest Environment
University of Borneo, East Kalimantan	8 Faculties, Fishery and Marine Science, Agriculture, Technology, Law	Tropical Marine Science and Resources

4.5. Research Network on Peatland and Peatland Mapping

The current climate change global environment issue has put the tropical peatland in Indonesia in general as a strategic element to eliminate the impact. The networking and cooperation among parties (countries, scientists/academicians, community stakeholders, etc.) is the key factor to tackle the climate change issues rather than a single player. For example:

- ***AsiaFlux*** is a regional research network bringing together scientists from universities and institutions in Asia to study the exchanges of carbon dioxide, water vapor, and energy between terrestrial ecosystems and the atmosphere across daily to inter-annual time scales (http://www.asiaflux.net/index.html).
- ***The Sentinel Asia (SA)*** Project initiative is collaboration between space agencies and disaster management agencies, applying remote sensing and Web-GIS technologies to support disaster management in the Asia-Pacific region. Objectives the Sentinel Asia Project aims to: (1) improve safety in society by Information and Communication, (2) Technology (ICT) and space technologies, (3) improve the speed and accuracy of disaster preparedness and early warning, and (4) minimize the number of victims and social/economic losses.
- ***The Indonesia Higher Education Network (INHERENT)*** is an inter-university educational network in Indonesia under Ministry of Education and Culture. For the first phase of development, the network consists of 32 universities. The main ring of this network is located on the island of Java; five universities (UI, ITB, ITS, UGM and

UNDIP) as a backbone network are connected using an STM1 line with a total 155 Mbit/s of bandwidth capacity.

- ***The Heart of Borneo (HoB)*** program is a the trans-boundary cooperation between 3 countries (Indonesia, Brunei Darussalam and Malaysia) consist of 220,000 km2 (22 mil ha) of inter-connected rainforests, consisting of a network of protected and well managed productive areas, to ensure the preservation of biodiversity and water resources for the benefits of local, national and international stakeholders.
- ***Kalimantan University Network/Consortium***; will become a strong link between research, education and extension science and technologies in Kalimantan related to climate change issues could translate into policies together with the decision makers in local, regional as well as national levels with the involvement of 5 core members of state universities (UNPAR, UNMUL, UNTAN, UNLAM and UB) and 120 private universities in Kalimantan closely. The network aims/objectives are: (1) to facilitate communication and collaboration: among core universities and research institutes; (2) to coordinate of internal, external and international research cooperation and collaboration; (3) exchange of research outputs, including broader dissemination of information; (4) facilitate necessary training to improve research workers capacity, uptake and application of research outputs; (5) establish of new idea, opportunities and inputs; and (6) facilitate policy makers for scientifically based decision.
- ***Asia Forum on Carbon Update (AFCU)*** is an annual forum among key stakeholders in Asian region aims at the following objectives: (1) to share ideas and experiences on the implementation of low carbon economy by elaborating various technical/practical issues; (2) to update the on-going initiatives and progresses on Asia's mitigation actions to reduce GHG emission, particularly the most recent issues such as REDD+, MRV, climate financing and capacity building; and (3) to develop any potentials collaborative efforts among Asian countries in seeking a viable mechanisms in tackling climate change issues.

4.6. Bringing-up Peatland Issues to International Communities

Globally, peat occupies only 2,7% of the world land mass, but it stores approximately 30% of terrestrial carbon content. This figure represents a huge amount of carbon that is stored in peatland area, much more compared to any other forest types in the world. It is understandable that peatland degradation results in larger emissions than from any other ecosystem.

Indonesia's tropical peatland covers only 5% of the global peatland area, but it contributes more than 50% of the world emission, originated from tropical peatland. Peatlands are threatened all over the world by drainage and uncontrolled fires. According to available data and information, in Indonesia more than 300,000 hectares of peatland is being degraded annually, resulting in degraded peat area of approximately 10 million hectares.

