Annex 03

Keynote Speaker : Dr. Stephen Hagen (Applied Geosolutions, US)
Title : Remote Sensing for Forest and Peatland Mapping (#01)

Applied GeoSolutions (AGS) and LAPAN

REMOTE SENSING FOR FOREST AND PEATLAND MAPPING

LAPAN – 21 JULY 2017

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Overview

- **Goal**: Continue to build the technical relationship between AGS and LAPAN for forest and peatland monitoring
- Agenda:
  - Applied Geosolutions company and mission
  - NASA Carbon Monitoring System Project review
  - Indonesian Peat Prize: Team Applied Geosolutions Accomplishments

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Applied Geosolutions (AGS)

- Office in Newmarket/Durham, NH USA and one employee in Washington, DC
- Nineteen full time employees with variety of education, experience and skills:
  - Earth systems science, data science, systems engineering, mathematician, IT professional, management professional
- Growth: 1 employee in 2001; 3 in 2006; 8 in 2012; 12 in 2014; 16 in 2015
- Last 10 years spent on technology development, R&D and government grants.
- **Grow the company for impact: to develop business case for environmental conservation and markets for ecosystem services.**

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Applied Geosolutions (AGS)

- What Applied GeoSolutions does:
  - Use ***satellite data*** to monitor agriculture, forests, water quality, and land use change.
  - Use ***biogeochemical models*** to estimate the impacts of management on productivity and greenhouse gas emissions.
  - Create ***software/web tools*** to make monitoring and reporting easy for non-experts.

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NASA Carbon Monitoring Systems Project

NASA Carbon Monitoring System

- Established in 2010
- Our team was funded in 2013 for a ~~3-year~~ 4-year project:
- **"Operational multi-sensor design for national scale forest carbon monitoring to support REDD+ MRV systems"**
- Project region: Kalimantan, Indonesia (all 5 provinces)

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NASA Carbon Monitoring Systems Project

NASA Carbon Monitoring System

- Two primary outcomes or deliverables:
  - Manuscripts:
    - Biomass mapping across Borneo (Ferraz et al. in prep)
    - LiDAR automated logging methods (Hagen et al. in prep)
    - Carbon impact of logging (Pearson et al in prep)
  - Open-source software packages for using LiDAR to monitor forests and training at LAPAN
  - Additionally, the CMS Project contributed to AGS's participation in the IPP

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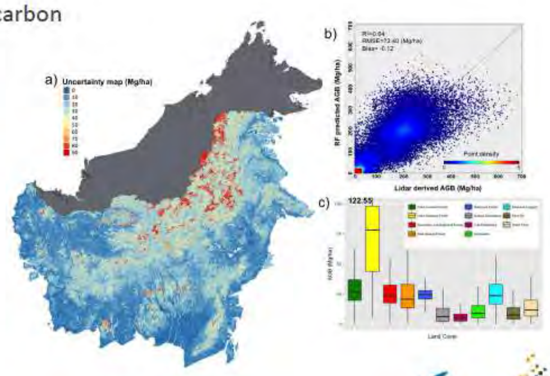
Biomass mapping

- Improved map of above ground live forest carbon (Ferraz et al. 2017 *in prep*)



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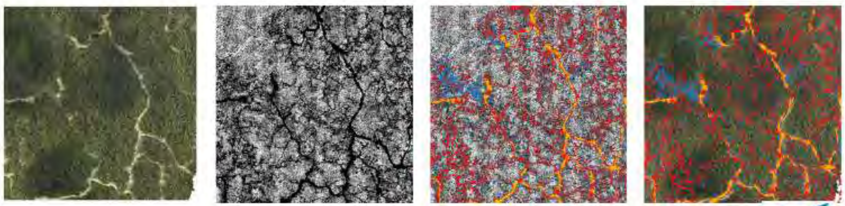
Automated mapping of logging features using LiDAR

- LiDAR and Automated LiDAR Logging Software provide very promising tool for identifying and quantifying logging and its associated impacts.
  - Timber companies can use software for planning
  - Government and researchers can use software for monitoring logging and carbon impacts
- Open Source Software installed at LAPAN



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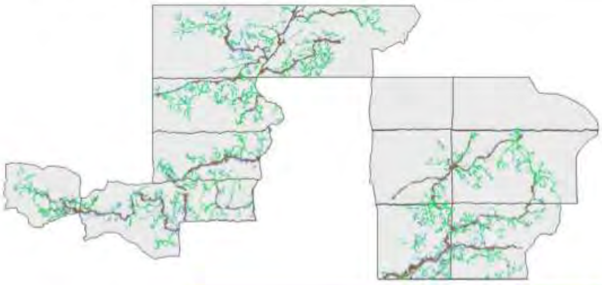
Automated mapping of logging features using LiDAR



1 km

	Roda Mas	Timberdana
Total area in Block (ha)	1245.5	800.8
Roads & Decks	42.0 (3.4%)	31.8 (4.0%)
Skid Trails	81.5 (6.5%)	113.5 (14.2%)
Gaps	50.3 (4.0%)	57.2 (7.1%)
Total logging	173.9 (14.0%)	202.5 (25.3%)

1 km

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Peatland mapping and monitoring

- Indonesian Peat Prize: Team Applied Geosolutions

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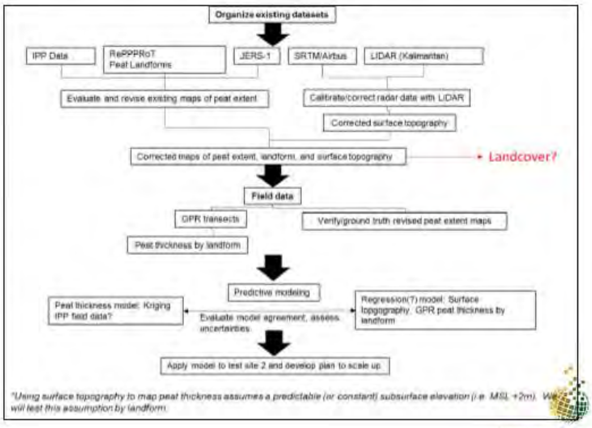
Peatland mapping and monitoring

- Link surface topography and other variables to peat depth *within each Landform*. Driving assumptions is that each landform type can have a distinct relationship driving depth.
- Requirements for this approach:
  - Accurate surface topography data across wide areas (calibrate SRTM/Airbus DEMS to LiDAR)
  - Accurate and abundant measurements of peat depth for model development and evaluation (use GPR and ERI)



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Progress and accomplishments during the IPP

- The team received limited outside support but made significant progress:
  - 1. Demonstration of ERI data in Bengkalis for measuring peat depth;
  - 2. Demonstration of empirical model relating surface topography to peat depth in Central Kalimantan;
  - 3. Processing of wide-area coverage satellite data in support of peat mapping
  - 4. Building a productive working relationship between team members in Indonesia, Europe, and the USA

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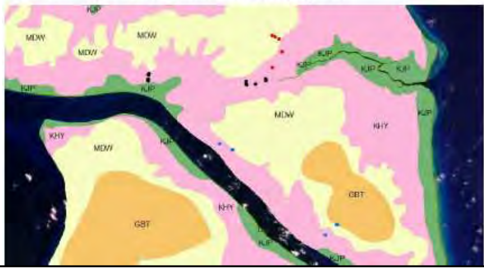
Demonstration of ERI data collection

- The objective was to collect both ERI measurements and coring samples to estimate peat depth.
- Analysis of these data is intended to provide information regarding the effectiveness of ERI for estimating peat depth.
- Applied Geosolutions will assist with this analysis.



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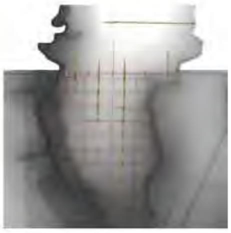
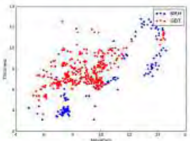
Design, deployment, and evaluation of an empirical model of peat depth

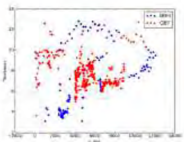
- Our team did not have access to LiDAR data in Bengkalis, so we proceeded with a demonstration in Central Kalimantan.
- Thickness vs. multiple variables:
  - Landform type
  - Surface topography
  - Distance to river
  - Distance to canal

Mawas site in Central Kalimantan

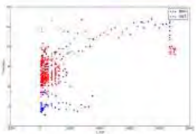




Thickness vs. 2011 LiDAR elevation (m)



Thickness vs. Distance From nearest river (m)



Thickness vs. Distance From nearest canal (m)

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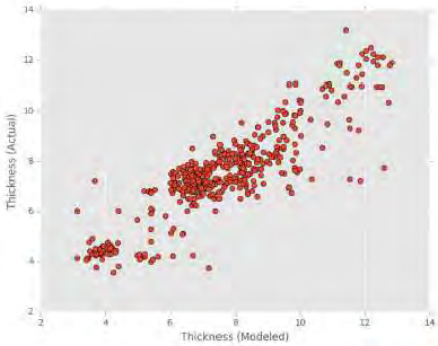
Design, deployment, and evaluation of an empirical model of peat depth

- Artificial Neural Network –
  - non-parametric modeling approach
  - minimizes over-fitting and improves generalizability
  - open-source routine implementation from AGS
- Independent variables:
  - (a) distance to nearest river
  - (b) distance to nearest canal
  - (c) landform type
  - (d) elevation.
- The out-of-sample results of the evaluation
  - R^2=0.78
  - RMSE=0.957 m
  - RMS/mean=0.13



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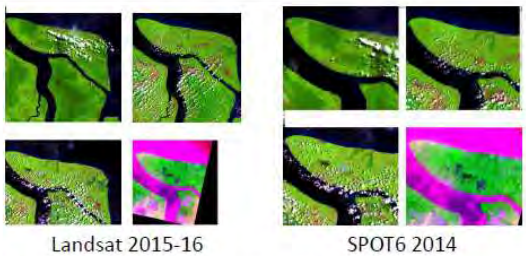
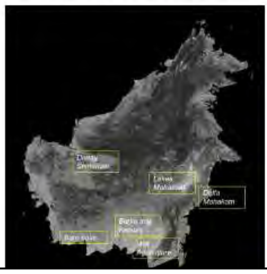
Processing of wide-area coverage satellite data needed to map peat depth

- The LAPAN team members processed Landsat and Spot imagery for the Bengkalis area. In the imagery, we note the land cover/land use changes in Bengkalis area from forest to plantation and paddy field area.





- The Wageningen and Sarvison team members has provided mapping flood frequency and wetlands across Indonesia, primarily with radar remote sensing.
- Provides flooding information over large areas, even in persistently cloudy areas
- C-band utilized by Sentinel-1, is capable of detecting open water.
- L-band utilized by PALSAR, have larger penetration capabilities and can even detect flooding under vegetation

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Peat loss: subsidence and burning

- Mawas – ex-Mega-Rice Project Area data sets
  - LiDAR acquisitions in 2011 and 2014 (KFCP and NASA CMS)
  - Annual burned area maps from Landsat (Cochrane, SDSU/UMD)
- Areas that did **not burn lost 3.9 cm of peat on average** between 2011 and 2014 (19,634 ha).
  - Note: This matches up well with the average subsidence at 279 dipwell sites in the area between 2011 and 2014 was estimated to be 3.1 cm.
- Area that registered at least one burn event between 2011 and 2014 lost 23.7 cm on average.
  - Therefore, the average peat lost due to fire was 3.1 cm or 3.9 cm fewer than the 23.7 cm estimated, or 20.6 cm or 19.8 cm lost to fire, on average.
- Again, assuming a 3.1 cm loss from subsidence, we note that burn frequency was inconsistent with amount of peat lost:

burn frequency	ha	average cm lost
0 burns	19,634	0.8
>0 burns	2,604	20.6
1 burn	2,375	20.3
2 burns	190	26.4
3 burns	23	8.9
4 burns	17	7.9

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Next steps

- Applied Geosolutions will coordinate with LAPAN to provide analysis of ERI data
- Continue to build the collaboration on Remote Sensing Technology and Applications between Applied Geosoltuions and LAPAN.
- AGS, UNH, and Dirk Hoekman will search for funding for the team to continue the peat mapping work

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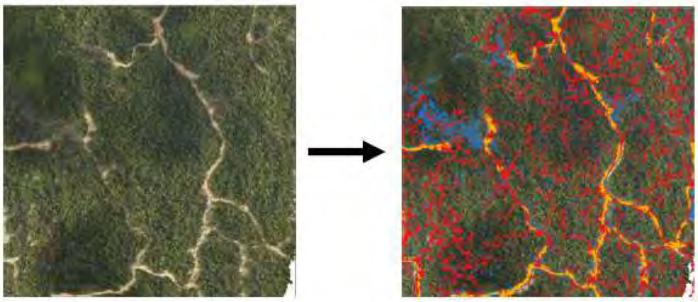
Annex 03

Keynote Speaker : Dr. Stephen Hagen (Applied Geosolutions, US)
Title : Automated Detection and Classification of Logging Features with LiDAR (#02)

Automated detection and classification of logging features with LiDAR

Applied Geosolutions 2017



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Background

- Logging is extensive in tropical forests and has a substantial impact on forest structure, animal habitats, and **carbon emissions** (Pearson et al. 2016);
- Indonesia is at the center of the logging world;
- Logging and the associated impacts are challenging to detect using traditional remote sensing methods;
- LiDAR is a very promising tool for identifying and quantifying logging and its associated impacts.

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Data

- LiDAR data collected over several concessions in Indonesia in late 2014
- Field mapping of logging features and biomass collected in two concessions in 2014/2015

3

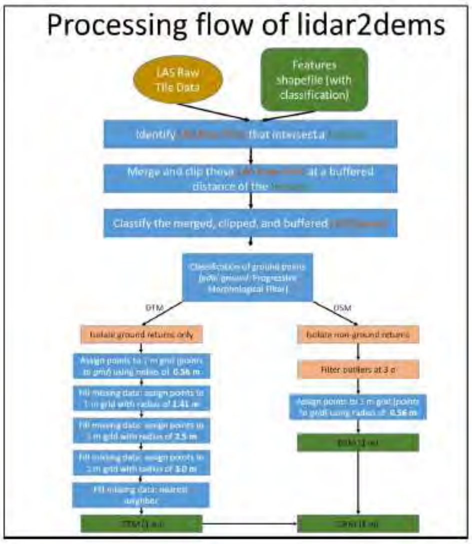
Methods: Overview

- Process the LAS point clouds into DSM, DTM, CHM, and voxels at 1 m resolution.
- Use our automated script to classify features: skid trail, road/deck, and logging gap.
  - Input: DTM, CHM, and RDM at 1 m
  - Output: Classified map of skid trails, road/deck, logging gap, mixed class of skid trail/logging gap.
- Indexing and quality control of the GPS data
- Compare the automated output classes to the features identified in the field using GPS and aerial photos.
  - How well do the features identified using the automated methods compare to the features mapped in the field with gps?
  - Where they don't agree, is there an indication of why they don't?

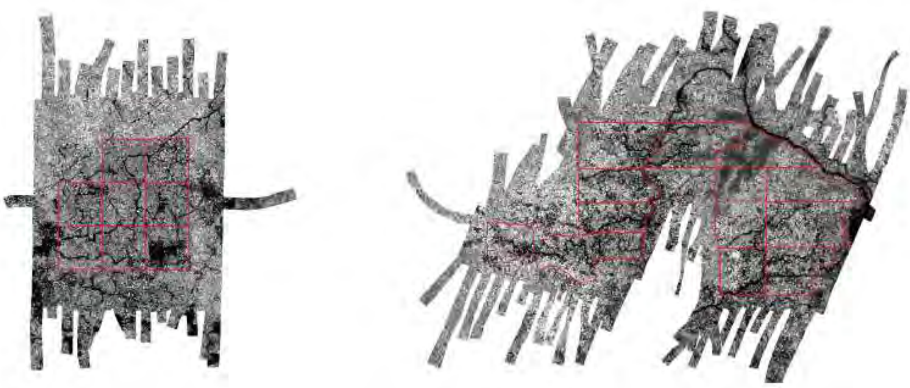
4

LiDAR Processing

- We created a free and open source software package to efficiently process high density and broad coverage LAS data on a linux platform.
- **lidar2dems** – open source software for classifying ground points and generating DTMs, DSMs, and CHMs from LAS point clouds
- The software is freely available:
- http://applied-geosolutions.github.io/lidar2dems/



LiDAR Canopy Height Models at two concessions



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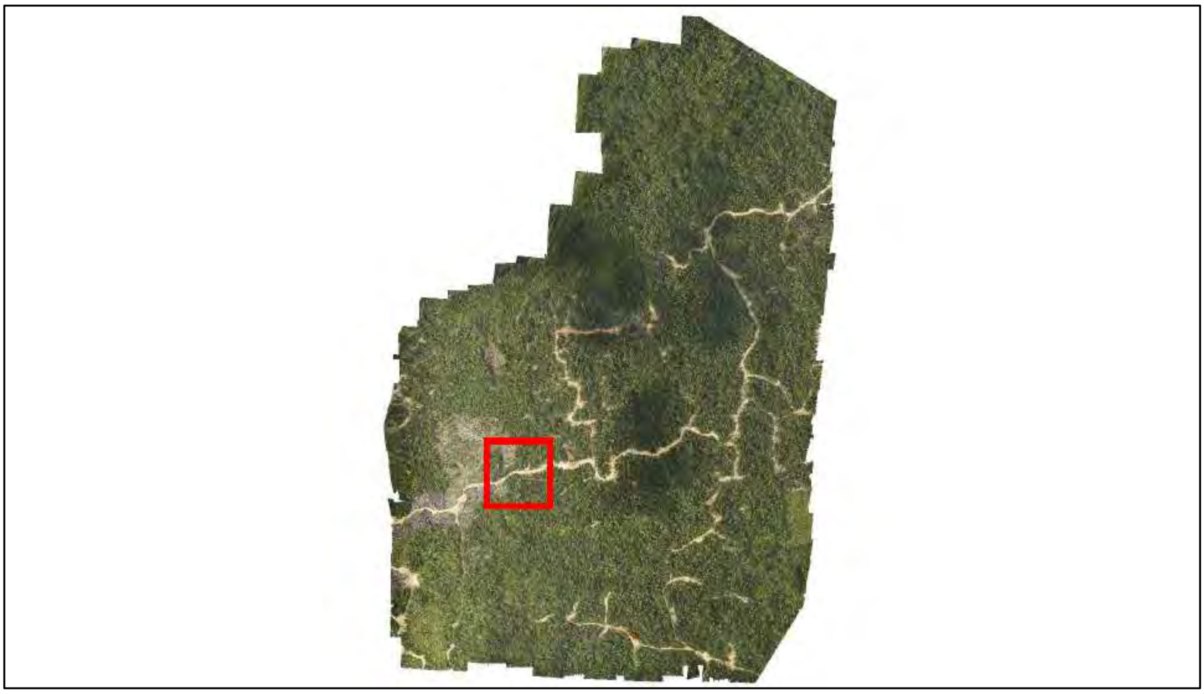

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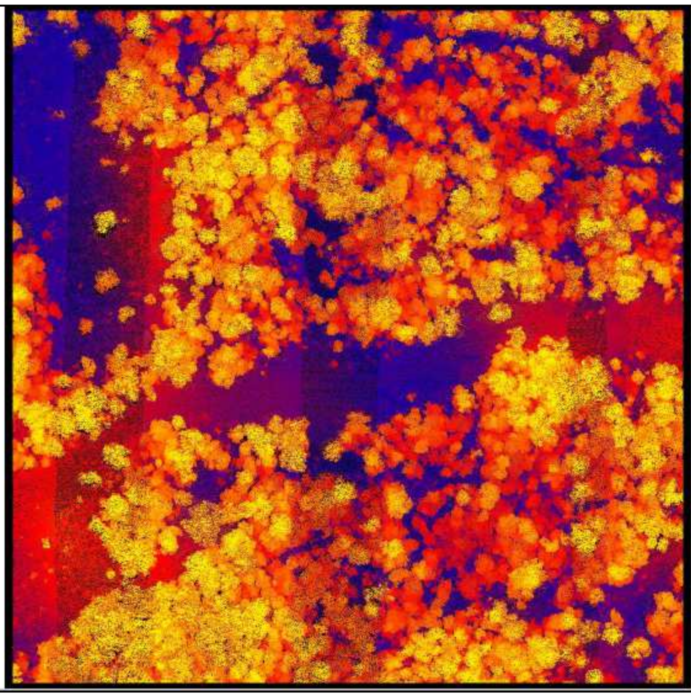

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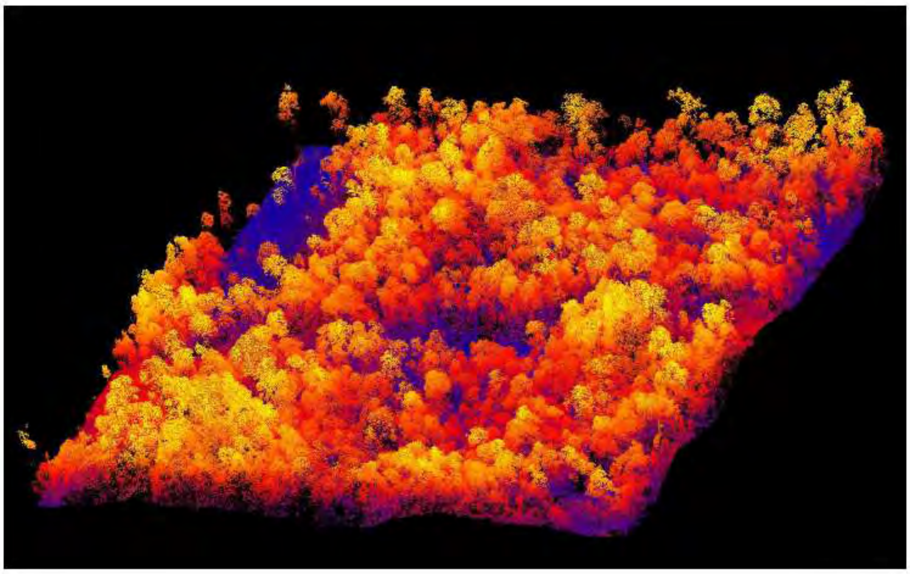

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Methods: Automated algorithm

A. Contiguous areas of extremely low canopy height.
1. pixels where the highest return was 1 m or less in height (binary map of pixels meeting this condition);
2. post-processed using a median filter and a clump/sieve process to eliminated clumped adjacent (using 8 neighbors) low canopy height areas covering less than 400 m^2

B. Contiguous areas with no understory.
1. relative density model from the voxels indicating the ratio of LiDAR returns in 2 - 8 meter vertical space to returns from the ground (0 m) up to 8 meters.
2. generated a binary map using a maximum 1:50 threshold, meaning that pixels with fewer than 2% of returns in the 2-8 m vertical space out of all returns from the ground to 8 meters were mapped with a value of 1, others 0
3. areas with no returns in the 0 to 8 meter space were also assigned a value of 0.
4. post-processed using a median filter and a clump/sieve process that eliminated clumped adjacent (using 8 neighbors) areas meeting the defined threshold covering less than 100 m^2.

C. Contiguous areas of reduced canopy height.
1. analogous to 1) above, all pixels where the highest return was 6 m or less in height above the ground (binary raster layer with 1 indicating the reduced canopy threshold was met)
2. post-processed using a median filter and a clump/sieve process that eliminated clumped adjacent (using eight neighbors) low canopy height areas covering less than 150 m^2.

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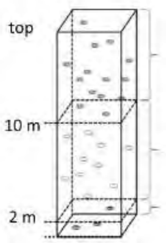
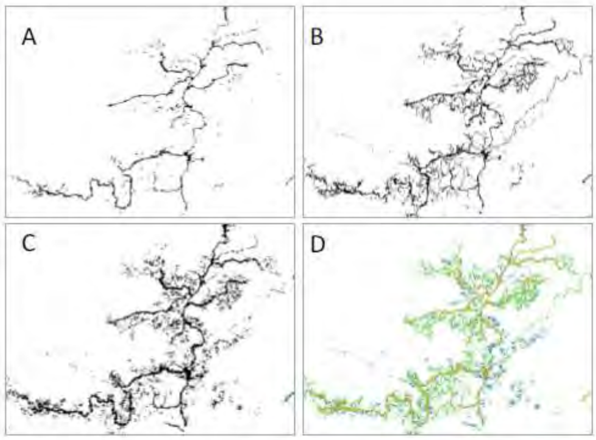
A. Extremely low canopy height
B. No understory
C. Reduced canopy height
D. Combined map



RDM example (Ellis et al 2016)



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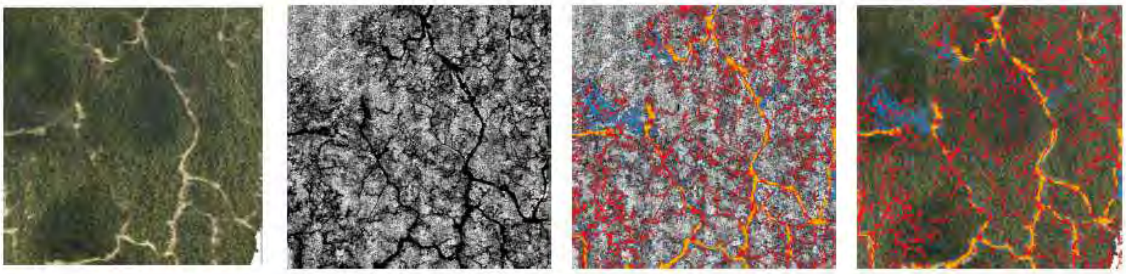

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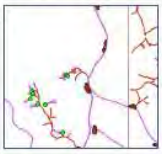
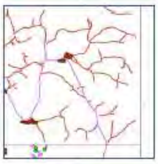
Field data collection

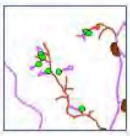
- The field teams measured logging features:
  - Roads and decks



  - Skid trails



  - Logging stumps & gaps



Winrock International and the Tropical Forest Foundation collected data at Roda Mas and Timberdana in Dec 2014.

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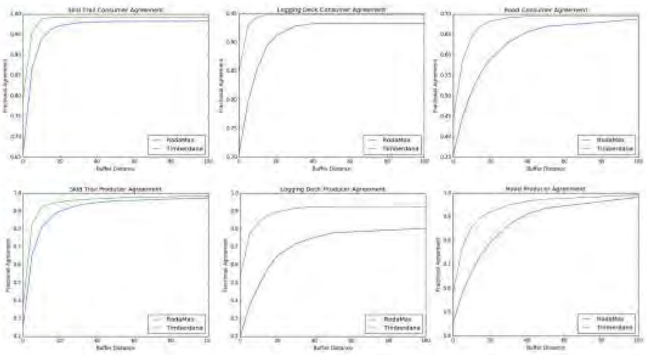
Methods: comparison approach

- Procedure for the comparison of the features: Automated algorithm vs. GPS mapped & photo evidence
  - Vectorize the automated output features:
    - Roads assigned an ID
    - Skid trails separated into primary and secondary components and assigned an ID
    - Decks assigned an ID
  - GPS:
    - Roads, common ID with the automated output features where segments are clearly matched
    - Skid trails into primary and secondary, common ID with the automated output features where segments are clearly matched
    - Decks ID with the automated output features where segments are clearly matched
  - Linked IDs: buffer target (accounting for GPS error) & calculate overlap in features as a fraction
  - Non-matching features:
    - Yes GPS, No Automated -> mismatch
    - No GPS, Yes Automated -> examine photo evidence for result

Comparison results

	Roda Mas					
	Roads		Skid Trails		Decks	
	Producer	Consumer	Producer	Consumer	Producer	Consumer
0	0.205	0.170	0.252	0.659	0.200	0.745
10	0.535	0.433	0.806	0.939	0.490	0.875
20	0.710	0.563	0.901	0.972	0.651	0.924
30	0.815	0.627	0.934	0.979	0.718	0.938

	Timberdana					
	Roads		Skid Trails		Decks	
	Producer	Consumer	Producer	Consumer	Producer	Consumer
0	0.323	0.261	0.368	0.793	0.535	0.881
10	0.801	0.630	0.917	0.987	0.843	0.951
20	0.902	0.694	0.949	0.992	0.896	0.955
30	0.940	0.707	0.960	0.992	0.917	0.955



Results

Consumer's accuracy: correctly classified features divided by total number of features assigned to a particular category. It takes **errors of commission** into account by telling the consumer that, for all areas identified as category X in the automated algorithm, a certain percentage are actually correct.

Timberdana: 63% for roads, 99% for skid trails, and 94% for decks.

Roda Mas: 72% for roads, 98% for skid trails, and 96% for decks.

We have many large open areas without canopy in the skid trails in both Roda Mas and Timberdana. These are classified by the algorithm as roads.

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Results

- **Producer's Accuracy**: the features correctly classified in a particular category as a percentage of the total features actually belonging to that category in the image. This provides a measure of **errors of omission**.

Timberdana: 94% for roads, 96% for skid trails, and 92% for decks.

Roda Mas: 82% for roads, 93% for skid trails, and 72% for decks.

The decks in Roda Mas are small and irregular. Some of this error stems from confusion between roads and decks. Questionable photo evidence.

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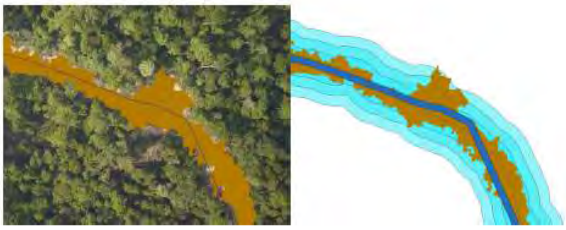
Results

Sources of error:

- GPS accuracy
- Road/deck definitions



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Results

- Examples:
  - One area of common error in our automated mapping routine is our classification of what the field team calls *skid trails* and the automated algorithm call *roads/decks*.

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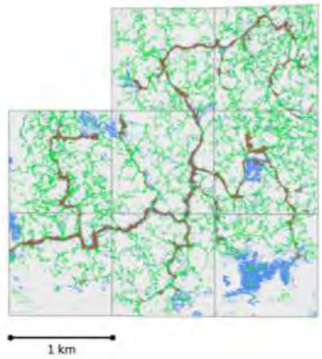
Annex 03

1 km



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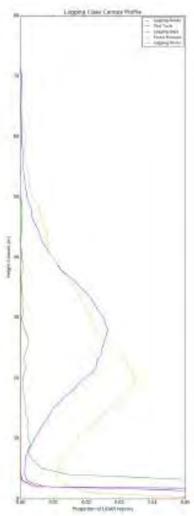

Discussion

- Definitional issues are at the center of some of these problems.
  - A skidder is only likely to cause damage associated with the removal of trees 30 cm in dbh or less. A road is defined as an area about 12 meters wide that is maintained for large vehicle traffic to transport logs. A deck is defined as a cleared area designed as a temporary holding spot for logs. Therefore, a lot of these areas classified by the GPS as skid trails and by our algorithms as roads/decks are not really any of these.
  - The ground data is not gospel and the GPS signals are weak. The ground data is an indication of where the road (or skid trail) can be and an approximate shape.

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Costs

- Typical Block Size of 1,200 ha x 10 blocks – 12,000 ha would cost $80,000 for data collection. With VAT $88,000. $7/ha.
- Cost of processing the data are similar, or about $70,000 for a 12,000 ha concession. Total products delivery could be $13ha or $150,000 per 12,000 ha concession.
- Products available:
  - Detailed planning for tree extraction
  - Detailed maps of logging infrastructure and estimates of carbon emissions

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Next steps

- Receive LAPAN coauthors input and publish in the next 4 weeks.
- Work with other groups to implement this system:
  - TNC
  - LAPAN and Ministry of Environment and Forestry?
  - Tropical Forest Foundation and Art Klassen
- Improve the software for efficiency

Data needed from Art

- Wood extraction volumes by compartment for the 2014 cutting season in Timberdana and Roda Mas
- In Roda Mas, 2 of the 12 compartments are labeled "Carry Over 2014", while the other 10 are labeled "2014". The same two with the carry over label have no logging damage, while the other 10 all have damage. Can you find out and let us know what this "Carry Over 2014" designation means?
- shapefiles of the 2014 harvest blocks for the three other concessions (Suka Jaya Makmur, Sindo Lumber, and Sari Bumi Kusuma)
- information from each of these concessions to complete the table
  - Location, harvested area, number of blocks, topography, logging history, diameter limit, extraction method (road, river), extraction limits, skidding equipment, RIL?

Annex 03

Keynote Speaker : Dr. Aritta Suwarno (Wageningen University, The Netherland)
Title : Development of Remote Sensing Application for Peatland Monitoring (#03)

Background

Interim report WetlandVision project
Dirk Hoekman, 10 September 2015

Flood frequency and wetland mapping with radar

Radar has the unique capability of providing flooding information over large areas (fast and frequent), even in areas of persistent cloud cover.

Short wavelengths, like C-band utilised by Sentinel-1, is well capable of detecting open water. Large wavelengths, like L-band utilised by PALSAR, have larger penetration capabilities and can even detect flooding under vegetation.

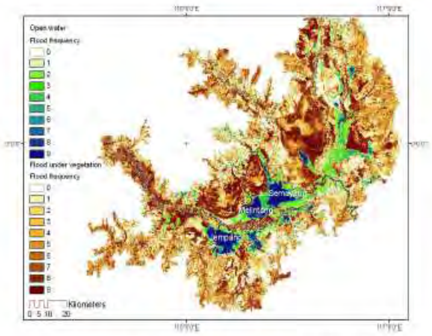
For this reason JAXA acquires PALSAR data over the World's wetlands systematically (PALSAR-1 for 2006-2011 and PALSAR-2 2014 onwards).

Wetland monitoring is studied within the K&C Wetland theme. Examples of the first published maps are shown in the next slide.

1

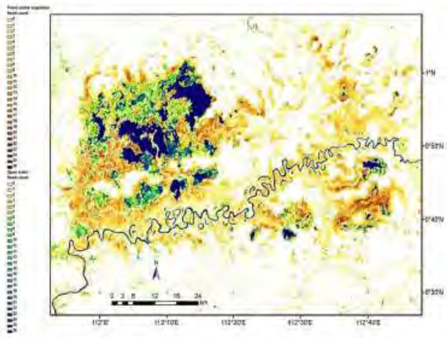
1

Published maps



Flood frequency of the **Mahakam watershed** derived from PALSAR ScanSAR images of the 2008-2009 period. Open water (light green – dark blue) and flooding under vegetation (light – dark brown).

Ref. Hidayat, H., D. H. Hoekman, M. A. M. Vissers, and A. J. F. Hoitink, 2012, Flood occurrence mapping of the middle Mahakam lowland area using satellite radar. *Hydrology and Earth System Sciences*, Vol.16, pp.1805-1816.



Flood frequency in the **Upper Kapuas area** derived from PALSAR ScanSAR images of the 2007–2010 period.

Ref. Hidayat, H., D. H. Hoekman, M.A.M. Vissers, Md. Monowar Hossain, A.J. Teuling, G.S. Haryani, 2014, Inundation mapping of the upper Kapuas wetlands using time series of radar images, *Int. Conference on Ecohydrology*, Yogyakarta, November 2014.

2

KC21, Dirk Hoekman, 3 Dec 201

2

Modeling

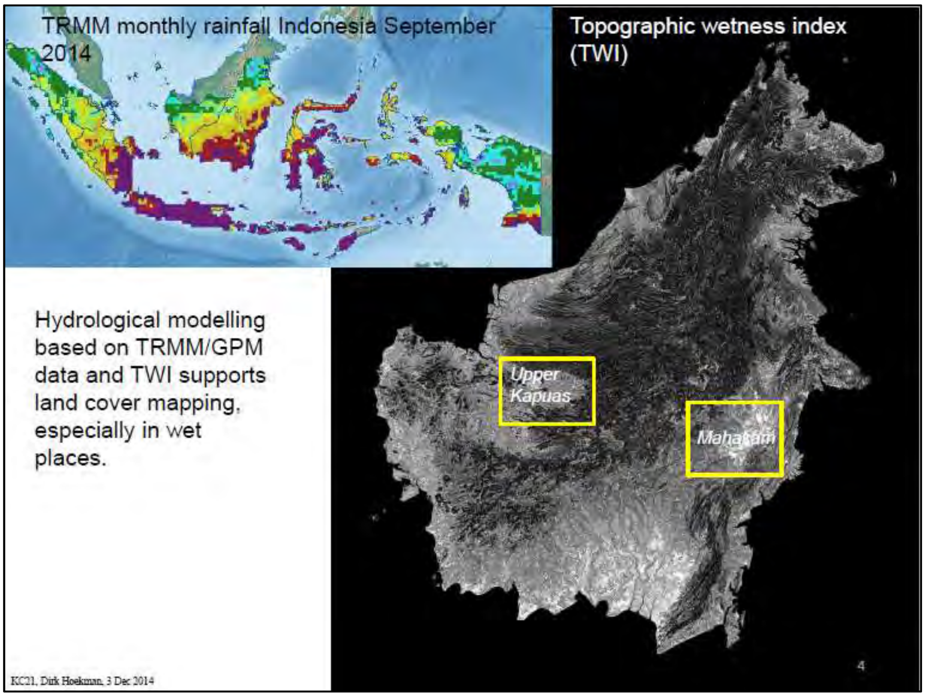
Flood frequency and wetland mapping with radar

Flooding events and dynamics in remote areas can be modelled and predicted using satellite rain radar (TRMM/GPM) data in combination with hydrological models, such as the Topographical Wetness Index (TWI).

The next slide shows a TWI model for Borneo. Areas with high TWI values are indicative for wetlands, very high TWI values usually coincide with lakes.

3

3



4

Automation for entire Borneo

Automated mapping

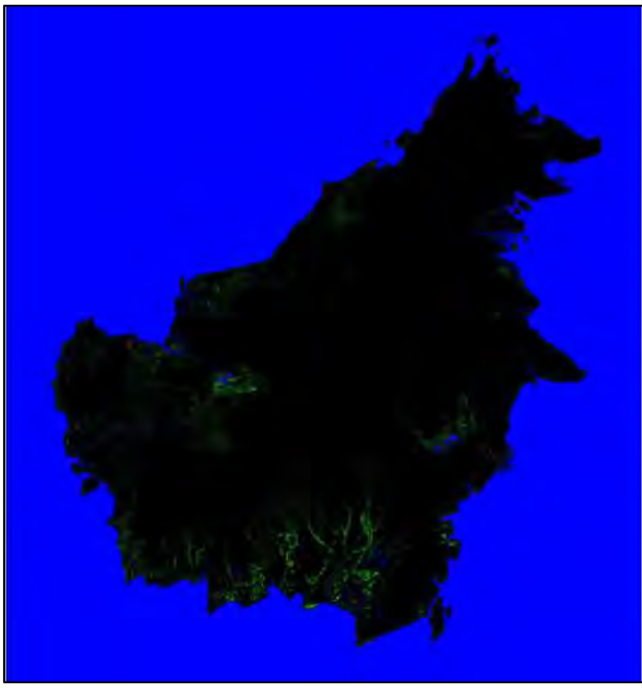
It is pursued to develop a fully automated flood mapping system based on PALSAR (open water and flooded vegetation) and Sentinel-1 (open water only).