A study undertaken by DNPI (2010) points out that emission from Indonesia peat is mainly caused by decomposition, following drainage and peat fires. The emission caused by the decomposition is approximately 600 million ton of CO_2, and from the fire about 650 million ton of CO_2 per year. Deforestation for conversion to other land uses and degradation through timber extraction has resulted in emission of about 240 and 45 million ton of CO_2, respectively. Drivers of peat conversion and degradation are many, ranging from the needs for development and land use change to improper policies such as the mega-rice project, and a lack of knowledge and awareness. Water management has a high feasibility because it would not only result in the emission reduction, but also a lower risk plantation and concession owners due to smaller number of fire occurrence in the dry season and less flooding in the rainy season.

Indonesia's is the largest peatland area in South-east Asia, and one of the five tropical peatland countries in the world. The other four countries are Brazil, Democratic Republic of Congo, Papua New Guinea, and Malaysia. According to Joosten (2009) in Wetland International (2011), about 30 countries are responsible for the largest greenhouse gas emissions from peatlands, including many from non-Annex I countries. The majority of the 130 million hectares of peatlands in non-Annex I countries are naturally forested, containing about 100 billion tonnes of carbon - most of which is in their soils.

The degradation of peatlands in developing countries through drainage and peat fires causes annual emissions of an estimated 1.2 billion tonnes of carbon dioxide. In Southeast Asia the loss of peatlands has been dramatic. In the last 20 years, more than 12 million ha has been drained; and more than 3 million ha has been burnt. The recent decline of peatland forests is twice the rate of decline of other forests.

There needs to be urgent action to halt this. In the context of global emission, however, unfortunately peatland has not been discussed specifically and intensively. In UNFCCC, peatland is included in wetland catagory, and it has been dicussed by the Ad Hoc Working Group on Further Commitments for Annex 1 Parties under the Kyoto Protocol (AWG-KP), specifically under Land Use, Land Use and Forestry (LULUCF) section. There has been little attention to bring up peatland into the global attention. Lack of information, unreliable data, and other uncertainties discourage party countries to discuss and negotiate peatland in the UNFCCC arena. However, a new accounting activity is proposed for the second commitment period to provide incentives to reduce emissions from drained peatlands in Annex-I countries. The UNFCCC definition of forest covers all peat forest, including all peat forests temporarily destocked (deforested) as these will naturally revert to forest at some point in time. In the future – those peatlands not naturally forested could possibly also be addressed under this or a similar mechanism.

The REDD mechanism offers tremendous opportunities for protecting and restoring peat forests. Under REDD+ negotiations, however, peatland has not yet been specifically brought up and treated as an important component. No one of party countries pays attention in this matter. Political and technical constraints are the main barrier for not bringing up the peatland into the global attention. Yet, inclusion of incentives to support the reduction of emissions from degradation of peatlands and other forest types with high carbon stocks is crucial in any future REDD mechanism.

Reducing emissions from peatlands in REDD could involve five areas, such as a) protection of remaining intact peat forests; b) restoration of degraded and drained peatlands; c) prevention of peat forest fires; d) restriction the development of new plantation concessions on peat; and e) reduction of emissions from existing plantations. In addition, REDD needs to generate sufficient financial incentives to address the economic drivers of peatland degradation and stimulate alternative sustainable development options. The inclusion of incentives to support the reduction of emissions from degradation of peatlands and other forest types with high carbon stocks is crucial in any future REDD mechanism. The better management of peatland forests, in particular, can make a substantial contribution to reducing atmospheric greenhouse gas concentrations in countries with significant peat forest carbon stocks.

5. AFTERWORD: MOVING FORWARD RESPONDING TO THE CHALLENGES

Problem of deforestation and forest degradation of peatland which occurs at the local level is a national problem which needs attention from the government. Government needs to adopt policies due to the problems in peatland, and to determine a policy, it needs accurate data, which can be produced understanding well of peatland, which is intended to obtain data such as mapping of peatland area, peat depth mapping , criteria of destructions in peatland, carbon emissions resulting from peatland destruction, etc.