The methodology as used for the published maps (see above) has been extended and developed to map large areas as frequent as possible, in a fully automated fashion. In the following examples all observation (±60 per pixel in the PALSAR-1 period) have been processed into a seamless map of the entire area of Borneo.

These maps show open water flood frequency and flooded vegetation frequency (both scaled between 0 and 100%). The problem of confusion between open water and bare soil (both have very low radar backscatter) has been solved. Consequently, bare soil frequency can also be mapped. City areas are mapped as well.

5

5



Borneo flood frequency map – Base data overview

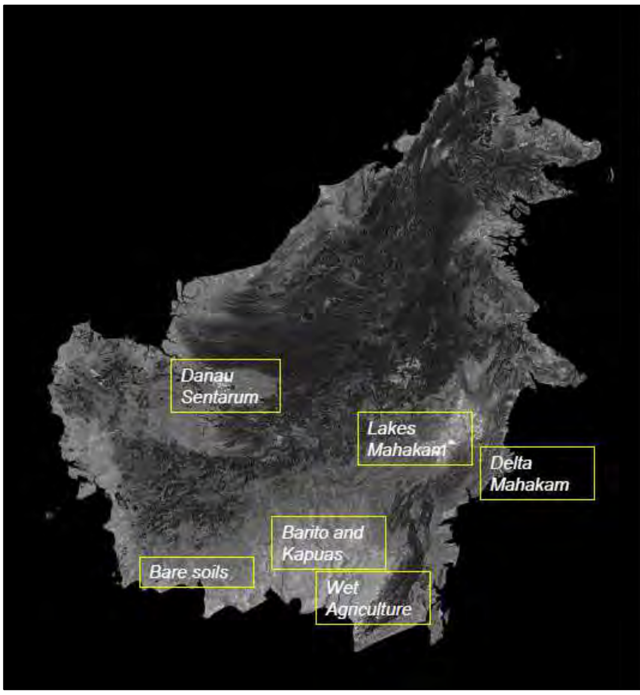
This version of the map shows basic continuous colours. Colours such as shown in the published map above (for discontinuous frequency classes) will be added in the final map production stage.

Pixel size: 70mx70m

Legend
- Blue: Open water frequency (0-100%)
- Green: Flooded vegetation frequency (0-100%)
- Red 1: Bare soil frequency (0-100%)
- Red 2: City

6

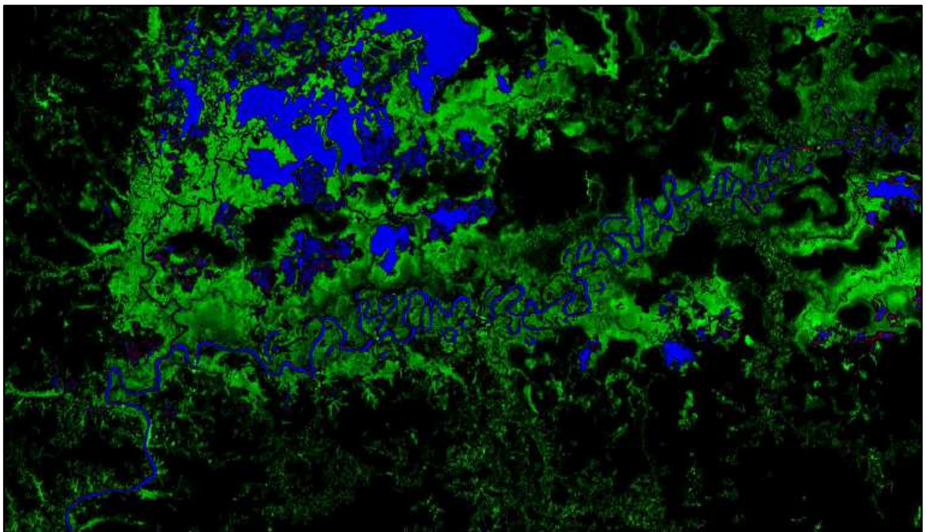
6



Borneo flood frequency map – Base data overview

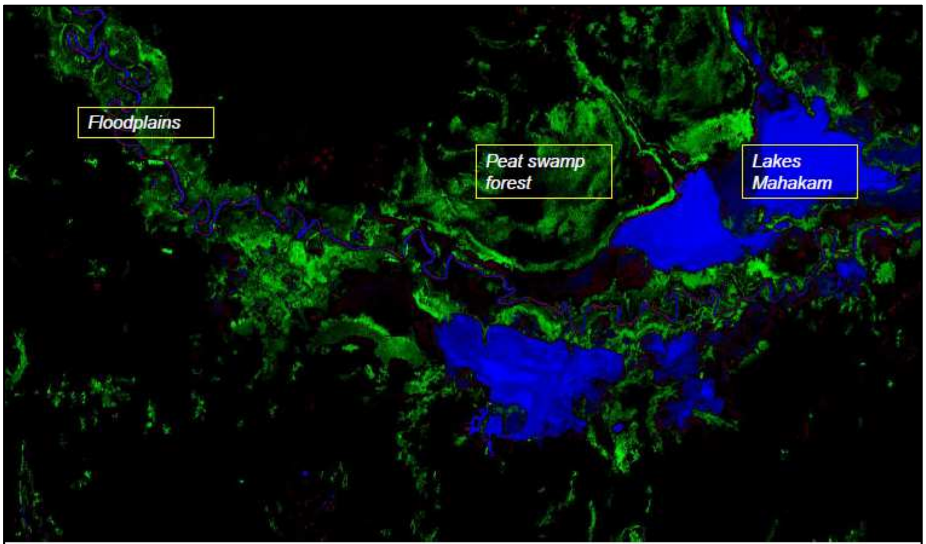
Examples for the areas indicated will be shown in the next sheets

7



Sentarum lake area in Upper Kapuas

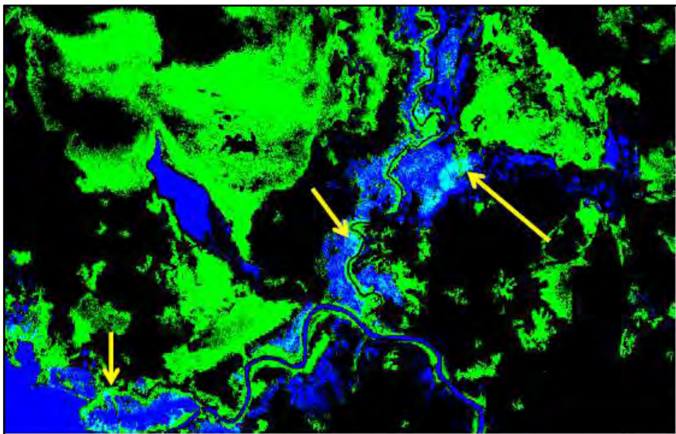
8



Mahakam lake area

9

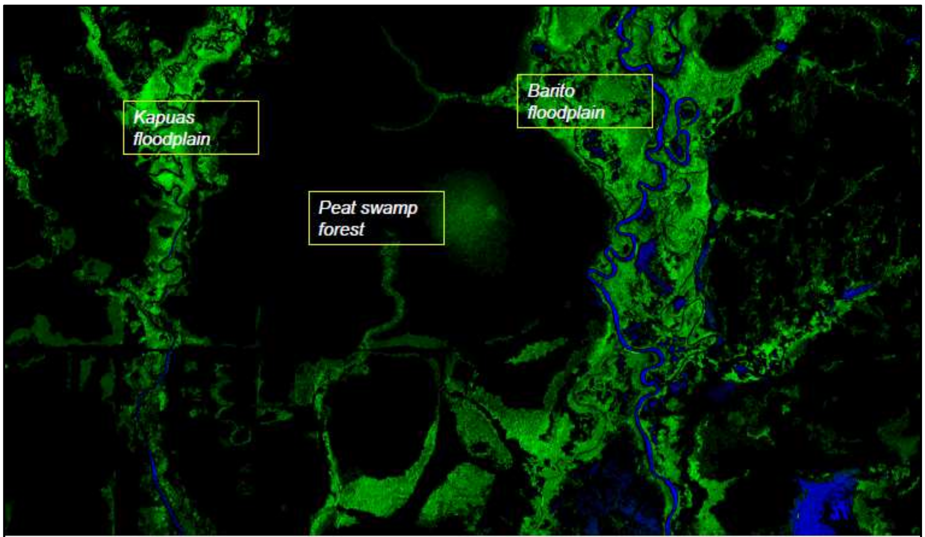
9



Same area, different spatial and colour scaling. Note that Mahakam river level varies over 8 meters. Cyan area shows flooded vegetation (i.e. flooding under vegetation) as well as open water (vegetation fully submerged).

10

10



Barito and Kapuas river and floodplain
Area in between is mainly peat swamp forest

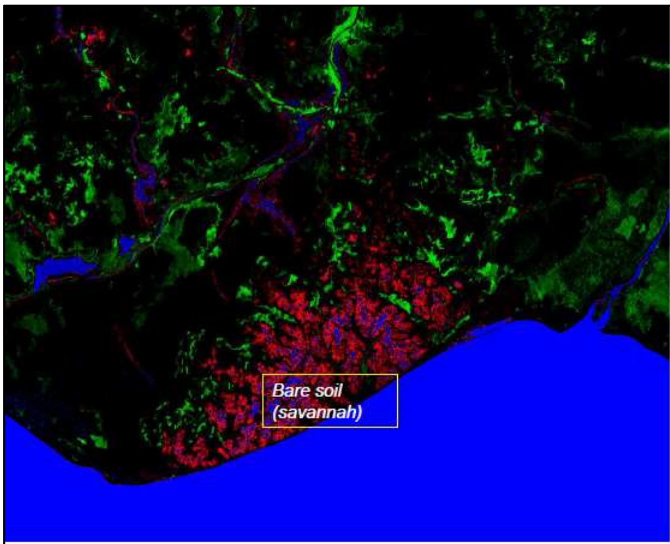
11

11

Mahakam delta
Cities can be mapped well with PALSAR data and are shown in red

12

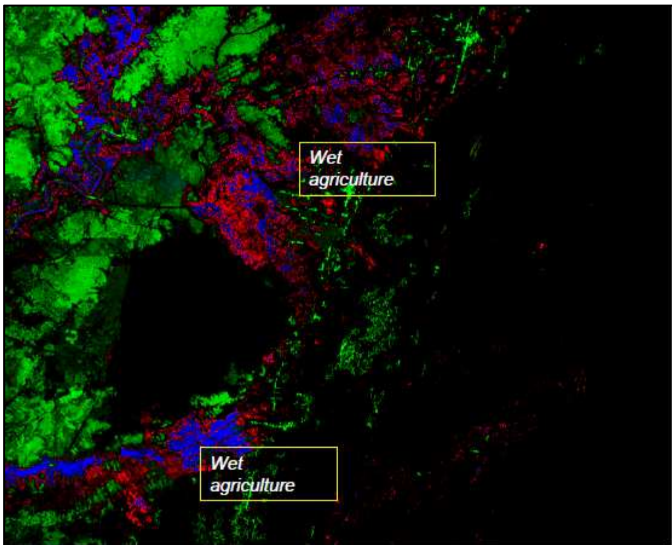
12



Bare soil frequency
Bare soils (in red) can be monitored as well

13

13



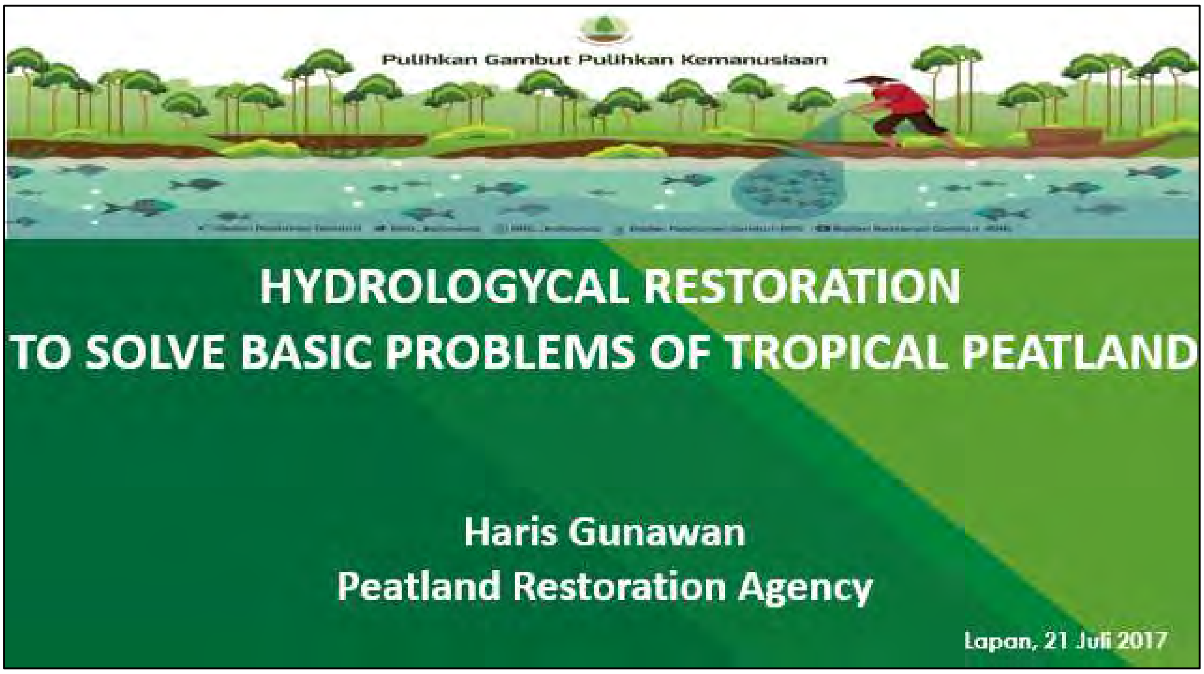
Wet agriculture near Banjarmasin
Though the system is not set up (nor calibrated) to map agriculture there is a large potential to map agricultural dynamics, especially for wet agriculture such as rice.

14

14

Annex 03

Keynote Speaker : Dr. Haris Gunawan (Peatland Restoration Agency, Indonesia)
Title : Hydrological Restoration to Solve Basic Problems of Tropical Peatland (#04)



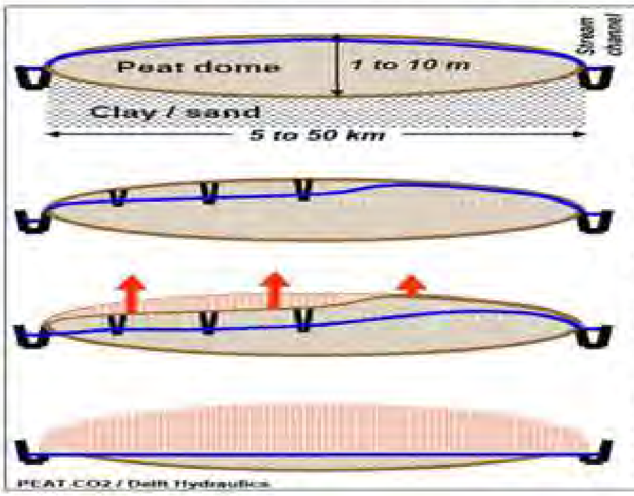
1

2

Annex 03

Badan Restorasi Gambut

The Different Scenario of Peatland



Natural situation:
- Water table close to surface
- Peat accumulation from vegetation over thousands of years

Drainage:
- Water tables lowered
- Peat surface subsidence and CO_2 emission starts

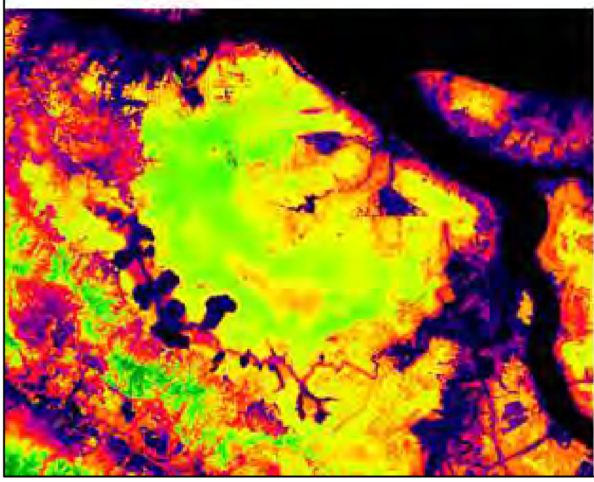
Continued drainage:
- Decomposition of dry peat: CO_2 emission
- High fire risk in dry peat: CO_2 emission
- Peat surface subsidence due to decomposition and shrinkage

End stage: FLOODING IN WET SEASON
- Most peat carbon above drainage limit released to the atmosphere within decades,
- unless conservation / mitigation measures are taken