By given the uniformity of understanding and using the accurate results will avoid the bias. Decision maker and policy maker will be easier to make a decision and regulation for the national interest in tackling the destruction in peatland. With the clear definition of peatland, it will lead to the certainty of taking action (Figure 18). The certainty of policy, regulation and action can be used as tool to convince the international level that Indonesia is serious in efforts to reduce emissions by 26% until 2020. Thus it can be more inviting donors to support carbon emission reduction efforts in Indonesia (associated with planning program organized by ICCC, which is responsible for adaptation and mitigation of climate change at national level in Indonesia).

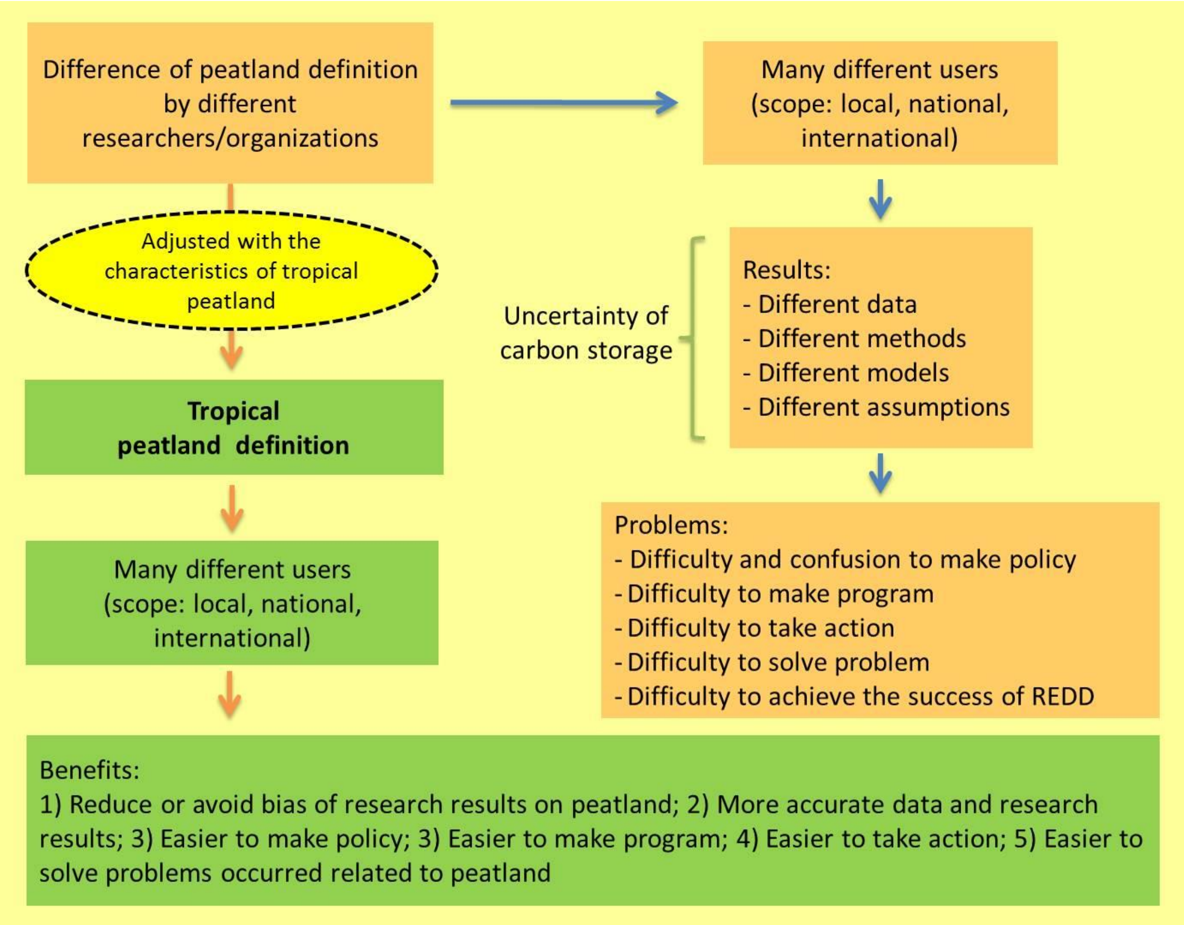


Figure 18: The importance and benefit of peatland definition

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ANNEX 1: Proceedings of technical expert groups on peatland and peatland mapping

No.	Meetings (venue and date)	Agenda	Summary
1.	DNPI, Jakarta 13 September 2011	• Methodology of peatland mapping • Program of Works • Establishment of expert group on peatland and peatland mapping	•
2.	Hotel Aryaduta, Jakarta 23 September 2011	• "*Expert Briefing Meeting on Peatland Measurement in Kalimantan and Papua"* delivered by Dr. J. Boone Kauffman (USDA Forest Service, Northern Research Station, USA)	•
3.	Hotel Morrissey, Jakarta 25 October 2011	• Indonesian Climate Change Activities Update/ICCC • Experts Working Group	•
4.	Hotel Novotel, Bandung 3-5 November 2011	• Indonesian Climate Change Activities Update/ICCC • Developed a proposal on *Peatland and Peatland Mapping* • Developed a proposal on ICT infrastructure for ICCC • Developed a *workplan*	•
5.	DNPI, Jakarta 13 January 2012	Discussion of various technical issues related to *Peatland and Peatland Mapping* definition	
6.	Hotel Borobudur, Jakarta 19 March 2012	• Developed better regulation, better governance and better management to achieve peatland sustainability • Developed criteria-indicator and independent monitoring system on peatland sustainability	• Necessary to provide briefing on peatland (workshop on expert briefing ICCC and USFS) • Subsidence is inevitable as many countries face • Natural peatland values needs re-inventeing and judgement • Prioritizing the regulation and environment licence audit to maintain the remaining peatdomes • Needs of projection of socio-economic impacts of the flooding: time-lining

ANNEX 2. Proposed research program on peatland and peatland mapping based on Bandung meeting

No	Activity/Program	Main Objectives	Specific Objectives	Indicator of achievement/ Output	Linking with policy
1	GPR Survey of Tropical Peatland in Indonesia	1. To acquire new knowledge and new information regarding tropical peat, especially in its physical as well as chemical properties. 2. To provide an alternative method in detecting peat depth and peat volume in tropical peat environment.	1. To verify the suitability of GPR in the detection of peat depth and in estimation of peat volume in tropical peat environment.	1. GPR surveys are conducted timely in accordance with technical requirements and specification 2. GPR data are processed accordingly with appropriate software and verified by core data. 3. Approved by DNPI, the results of GPR survey are publishable in international referred journals. **Output:** 1. Depth profile of GPR lines that show verified peat depth. 2. Estimated peat volume in each peatland site. 3. Protocol for GPR survey in tropical environment	Better estimate of peat depth and peat volume would improve the quality of decision and policy on peat and peatland issues.
2	A multiscale and multisensor remote sensing approaches to inventory peatland in Indonesia	The research aims to inventory peatland in Sumatera, Kalimantan and Papua using	1) To develop standard procedure of digital image processing based on remote sensing data from different sources	- The research result is providing better accuracies (map); - International publications (seminar, journal) - The integrated methods will	- Community development (continuing education); economic growth; sustainable development; public domain - Capacity building;conservation; - Scientific knowledge dissemination

		multi-scale and multi-sensor remote sensing data	2) To integrate multi-sensor remote sensing data with developing specific algorithms and methods 3) To generate Indonesia peatland spectral library	be a standard operating procedure; Peatland spectral library will be the first library in understanding peatland systems **Output:** 1) Peatland Distribuon Map 2) Indonesia Peatland Spectral Library	(books) -
3	Assessment of Social and Economic Dynamic at Village Level	To assess social and economic dynamic at village level	1. Village map scale 1:5.000 2. Land Use Management. 3. Green business opportunity for local people. 4. Support for climate change program.	1) Map collation - Peta Dasar 1:50.000 untuk Sumatera dan Kalimantan - Peta Dasar 1:100.000 untuk Papua. - Peta persil atau bidang tanah. - Peta Kesesuaian lahan. 2) Survei Sosial Ekonom dan antropologi. - Data atribut Sosial dan ekonomi. - Data spasial sosial dan ekonomi. - Data kultural masyarakat desa.	