3

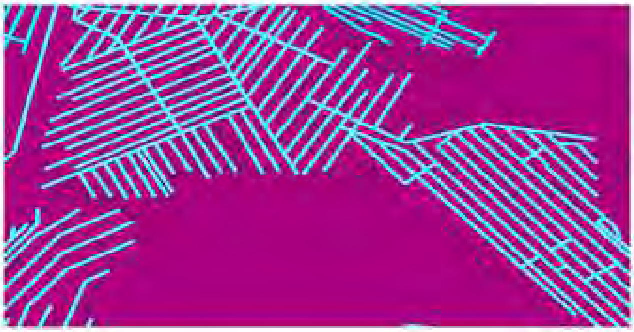
Badan Restorasi Gambut

Pressures on The Peatland: Drainage

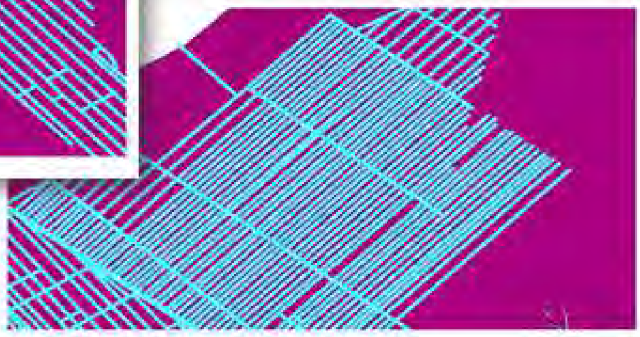


4

The Density of Canal Drainage



Drainase HTI= 14.6 km/ha



Drainase sawit= 46.2 km/ha

5

Badan Restorasi Gambut

Developed peat land Become Easier Dry

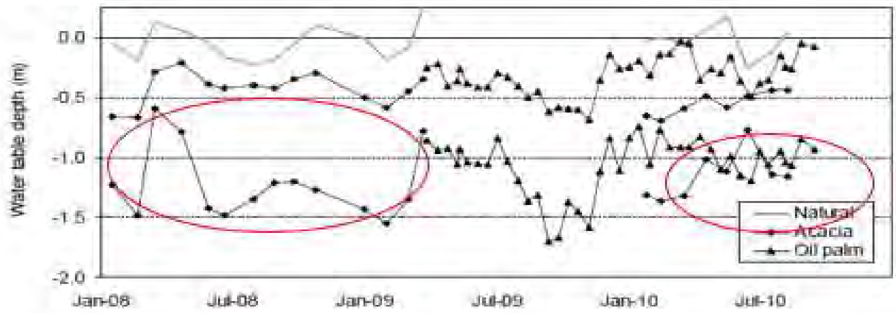
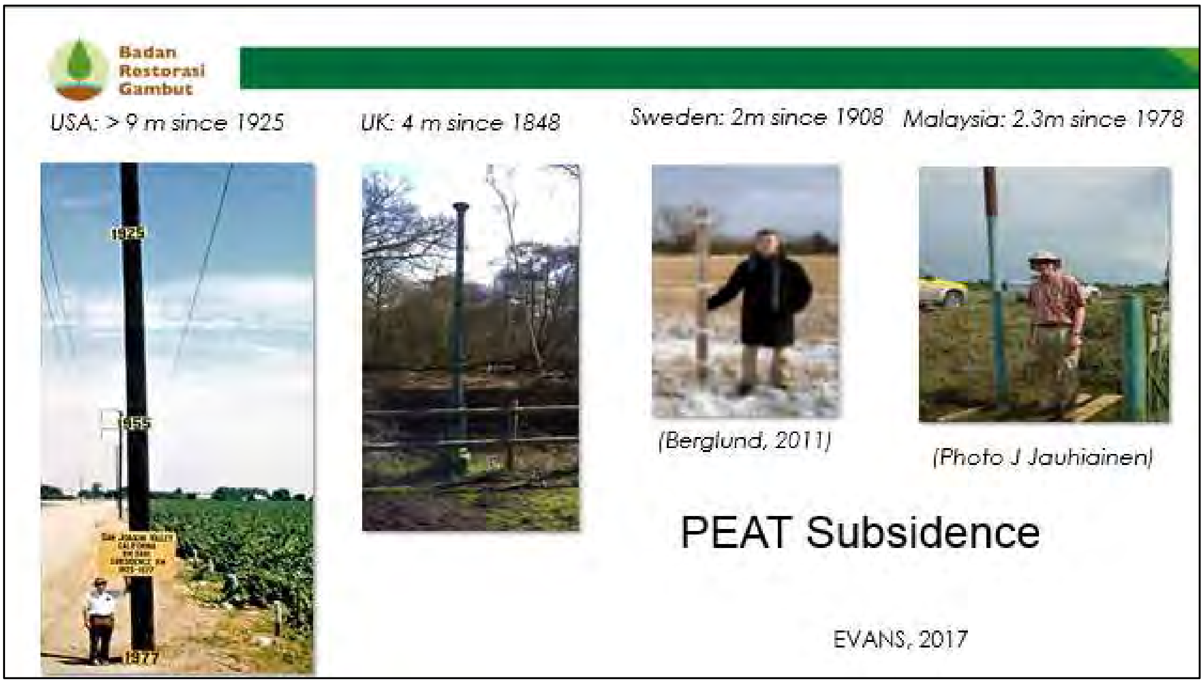


Fig. 10. Time series of water table depth as measured at individual locations in the studied *Acacia* and oil palm plantations, and in nearby natural forest at 2 km from the acacia plantation, over a 3-year period. In plantations, the records nearest the lower and upper 10-percentile average water levels were selected.

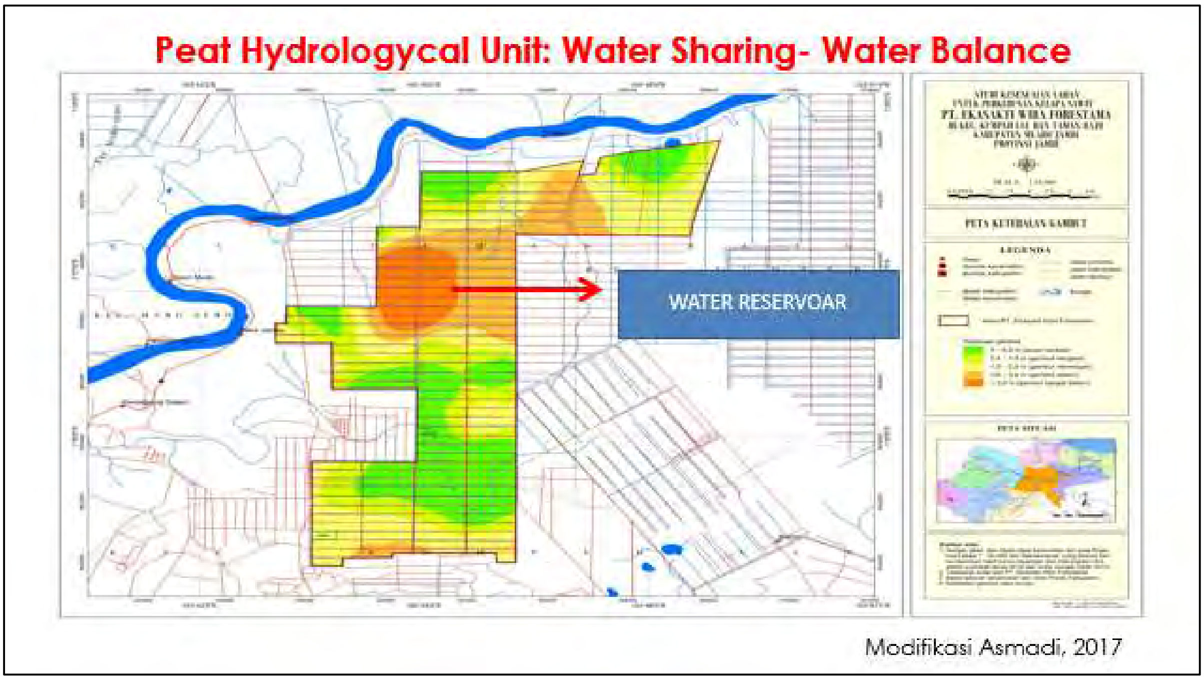
(Hooijer et al. 2011)

6

Annex 03


Badan
Restorasi
Gambut
USA: > 9 m since 1925
UK: 4 m since 1848
Sweden: 2m since 1908
Malaysia: 2.3m since 1978
1925
1955
1977
(Berglund, 2011)
(Photo J Jauhiainen)
PEAT Subsidence
EVANS, 2017

7


Peat Hydrologycal Unit: Water Sharing- Water Balance
WATER RESERVOAR
PETA KETEBALAN GAMBUT
LEGENDA
Modifikasi Asmadi, 2017

8

Annex 03


PENGENDALIAN TINGGI MUKA AIR DI SALURAN DAN LAHAN DENGAN SISTEM POMPA

9


Badan
Restorasi
RESTORATION EXPERIMENTAL PLOTS since 2009
2,5 ha to 2 Million ha?
SHOW WINDOW SUCCES STORY OF
RESTORING DEGRADED PEATLAND BASED ON
COMMUNITY PARTICIPATION

10

Badan Restorasi Gambut

Monitoring Ground Water Level

- **Installed :** 20 May 2016

- **Location :**

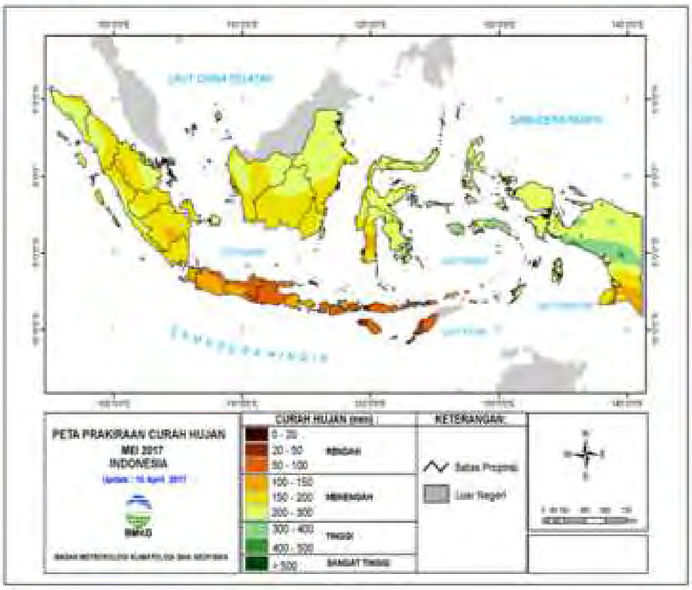
  Tanjung Leban Village,
  Bukit Batu Sub-District,
  Bengkalis Regency,
  Riau Province

- **Position :**

  1° 38' 32.51'' N
  101° 44' 14.02 E

Badan Restorasi Gambut

Footer



QUICKLY RESPOND IN REAL TIME

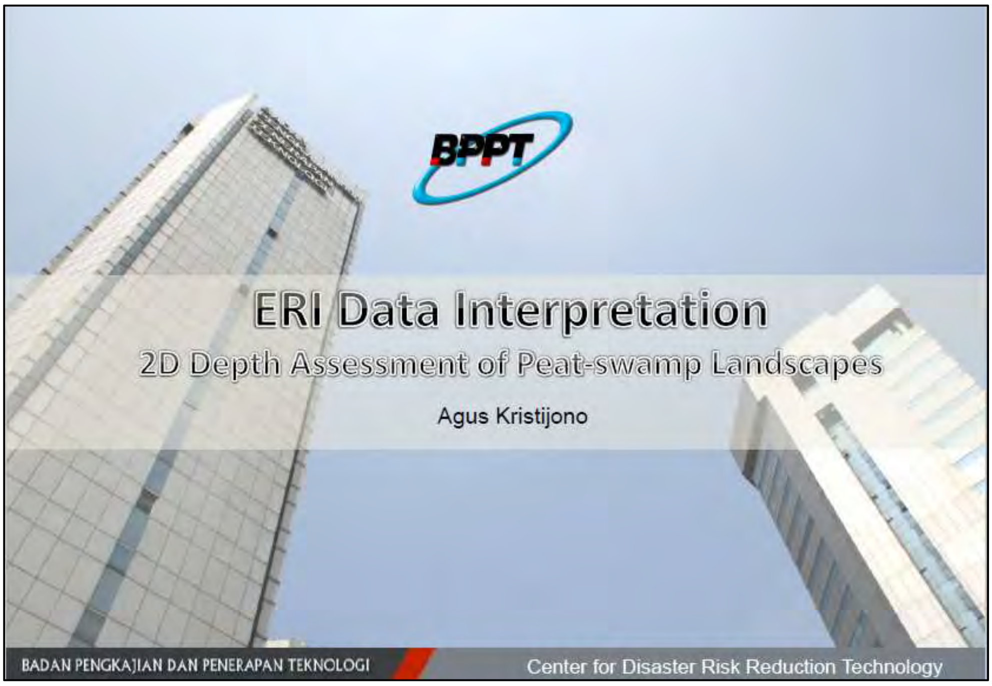
Annex 03


Badan
Restorasi
Gambut
TERIMAKASIH
"Pulihkan gambut, pulihkan kemanusiaan"
PANDUAN TEKNIS PEMANTAUAN
TINGGI MUKA AIR
LAHAN GAMBUT
SISTEM TELEMETRI

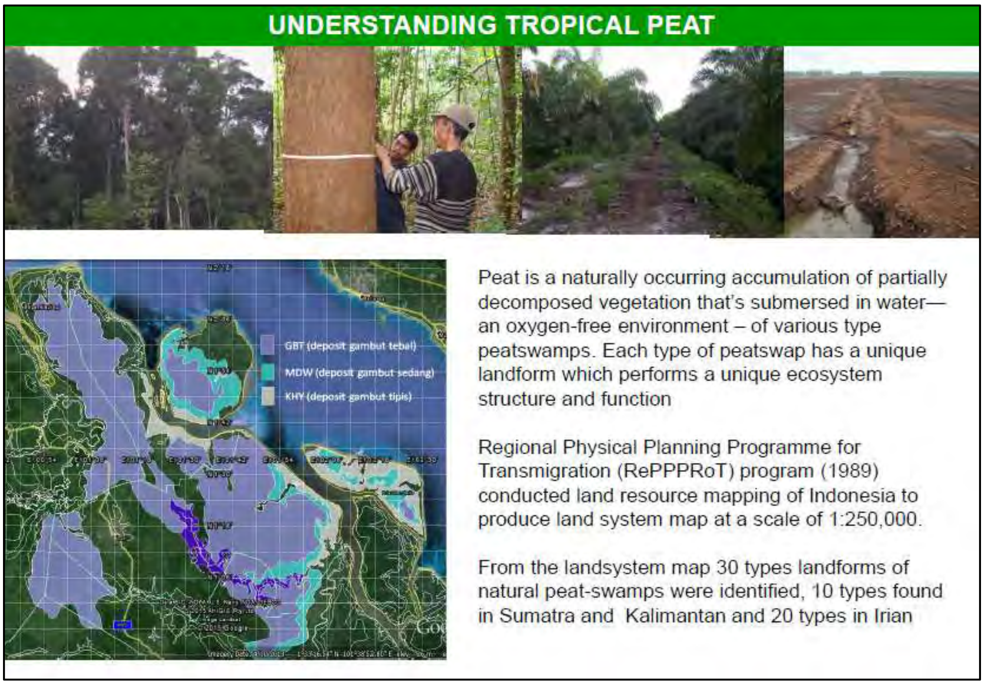
Annex 03

Keynote Speaker : Dr. Agus Kristiyanto (Agency for the Assessment and Application of Technology, Indonesia)

Title : ERI Data Interpretation: 2D Depth Assessment of Peat-swamp Landscape (#05)

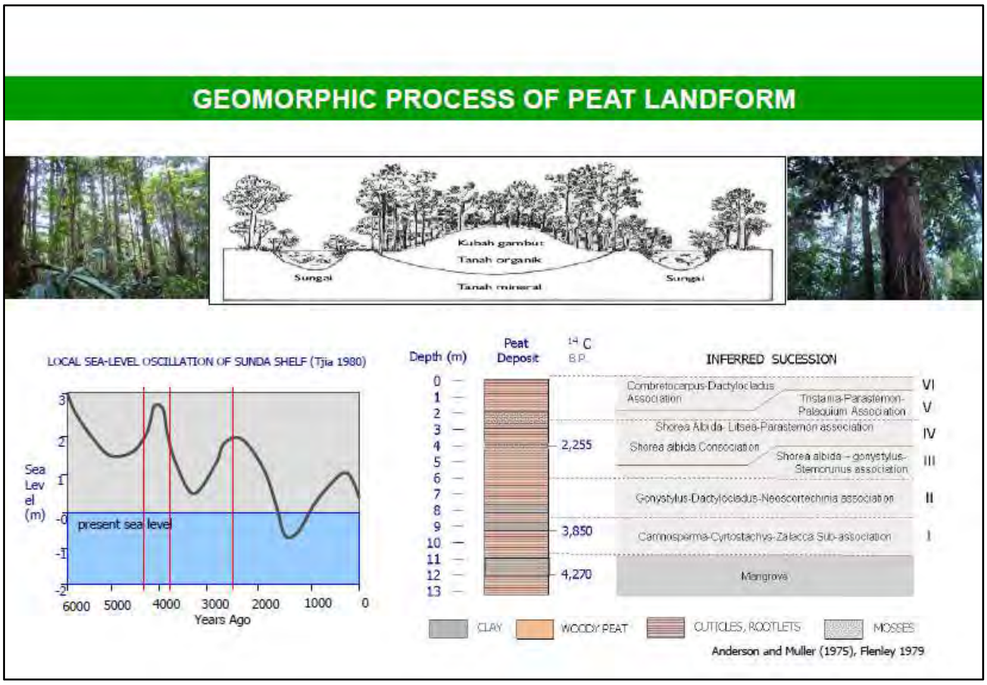


1

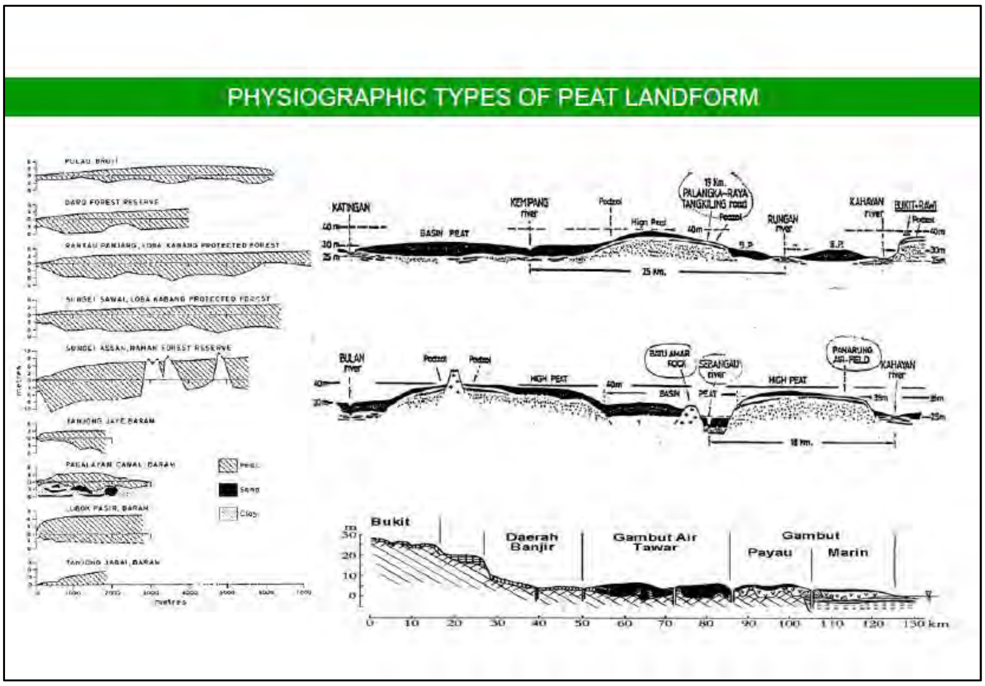


2

Annex 03

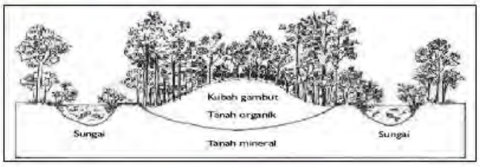

GEOMORPHIC PROCESS OF PEAT LANDFORM
Kubah gambut
Tanah organik
Tanah mineral
Sungai
Sungai
LOCAL SEA-LEVEL OSCILLATION OF SUNDA SHELF (Tjia 1980)
Sea Level (m)
present sea level
6000 5000 4000 3000 2000 1000 0
Years Ago
Depth (m)
Peat Deposit
14 C B.P.
INFERRED SUCESSION
Combretocarpus-Dactylocladus Association
Tristania-Parastemon-Palaquium Association
Shorea Albida- Litsea-Parastemon association
Shorea albida Consociation
Shorea albida – gonystylus-Stemonurus association
Gonystylus-Dactylocladus-Neoscortechinia association
Carnnosperma-Cyrtostachys-Zalacca Sub-association
Mangrove
VI
V
IV
III
II
I
2,255
3,850
4,270
CLAY
WOODY PEAT
CUTICLES, ROOTLETS
MOSSES
Anderson and Muller (1975), Flenley 1979