				3) Survei batas desa (participatory mapping) - Pilar batas desa dan koordinat batas desa. 4) Survei luasan penguasaan lahan (participatory mapping) - Land ownership data 5) Airborne Survey - Peta Topografi dan peta 3D. 6) Data Integration - GIS Database	
4	Pembangunan ICT pada Indonesia Climate Change Center	To develop Indonesia Climate Information System	To develop Data Center	**General obj.:** - Data Center - Climate Database - Web GIS Appl./ - Indonesia Climate Portal - Integrated DMS - Integrated w/ NSDI - Climate Awareness **Specific obj.:** ICT Infrastructure Initial Climate Database Skilled SDM	1) Provide Accurate Spatial Information on Policy Development 2) Get Involve on Policy Dev 3) Support on Policy Dev

				Output: 1) Data Center; 2) Peatland & PeatLand Mapping Portal 3) Skilled Human Resources 4) Socialization	
5	NATIONAL PEATLAND GEODATABASE DEVELOPMENT	To update National peat land map to support one Map reference / basemap	1) Providing peatland map to support one map policy (UKP4) and supporting the Perpres 61/2011 on reducing GHG through development of long-term policy and strategy for sustainable peatland management with the availability of accurate peatland maps 2) Supporting measureable, reportable and verifiable (MRV) monitoring system on peatland. 3) Supporting the strategy for peatland emission reduction and development of	1) Penyusunan pedoman dan standard pemetaan gambut skala tinjau 1:250.000 2) peatland maps (1:250 000) for Sumatera and Papua 3) development and updated peatland database 4) Carbon management and strategies of emission reduction on peatland areas. 5) Land use and landuse change in peatland 6) Pemetaan Landcover dan fragmentasi lahan gambut Kalimantan dengan landsat archeive 7) Pelatihan dan peningkatan SDM untuk partisipatory mapping lahan gambut **Output 1**	- Penyediaan dokumen rumusan kebijakan terkait definisi, klasifikasi, metode, desain layout peta dan index penomoran - Menyediakan peta seamless lahan gambut dan - Provides peatland map to support one map reference for UKP4 activities and - supports the Perpres 61/2011 by development of long-term policy and strategy for sustainable peatland management with the availability of accurate peatland maps. - Support the Perpres 71/2011 on inventory of GHG by accurate and rationale carbon stocks and GHG emission database under different types of peatland. - Supporting measureable, reportable and verifiable (MRV) monitoring system. - Menyediakan peta fragmentasi atas

			emission factors .	Availability of peatland map of Sumatra and Papua with the scale of 1: 250.000 **Baseline:** Current spatial data lacks ground truthing and thus lots of deviation between the map and actual field condition. In addition there is no delineation of degraded peatland in the current maps **Indicator:** 3 volumes of Atlas of degraded peatland, and land potential suitability and conservation areas **Target:** peatland atlas of Sumatra and Papua at 1:250.000 scale **Output 2:** development and updated peatland database **Baseline:** Limited data on peatland especially its characteristics, trigger factors for emission **Indicators:** Data house of peatland information	kondisi lahan gambut sebagai pemahaman menyeluruh kondisi ekologis gambut

				Output 3 Carbon management and strategies of emission reduction on peatland areas. **Baseline:** - High variation in temporal and spatial peat C stock and emission. - Very limited wall to wall analysis of GHG emission and strategies of emission reduction to support the implementation of RAN-GRK for voluntary market **Indicator:** A set of data and Report on GHG emission, REL and mitigation options **Target:** Completion of mitigation options form peatland in one peat districts.	

...ings of International Symposium on Wild Fire and Carbon Management in Peat Forest in Indonesia 20...