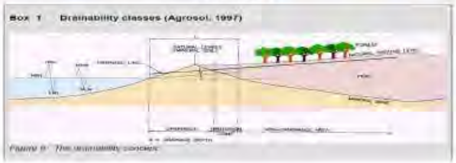
3

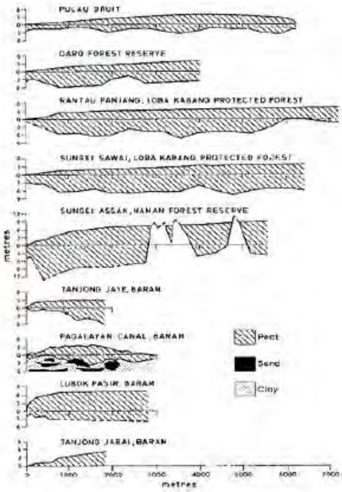

PHYSIOGRAPHIC TYPES OF PEAT LANDFORM
KATINGAN
KEMPANG river
BASIN PEAT
High Peat
RUNGAN river
KAHAYAN river
BUKIT-RAWI
25 km.
BULAN river
HIGH PEAT
BASIN PEAT
SERANGAU river
KAHAYAN river
18 km.
Bukit
Daerah Banjir
Gambut Air Tawar
Gambut
Payau
Marin
0 10 20 30 40 50 60 70 80 90 100 110 120 130 km

4

PHYSIOGRAPHIC TYPES OF DOME-SHAPED PEAT LANDFORM







LAND RESOURCES MAPPING IN INDONESIA: Peat Landforms

LAND UNIT AND SOIL MAP

SYMBOL	Physiographic Group	Subdivision		
A	Alluvial			
B	Marine			
D	Peat Domes	1.Eutropic	1.Fresh Water	1.Thin <0.5 m 2. Medium 0.5 – 2m 3. Thick >2m
			2. Tidal/Saline	1.Thin <0.5 m 2. Medium 0.5 – 2m 3. Thick >2m
			3.Cultivated	1.Thin <0.5 m 2. Medium 0.5 – 2m 3. Thick >2m
		2.Oligotropic	1.Fresh Water	1.Thin <0.5 m 2. Medium 0.5 – 2m 3. Thick >2m
			2. Tidal/Saline	1.Thin <0.5 m 2. Medium 0.5 – 2m 3. Thick >2m
			3.Cultivated	1.Thin <0.5 m 2. Medium 0.5 – 2m 3. Thick >2m
H	Hilly			
I	Acid Tuff Plain			
K	Karst			
M	Mountain/Plateau			
P	Plain			
Q	Toba Acid Tuff			
T	Marine Terrace			
V	Volcanic			
X	Miscellaneous Landforms			

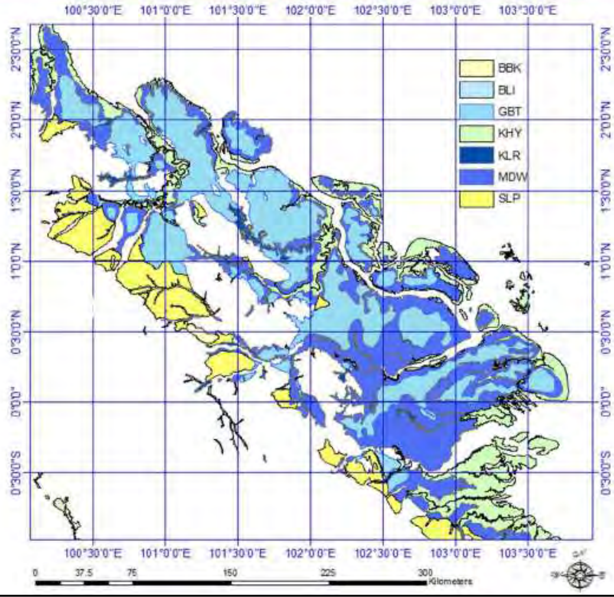
LREP (1990)
(Land Resources Evaluation and Planning Project)

LAND SYSTEM MAP

LANDFORM	SISTEM LAHAN		TIPOLOGI DAN PENAMPANG MELINTANG
. Pantai Berpasir	1.Banjar Lawas	BLW	Peat Covered Beach Deposit
. Rawa rawa	2. Klaru	KLR	Permanently Waterlogged Peaty Floodplain
	3. Beliti	BLI	Swampy Floodplain of Narrow Valley
	4. Mendawai	MDW	Shallower Peatswamps
	5. Gambut	GBT	Deep Peatswamps, commonly domed
. Dataran Aluvial	6. Kahayan	KHY	Coalescen Estuarine Riverine Plains
. Teras Teras	7. Benjah Bekasik	BBK	Low Peat Covered Old Marine Terasces
	8.Sikladipanjang	SLP	Low Sandy and Clayed Old Marine Terraces

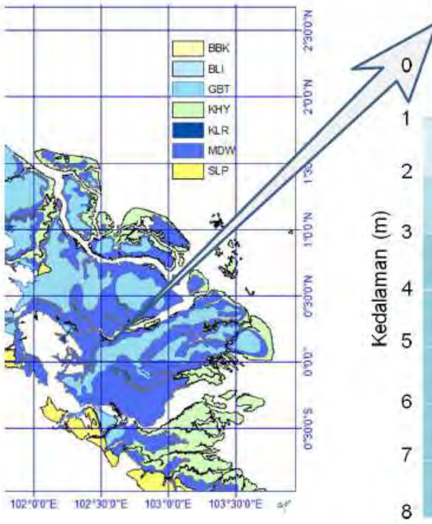
RePPProt (1988)
(*Regional Physical Planning Programme for Transmigration*)

Distribution of Peat Landforms in Riau Province



7

Degree of Decomposition of Peat Deposit Column of Kampar Peninsula

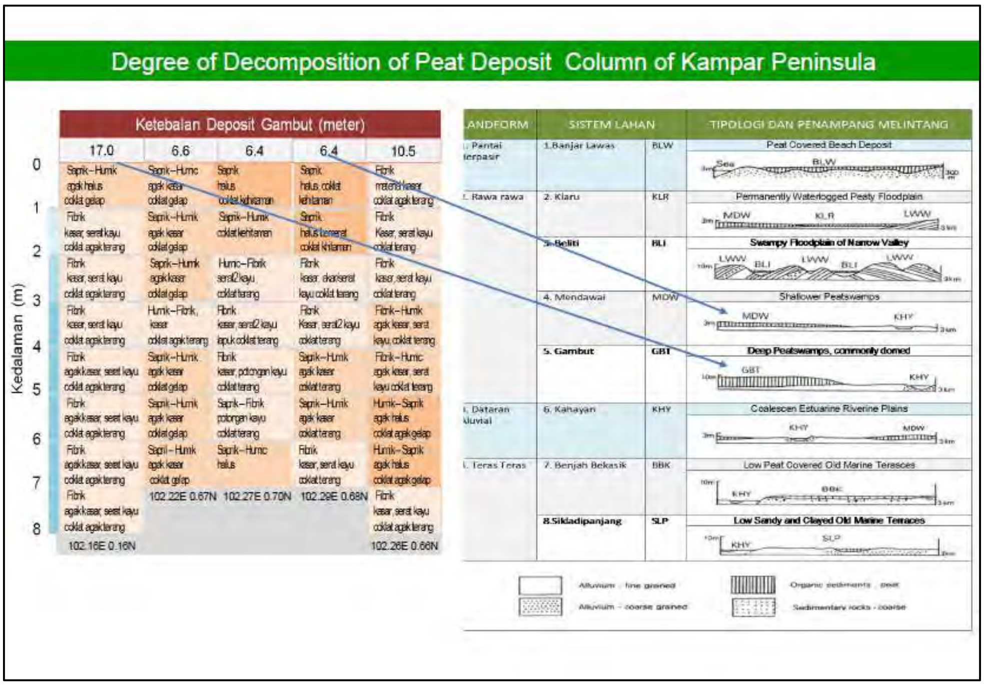


Kedalaman (m): 0 1 2 3 4 5 6 7 8

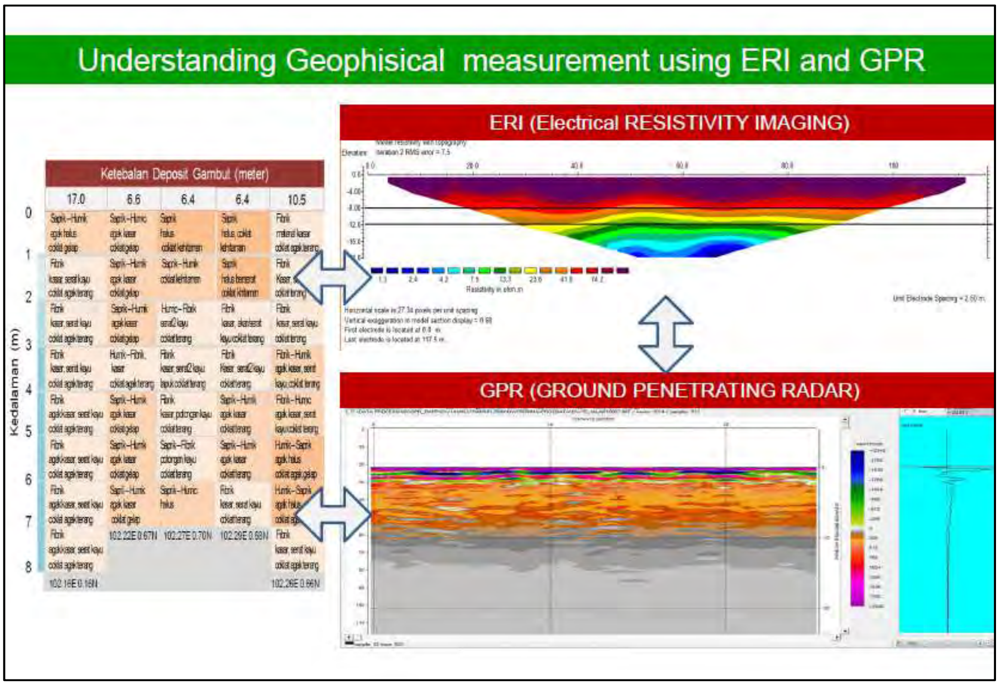
Ketebalan Deposit Gambut (meter)				
17.0	6.6	6.4	6.4	10.5
Saprik–Humik agak halus coklat gelap S-H	Saprik–Humic agak kasar coklat gelap	Saprik halus coklat kehitaman	Saprik halus, coklat kehitaman	Fibrik material kasar coklat agak terang
Fibrik kasar, serat kayu coklat agak terang	Saprik–Humik agak kasar coklat gelap	Saprik–Humik coklat kehitaman	Saprik halus berserat coklat khitaman	Fibrik Kasar, serat kayu coklat terang
Fibrik kasar, serat kayu coklat agak terang	Saprik–Humik agak kasar coklat gelap	Humic–Fibrik serat2 kayu coklat terang	Fibrik kasar, akar/serat kayu coklat terang	Fibrik kasar, serat kayu coklat terang
Fibrik kasar, serat kayu coklat agak terang	Humik–Fibrik, kasar coklat agak terang	Fibrik kasar, serat2 kayu lapuk coklat terang	Fibrik Kasar, serat2 kayu coklat terang	Fibrik–Humik agak kasar, serat kayu, coklat terang
Fibrik agak kasar, serat kayu coklat agak terang	Saprik–Humik agak kasar coklat gelap	Fibrik kasar, potongan kayu coklat terang	Saprik–Humik agak kasar coklat terang	Fibrik–Humic agak kasar, serat kayu coklat terang
Fibrik agak kasar, serat kayu coklat agak terang	Saprik–Humik agak kasar coklat gelap	Saprik–Fibrik potongan kayu coklat terang	Saprik–Humik agak kasar coklat terang	Humik–Saprik agak halus coklat agak gelap
Fibrik agak kasar, serat kayu coklat agak terang	Sapril–Humik agak kasar coklat gelap	Saprik–Humic halus	Fibrik kasar, serat kayu coklat terang	Humik–Saprik agak halus coklat agak gelap
Fibrik agak kasar, serat kayu coklat agak terang	102.22E 0.67N	102.27E 0.70N	102.29E 0.68N	Fibrik kasar, serat kayu coklat agak terang
102.16E 0.16N				102.26E 0.66N

8

Annex 03


Degree of Decomposition of Peat Deposit Column of Kampar Peninsula
Ketebalan Deposit Gambut (meter)
17.0
6.6
6.4
6.4
10.5
Kedalaman (m)
102.16E 0.16N
102.22E 0.67N
102.27E 0.70N
102.29E 0.68N
102.26E 0.66N
SISTEM LAHAN
TIPOLOGI DAN PENAMPANG MELINTANG
1.Banjar Lawas
BLW
Peat Covered Beach Deposit
2. Klaru
KLR
Permanently Waterlogged Peaty Floodplain
3. Beliti
BLI
Swampy Floodplain of Narrow Valley
4. Mendawai
MDW
Shallower Peatswamps
5. Gambut
GBT
Deep Peatswamps, commonly domed
6. Kahayan
KHY
Coalescen Estuarine Riverine Plains
7. Benjah Bekasik
BBK
Low Peat Covered Old Marine Terraces
8.Sikladipanjang
SLP
Low Sandy and Clayed Old Marine Terraces

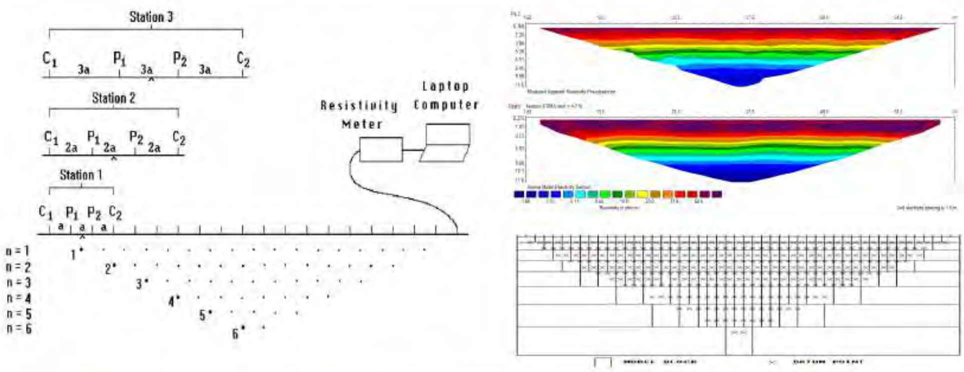
9


Understanding Geophisical measurement using ERI and GPR
ERI (Electrical RESISTIVITY IMAGING)
GPR (GROUND PENETRATING RADAR)
Ketebalan Deposit Gambut (meter)
17.0
6.6
6.4
6.4
10.5
Kedalaman (m)

10

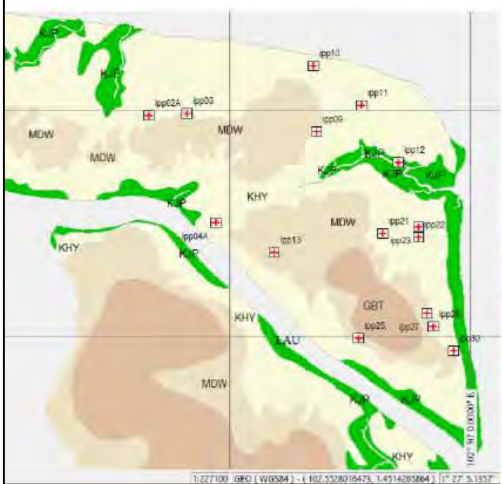
Annex 03

Understanding 2D Resistivity measurement -- ERI



11

Three types of peatswamps can be found in Bengkalis Island



Peatlands are landscpes of peatswamps formed on the riverine, estuarine, and alluvium environments.

1. Shallow peat swamps on riverin-marine alluvial plains (KHY)
2. Deeper peat swamps, commonly dome shaped (GBT)
3. Shallower peat swamp (MDW)

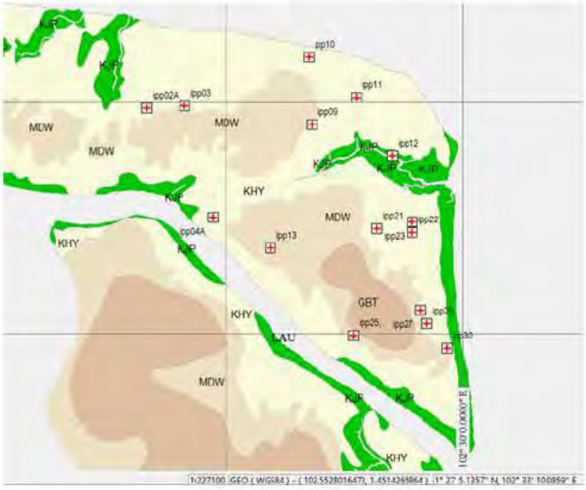
Physiographic type	LANDSYSTEMS*) Symbol	LANDSYSTEMS*) Name	LANDFORM TYPE	LITHOLOGY
Alluvial Plains	**KHY**	Kahayan	Coalescent Estuarine/Riverine Plains	*Peat, Alluvium, recent marine - riverine Alluvium, recent riverine*
Swamps	**GBT**	Gambut	Deeper Peat Swamps, commonly Domed	*Peat*
	MDW	Mendawai	Shallower Peat Swamps	*Peat*
Tidal Swamps	**KJP**	Kajapah	Inter-tidal mudflats under mangrove and nipah	*Alluvium, recent eustarine - riverine*

*) Landsystems are distinctive landscapes in which certain types of rocks, topography, climate, soil, and vegetation are closely interrelated. The same landscape components and properties should be found in the proportion whenever a landsystem occurs (Source: RePPProT 1990. *The Land Resources of Indonesia: A National Overview*)

12

Annex 03

Peat Depth Estimation Based on Peat Swamp Types



No	ID	Land System	Estimated Depth
1	IPP 02A	KHY	Shallow
2	IPP 10	KHY	Shallow
3	IPP 11	KHY	Shallow
4	IPP 21	KHY	Shallow
5	IPP 09	KHY/MDW	Shallow/ Medium
6	IPP 29	KHY/MDW	Shallow/ Medium
7	IPP30	MDW	Shallow/ Medium
8	IPP 27	MDW	Medium
9	IPP 13	MDW	Medium
10	IPP 14	MDW	Medium
11	IPP 03	KHY	
12	IPP 25	MDW/ GBT	Medium/ Deep

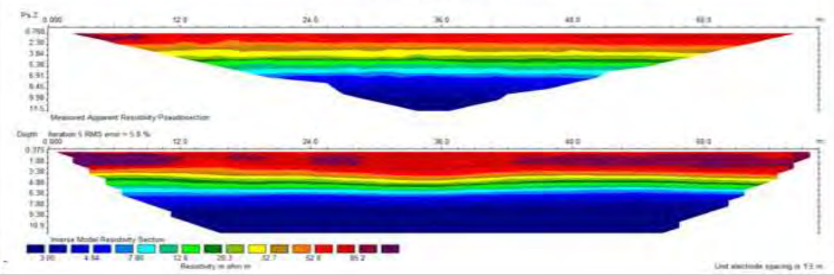
Peat Depth Survey and ERI measurement Results

POINT : IPP 13

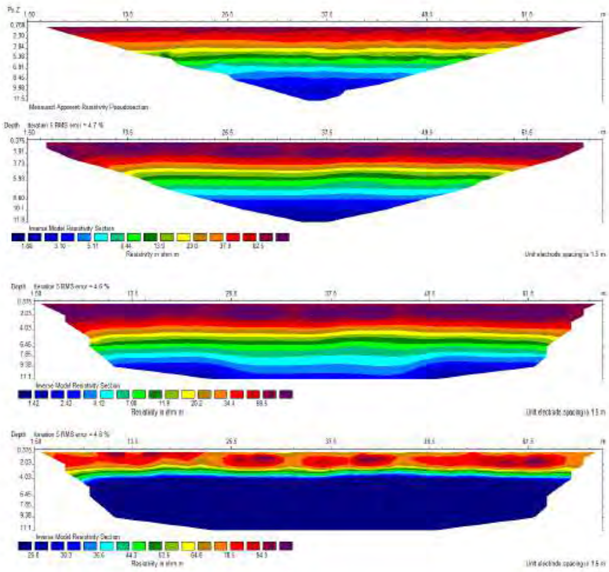
Location: Ketamputih
Peat Depth : 6.0 m at electrode 27 (39m)

Depth (m)	Soil Type	Note	Von Post
0-0.5	Peat	Hemic	H5
0.5-1.0	Peat	Hemic	H6
1-1.5	Peat	Hemic	H5
1.5-2.0	Peat	Hemic	H6
2.-2.5	Peat	Hemic	H4
2.5-3.0	Peat	Hemic	H5
3.0-3.5	Peat	Hemic	H5
3.5-4.0	Peat	Hemic	H5
4.0-4.5	Peat	Hemic	H4
4.5-5.0	Peat	Hemic	H5
5.0-5.5	Peat	Hemic	H4
5.5-6.0	Peat	Fibric	H3
6.0-6.5	Clayey Peat		
6.5-7.0	Clayey		

ERI Profile : measured resistivity (top) and the Inverse Model (bottom)

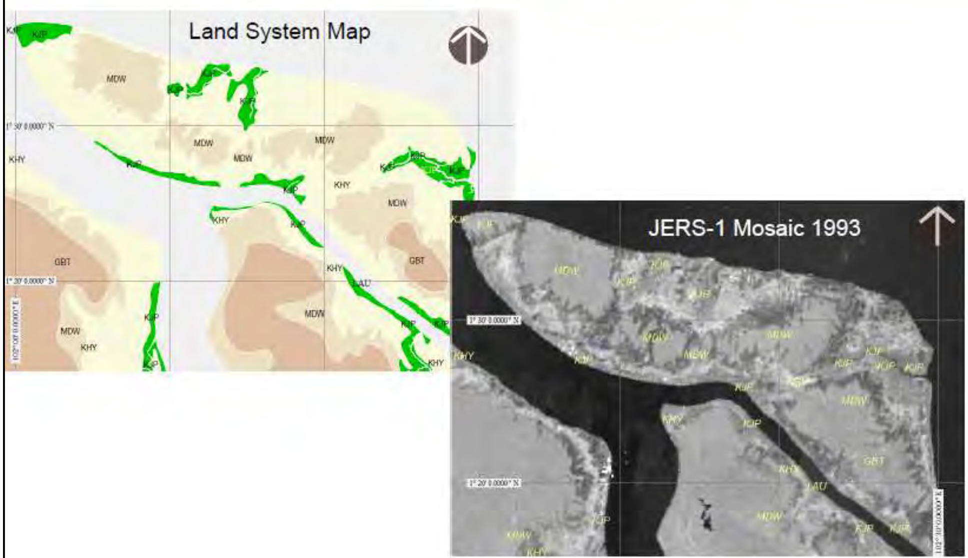


Matching Depth with using ERI measurement and Inverse Model



15

Assessment of Peatswamp Boundaries



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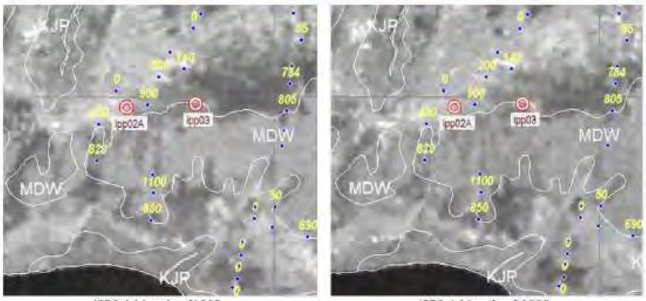
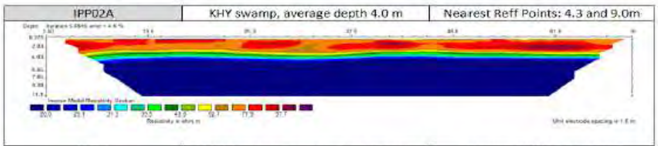
Annex 03

Assessment of 2D Depth KHY and MDW Peatswamps

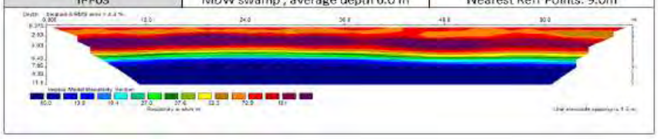


JERS-1 Mosaic of1993 JERS-1 Mosaic of 1998

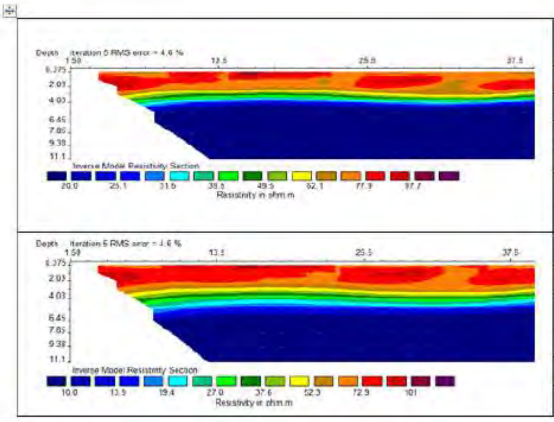
IPP02A	KHY swamp, average depth 4.0 m	Nearest Reff Points: 4.3 and 9.0m



IPP03	MDW swamp , average depth 6.0 m	Nearest Reff Points: 9.0m



Assessment of 2 D KHY and MDW Peatswamps – Disturbance Impact?

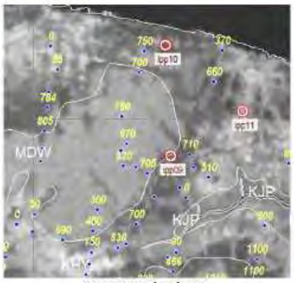


Peat Depth	Degree of decomposition	
	IPP02A	IPP03
0.0 – 0.5	Fibric	Fibric
0.5 – 1.0	Fibric	Fibric
1.0 – 1.5	Hemic	Fibric
1.5 – 2.0	Hemic	Hemic
2.0 – 2.5	Hemic	Hemic
2.5 – 3.0	Hemic	Hemic
3.0 – 3.5	Clayed peat	Hemic
3.5 – 4.0	Peaty Clay	Hemic
4.0 – 4.5		Hemic
4.5 -5.0		Hemic
5.0 – 5.5		Hemic
5.5 – 6.0		Hemic

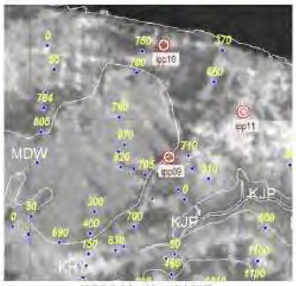
Figure 11. Re-adjusment of minimum resistivily value of IPP02A and the vertical structure of peat column at IPP02A and IPP03.

Annex 03

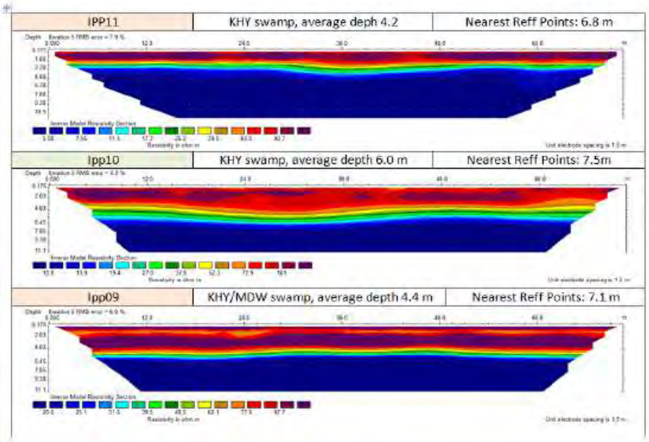
Assessment of 2D Depth of KHY Peatswamps



JERS-1 Mosaic of1993



JERS-1 Mosaic of 1998



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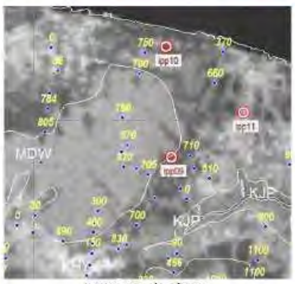
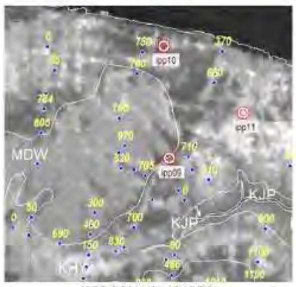
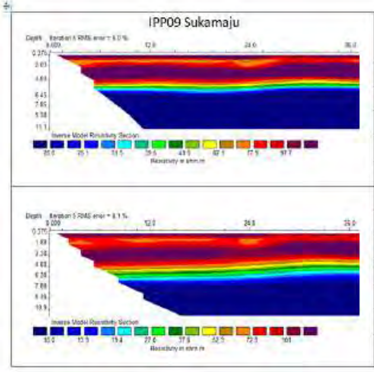
Assessment of 2D Peatdepth of KHY Peatswamps – Disturbance Impact?



JERS-1 Mosaic of1993



JERS-1 Mosaic of 1998



Depth (m)	Degree of Decomposition		
	IPP09	IPP10	IPP11
0.0 – 0.5	Fibric	fibric	fibric
0.5 – 1.0	Fibric	fibric	fibric
1.0 – 1.5	Fibric	fibric	fibric
1.5 – 2.0	Fibric	fibric	fibric
2.0 – 2.5	Fibric	fibric	fibric
2.5 – 3.0	Fibric	fibric	fibric
3.0 – 3.5	Fibric	fibric	fibric
3.5 – 4.0	Hemic	fibric	fibric
4.0 – 4.5	Hemic	Hemic	fibric
4.5 -5.0		Hemic	
5.0 – 5.5		Fibric	
5.5 – 6.0		Hemic	

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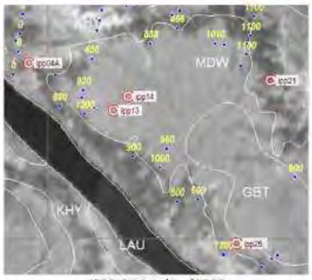
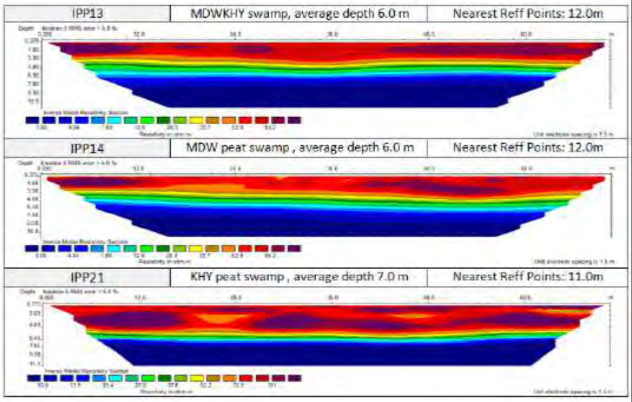
Annex 03

Assessment of 2D Depth of MDW Peatswamps

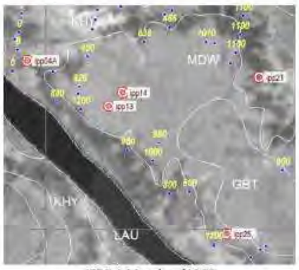


JERS-1 Mosaic of1993

JERS-1 Mosaic of 1998

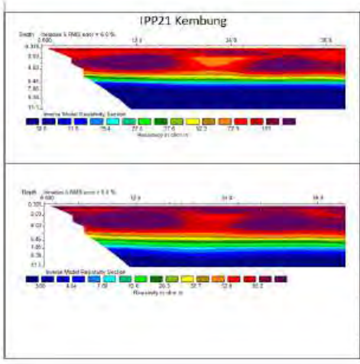


Assessment of 2D Peatdepth of MDW Peatswamps – Disturbance Impact?



JERS-1 Mosaic of1993

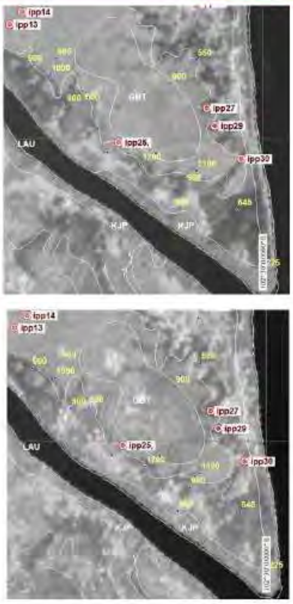
JERS-1 Mosaic of 1998

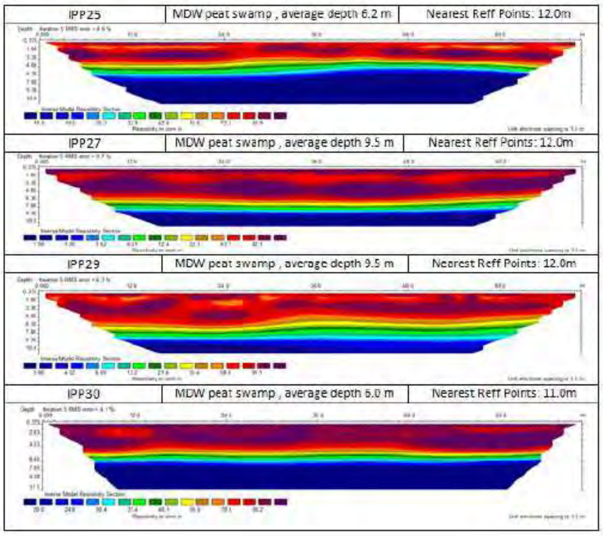


Depth (m)	Degree of Decomposition		
	IPP13	IPP14	IPP21
0.0 – 0.5	Hemic	Hemic	Fibric
0.5 – 1.0	Hemic	Hemic	Fibric
1.0 – 1.5	Hemic	Hemic	Fibric
1.5 – 2.0	Hemic	Hemic	Fibric
2.0 – 2.5	Hemic	Hemic	Fibric
2.5 – 3.0	Hemic	Hemic	Fibric
3.0 – 3.5	Hemic	Hemic	Fibric
3.5 – 4.0	Hemic	Hemic	Fibric
4.0 – 4.5	Hemic	Hemic	Hemic
4.5 -5.0	Hemic	Hemic	Hemic
5.0 – 5.5	Hemic	Hemic	Fibric
5.5 – 6.0	Fibric	Fibric	Fibric
6.0 – 6.5			Hemic
6.5 – 7.0			Hemic

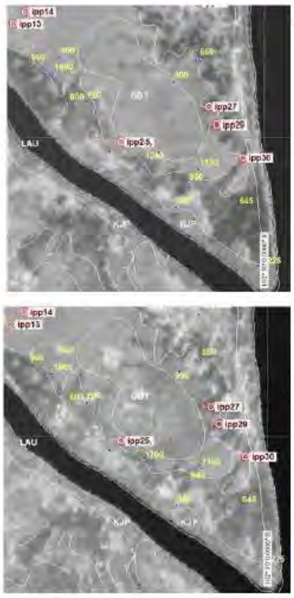
Annex 03

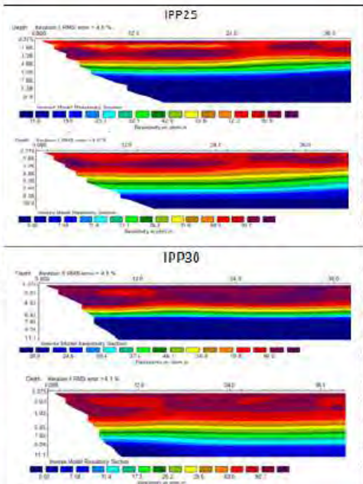
Assessment of 2D Depth of GBT Peatswamps





Assessment of 2D Peatdepth of GBT Peatswamps – Disturbance Impact?



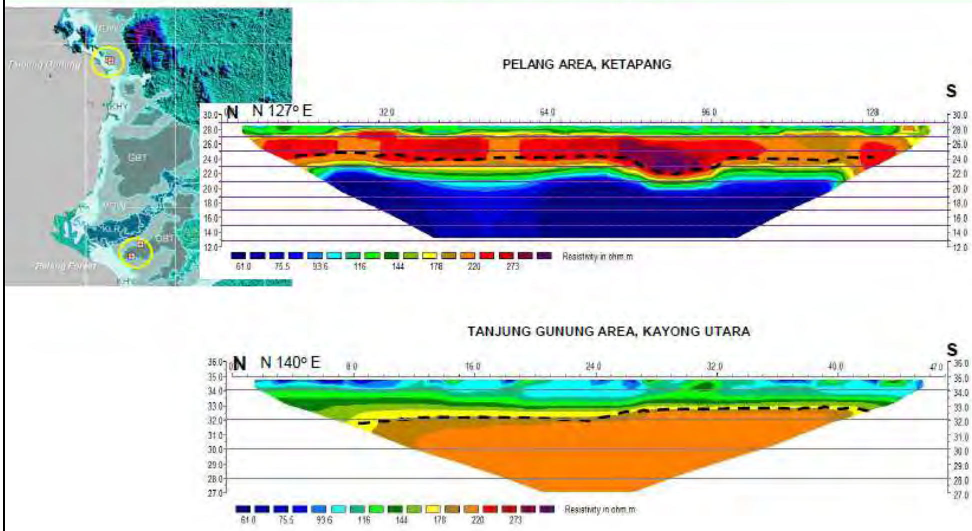


Depth (m)	Degree of Decomposition			
	IPP25	IPP27	IPP29	IPP30
0.0 – 0.5	fibric	fibric	fibric	fibric
0.5 – 1.0	fibric	fibric	fibric	fibric
1.0 – 1.5	fibric	fibric	fibric	fibric
1.5 – 2.0	fibric	fibric	fibric	fibric
2.0 – 2.5	fibric	fibric	fibric	fibric
2.5 – 3.0	hemic	fibric	fibric	fibric
3.0 – 3.5	hemic	fibric	fibric	fibric
3.5 – 4.0	fibric	fibric	fibric	fibric
4.0 – 4.5	fibric	fibric	fibric	hemic
4.5 -5.0	fibric	fibric	fibric	fibric
5.0 – 5.5	fibric	fibric	fibric	fibric
5.5 – 6.0	fibric	fibric	fibric	fibric
6.0 – 6.5	fibric	fibric	fibric	
6.5 – 7.0		fibric	fibric	
7.0 – 7.5		fibric	fibric	
7.5 – 8.0		fibric	fibric	
8.0 – 8.5		fibric	fibric	
8.5 – 9.0		fibric	fibric	
9.0 – 9.5		fibric		

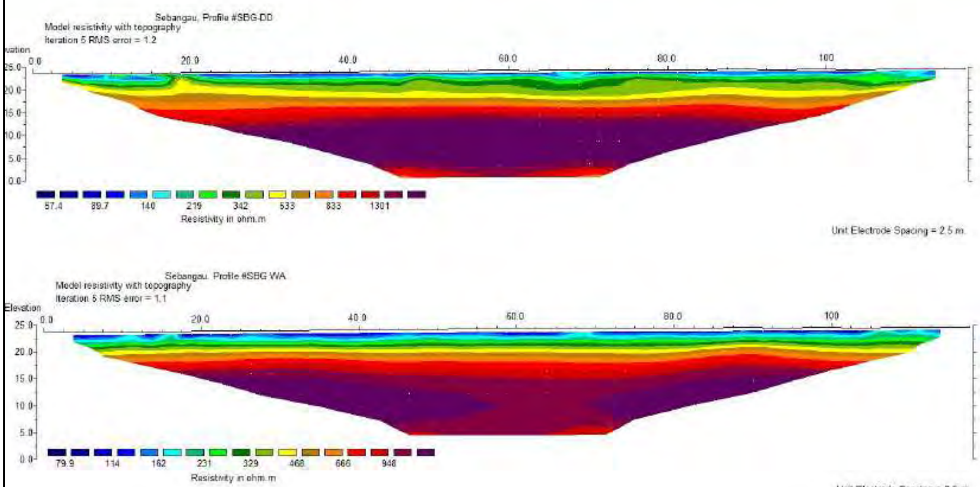
Figure 18. Re-adjusment of minimum resistivily value of IPP25 and the vertical structure of peat column at IPP27, IPP29, and IPP30

Annex 03

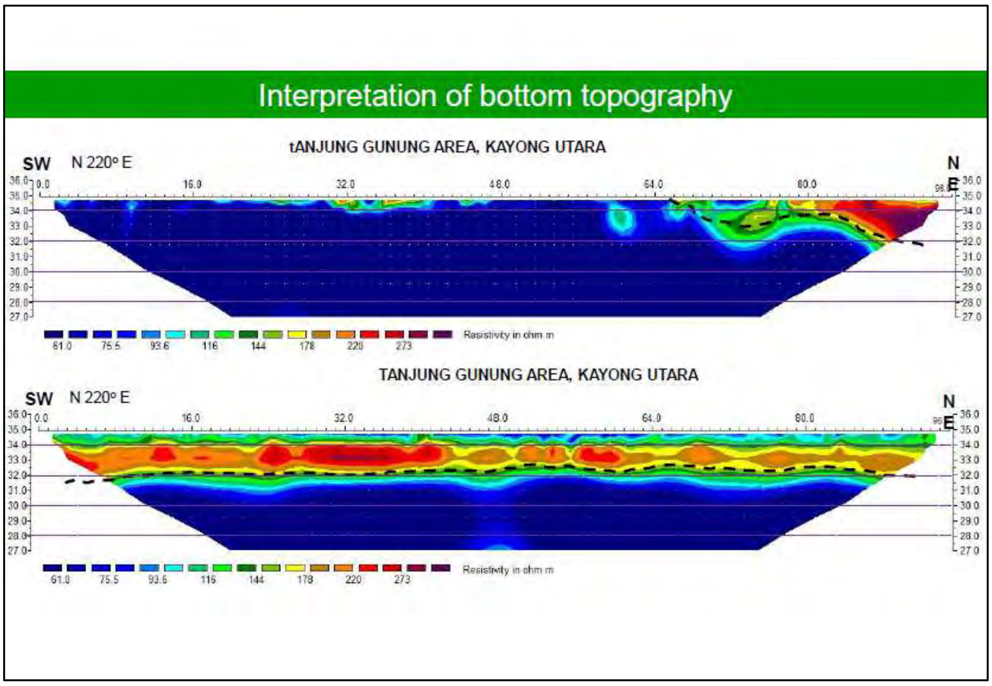
Interpretation of sub-soil types



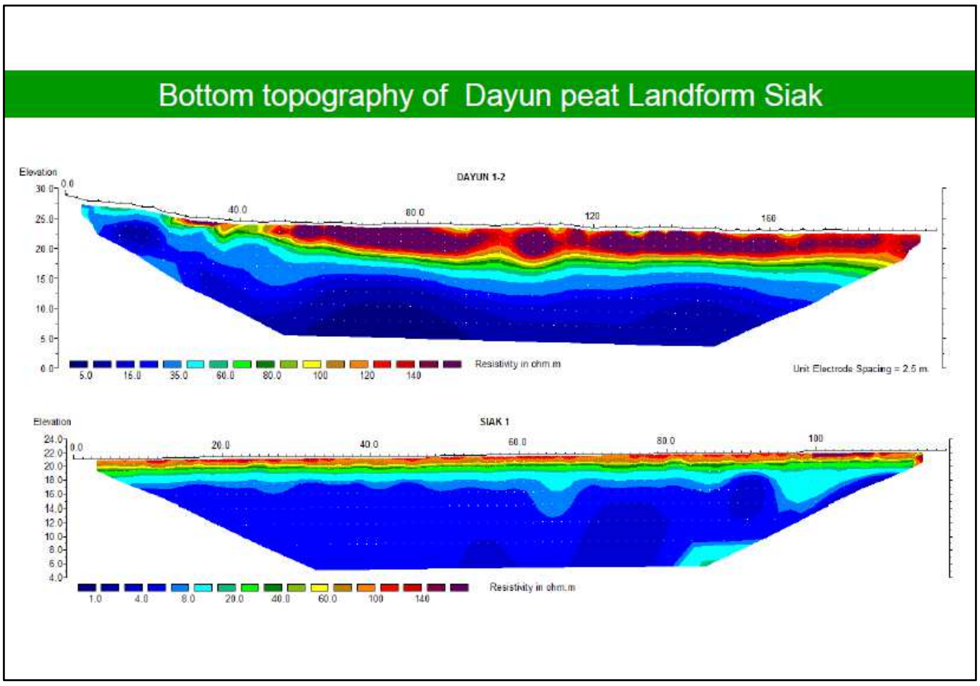
High resistivity sub-soil type of Sebangau peat landform



Annex 03



27

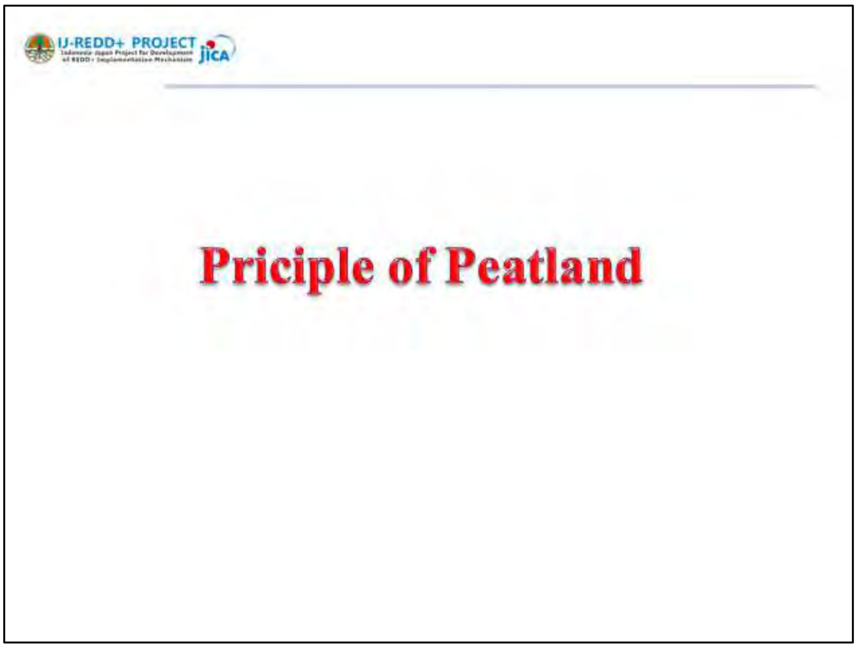


28

Annex 03

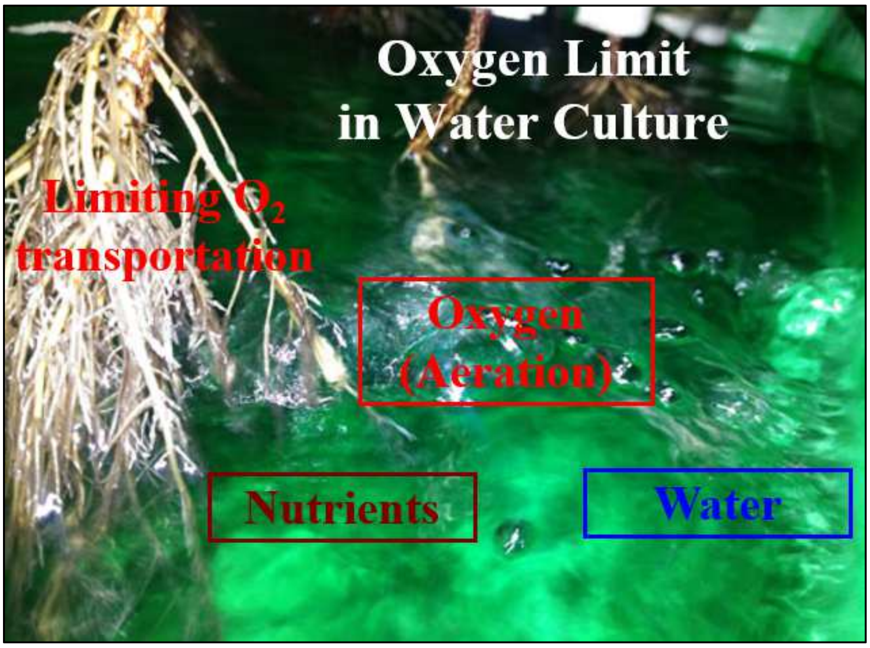
Keynote Speaker : Prof. Mitsuru Osaki (Hokkaido University, Japan)
Title : Breakthrough of Oil Palm Cultivation in High Watertable (#06)

1

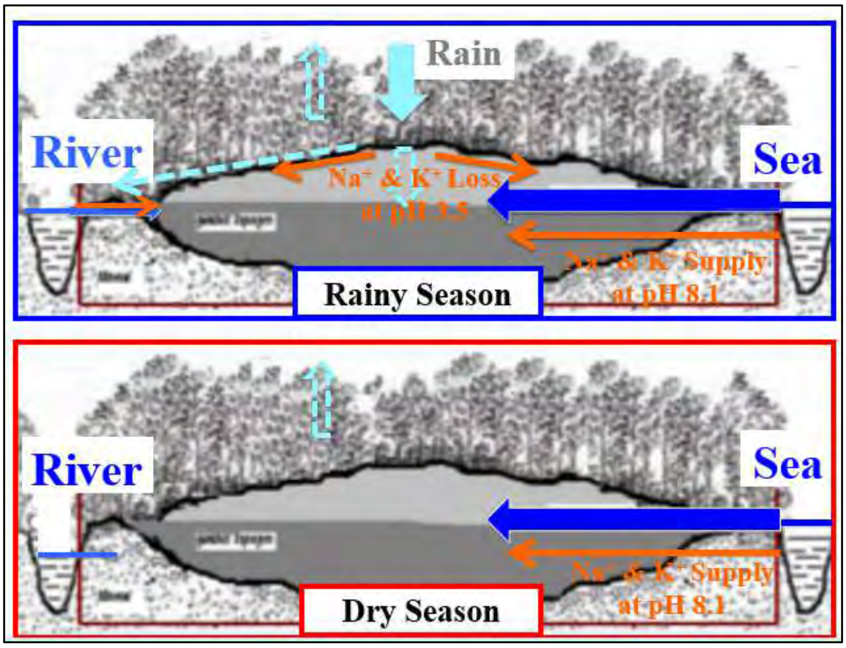


2

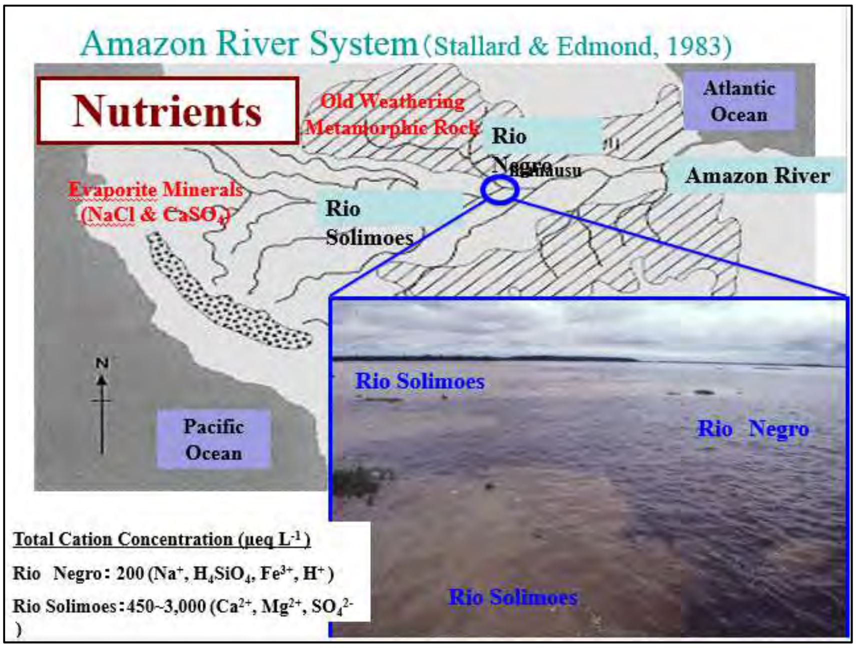
Annex 03


Oxygen Limit
in Water Culture
Limiting O_2
transportation
Oxygen
(Aeration)
Nutrients
Water

3


Rain
River
Sea
Na^+ & K^+ Loss
at pH 3.5
Na^+ & K^+ Supply
at pH 8.1
Rainy Season
River
Sea
Na^+ & K^+ Supply
at pH 8.1
Dry Season

4



5

Nutrients

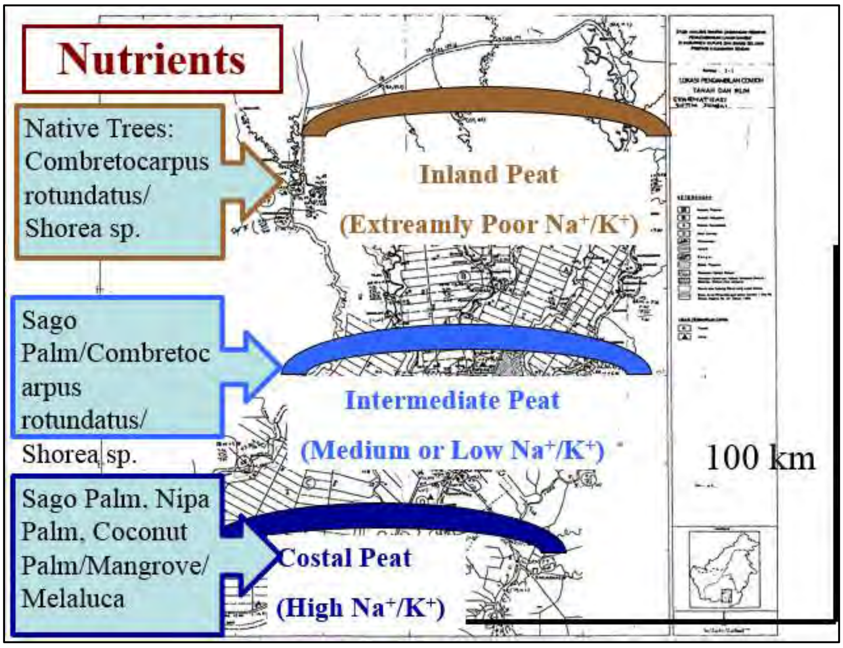
	Area	Site	pH	EC mS/m	TOC mg/l
River water	Kahayan	Bridge	5.15	4.31	46.20
Peat discharged water	Sebangau	Kya canal	3.70	6.43	75.68
Sea salt affected	Sebangau	Paduran canal	2.60	104.50	12.87

Cl^- mg/l	NO_3^- mg/l	PO_4^- mg/l	SO_4^{2-} mg/l	Na^+ mg/l	NH_4^+ mg/l	K^+ mg/l	Mg^{2+} mg/l	Ca^{2+} mg/l
2.93	0.00	0.00	1.22	2.17	0.63	2.05	0.30	2.32
0.58	0.23	0.00	0.37	0.65	0.00	0.25	0.11	0.20
3.76	0.00	0.00	675.73	3.86	1.14	2.60	12.40	5.77

From Haraguchi

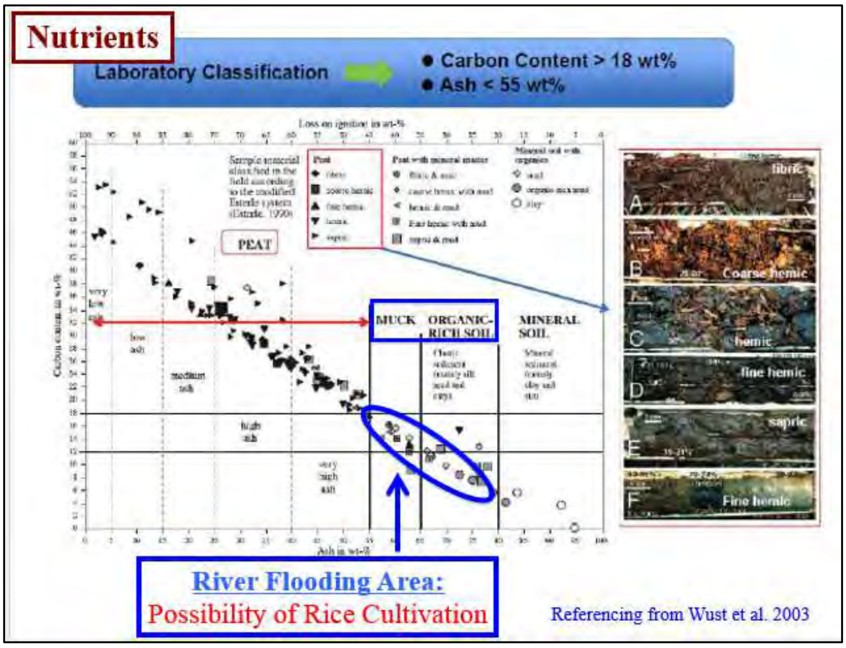
6

Annex 03



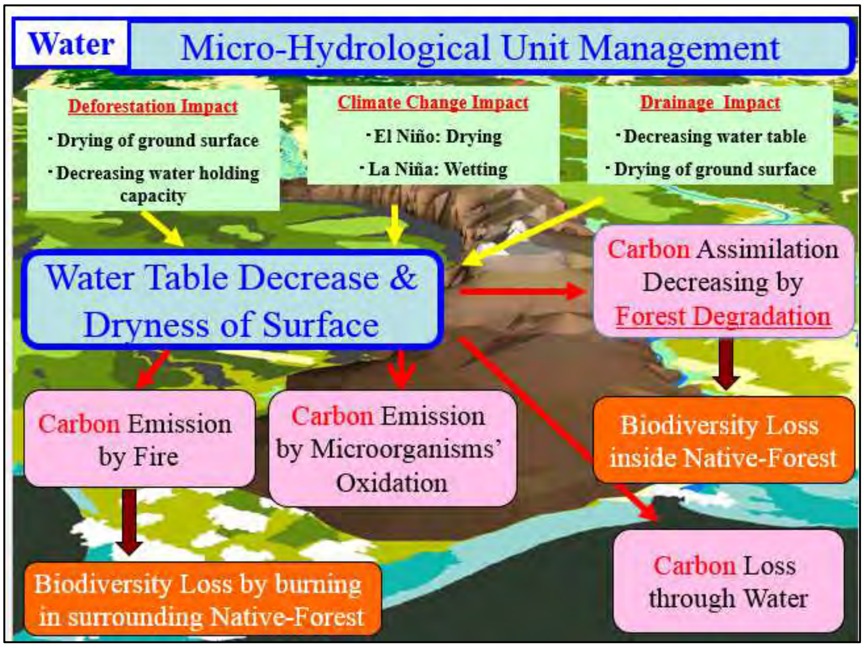
Nutrients
Native Trees: Combretocarpus rotundatus/ Shorea sp.
Inland Peat
(Extreamly Poor Na⁺/K⁺)
Sago Palm/Combretocarpus rotundatus/ Shorea sp.
Intermediate Peat
(Medium or Low Na⁺/K⁺)
100 km
Sago Palm, Nipa Palm, Coconut Palm/Mangrove/ Melaluca
Costal Peat
(High Na⁺/K⁺)

7



Nutrients
Laboratory Classification
Carbon Content > 18 wt%
Ash < 55 wt%
Loss on ignition in wt-%
PEAT
MUCK
ORGANIC-RICH SOIL
MINERAL SOIL
Ash in wt-%
fibric
Coarse hemic
hemic
fine hemic
sapric
Fine hemic
River Flooding Area:
Possibility of Rice Cultivation
Referencing from Wust et al. 2003

8

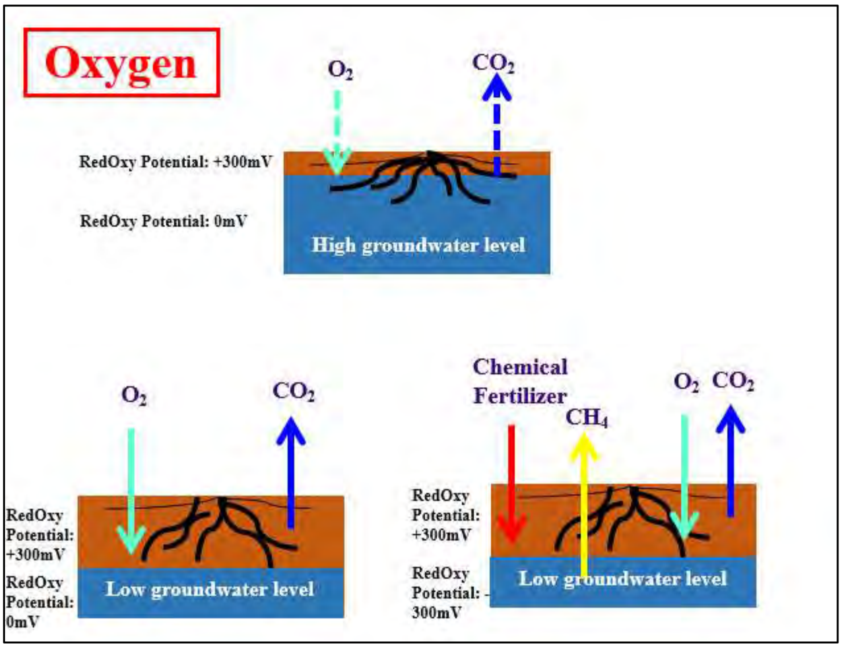

Water
Micro-Hydrological Unit Management
Deforestation Impact
･Drying of ground surface
･Decreasing water holding capacity
Climate Change Impact
･El Niño: Drying
･La Niña: Wetting
Drainage Impact
･Decreasing water table
･Drying of ground surface
Water Table Decrease & Dryness of Surface
Carbon Assimilation Decreasing by Forest Degradation
Carbon Emission by Fire
Carbon Emission by Microorganisms' Oxidation
Biodiversity Loss inside Native-Forest
Biodiversity Loss by burning in surrounding Native-Forest
Carbon Loss through Water

9


Oxygen
Combretcarpus rotundatus (Tumih or Perepat in local)
･Water Tolerance
･Aerial Root
･N2 Fixing
･Fire Tolerance

10

Annex 03



11

IJ-REDD+ PROJECT

High Watertable! Is Limiting for Oil Palm Growth?

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Annex 03

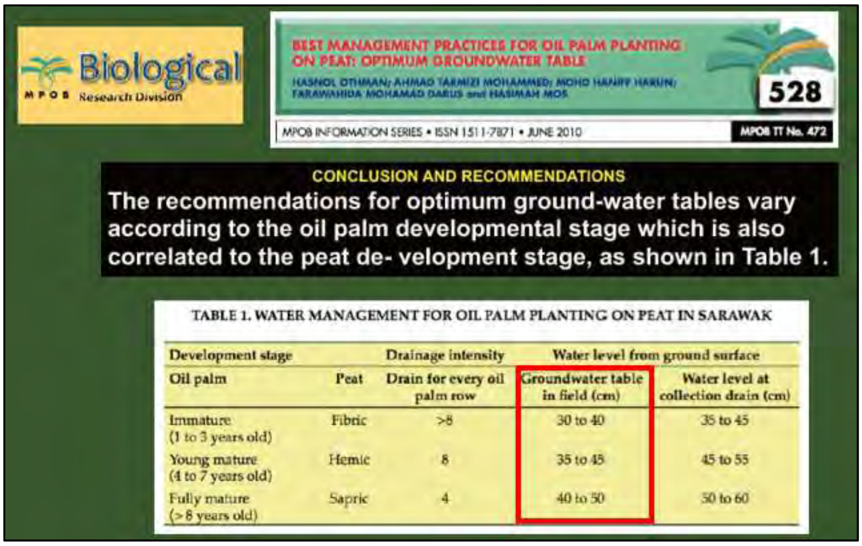

TABLE 1. WATER MANAGEMENT FOR OIL PALM PLANTING ON PEAT IN SARAWAK

Development stage		Drainage intensity	Water level from ground surface	
Oil palm	Peat	Drain for every oil palm row	Groundwater table in field (cm)	Water level at collection drain (cm)
Immature (1 to 3 years old)	Fibric	>8	30 to 40	35 to 45
Young mature (4 to 7 years old)	Hemic	8	35 to 45	45 to 55
Fully mature (>8 years old)	Sapric	4	40 to 50	50 to 60

13

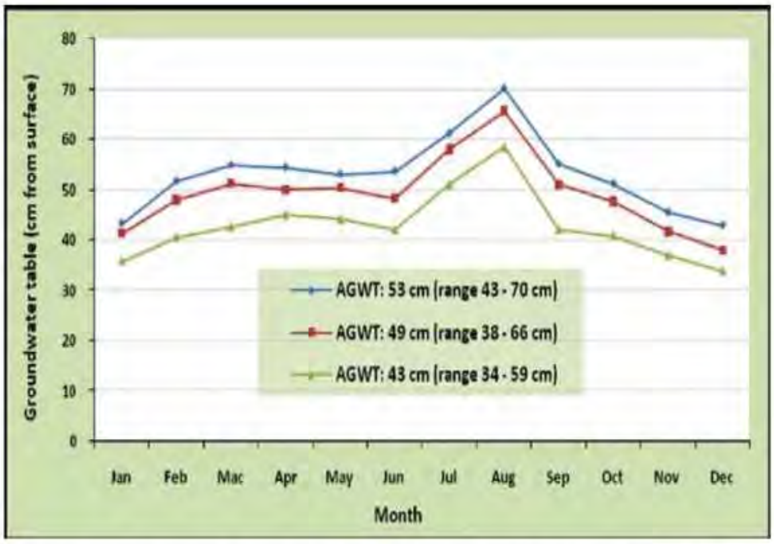

Figure 1. Monthly mean groundwater table in three different blocks planted with oil palm (AGWT: average groundwater table).

14

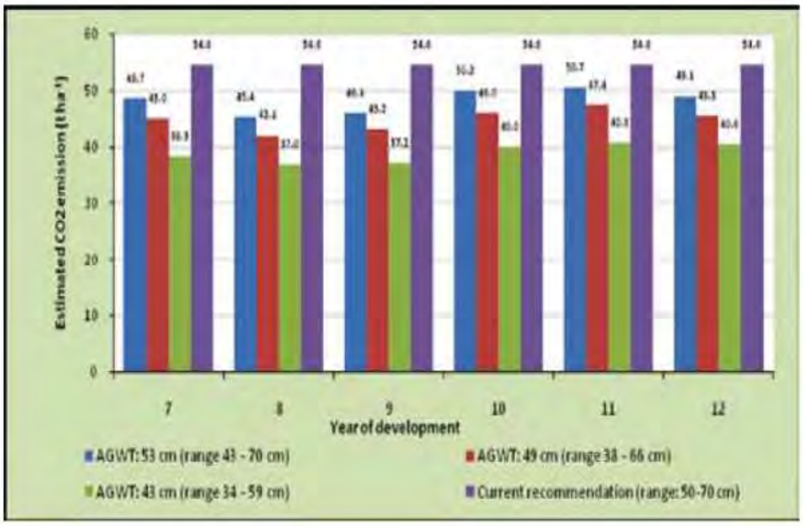

Figure 7. Estimated CO_2 emission at different groundwater tables after 7 to 12 years of peat development.

15

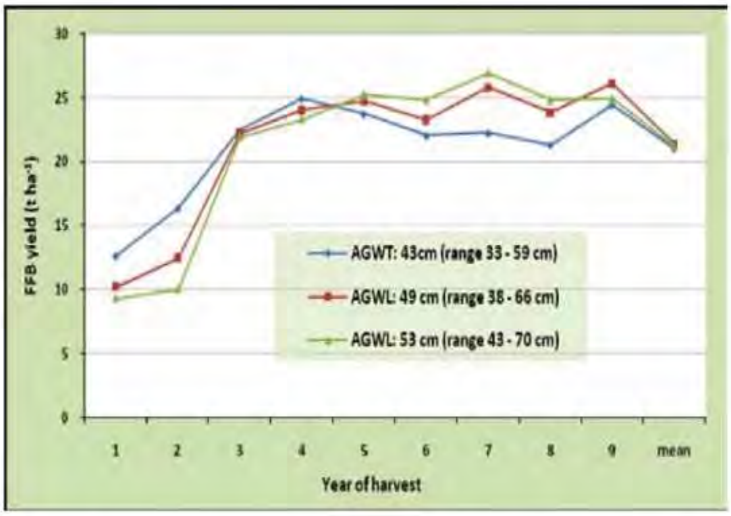

Figure 8. Fresh fruit bunches (FFB) yield profile of three blocks with different groundwater tables.

16

Oil Palm grown in High Water Table

17

Oil Palm grown high water table @Mega Timur Village, Sungai Ambawang Distric, Kubu Raya Regency, Pontianak

1) 8 years palm for 14 ha by Mr. Suparjo (farmer)
2) High productivity: 40 ton/ha/year (very high productivity)
3) Sallow peat (1~2 m depth)
4) High water table (10~20 cm from surface)
4) Final stage of peat
5) Tidal effect
6) Soil surface management by organic matters

Research Topics

1) Root matte distributed at only surface (shallow peat, organic matter application), which is main reason of high water table tolerance
2) Tidal effect (keeping wet, supplying O_2, nutrients supply (K/Na or micro nutrients)

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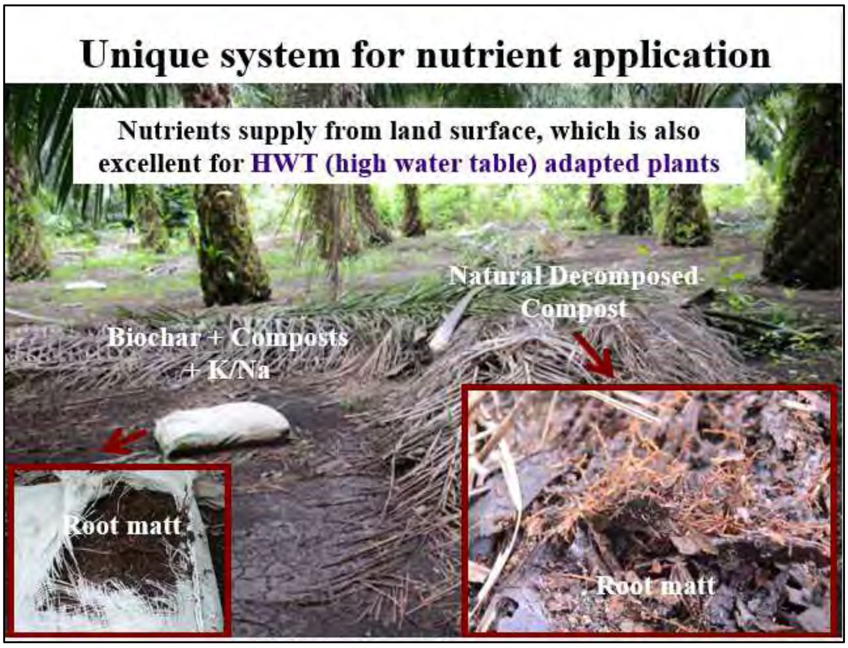
Annex 03



19

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Annex 03

21

22

Annex 03

23

24

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IJ-REDD+ PROJECT

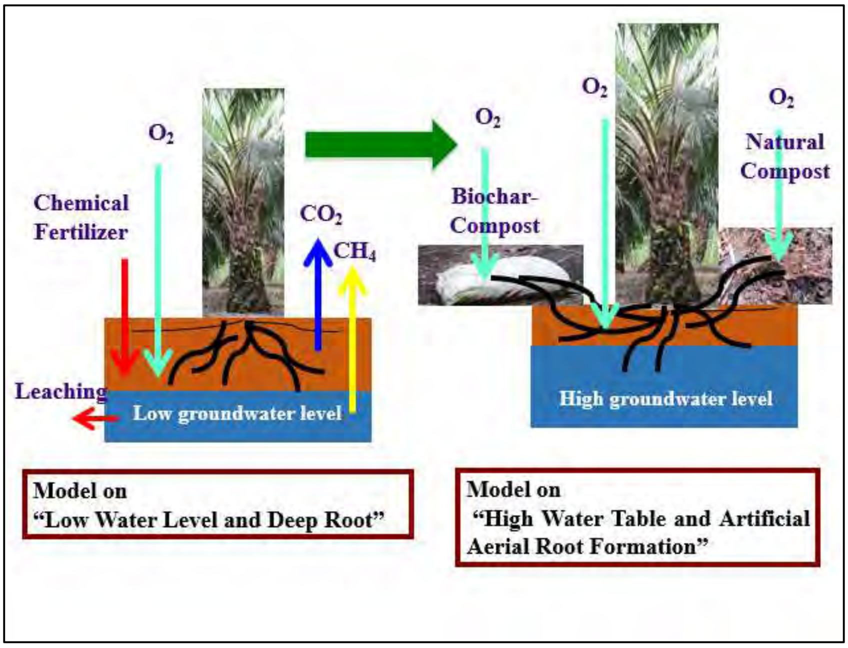
Indonesia-Japan Project for Development of REDD+ Implementation Mechanism

JICA

Conclusion

26

Annex 03



27

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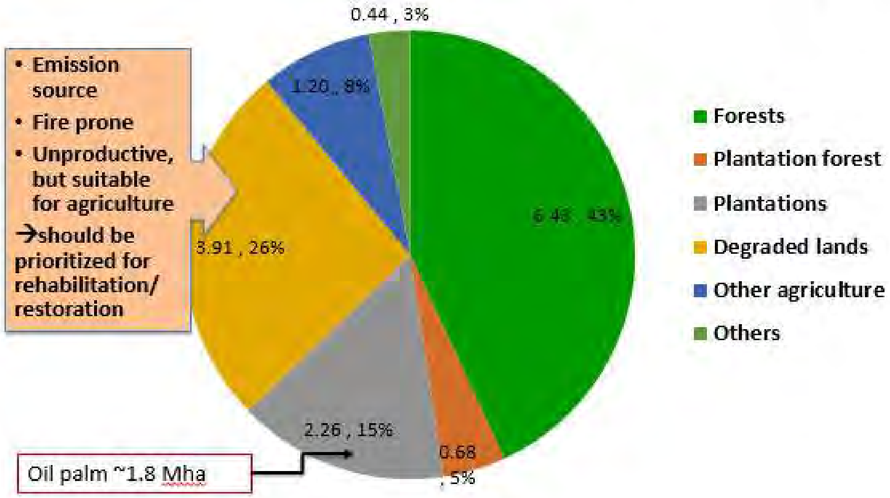
Annex 03

Keynote Speaker : Prof. Dr. Fahmuddin Agus (BBSDLP, Indonesia)
Title : Water Table, CO2 Emissions and Oil Palm Performance on Peatland (#07)

Annex 03

Various uses of Peatland as of 2015 (Mha, %)



2

Peatshrub

3

Annex 03

Peat shrub, a fire subscriber

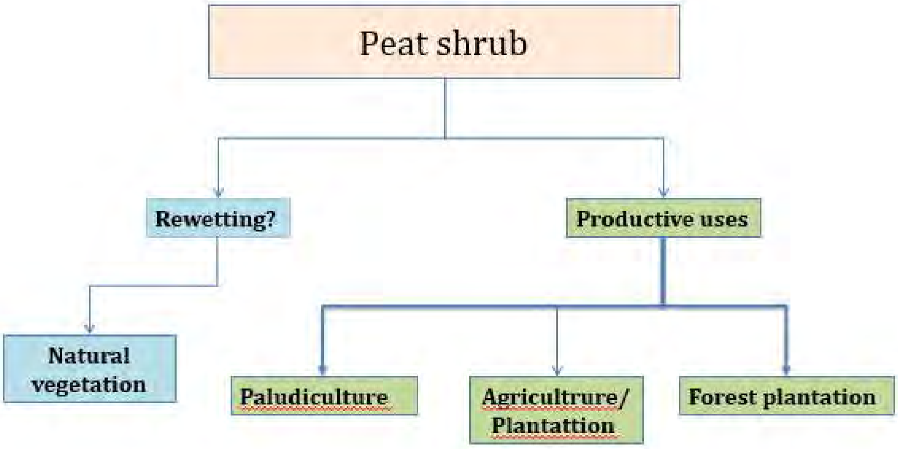
4

Peat shrub suitability for Agriculture

Island	Area (Mha)			
	Paddy	Horticulture	Plantation	Total
Sumatera	0.48	0.34	0.27	1.09
Kalimantan	0.01	0.53	0.47	1.01
Papua	0.89	0.60	0.19	1.67
INDONESIA	1.37	1.47	0.93	**3.77**

5

Restoration options



6

Responsible Peat Management

Management for high Agricultural production with minimal environmental negative effects:

- Low incidence of fire
- Low GHG emissions
- Low subsidence

7

Annex 03

Pengukur muka air tanah di Labuhanbatu, Sumut. Foto: A

Sistem tabat digunakan untuk pengaturan muka air tanah antara 50-70 cm pada perkebunan kelapa sawit sesuai rekomendasi **RSPO dan ISPO.**

Pintu air, dan legume cover crop. Sumut. Foto: PPKS

Pintu air, Labuhanbatu, Sumut. Foto: AA

8

Sungai Buluh Protection area, Tanjabtim, Jambi, and the surroundings

9

Annex 03

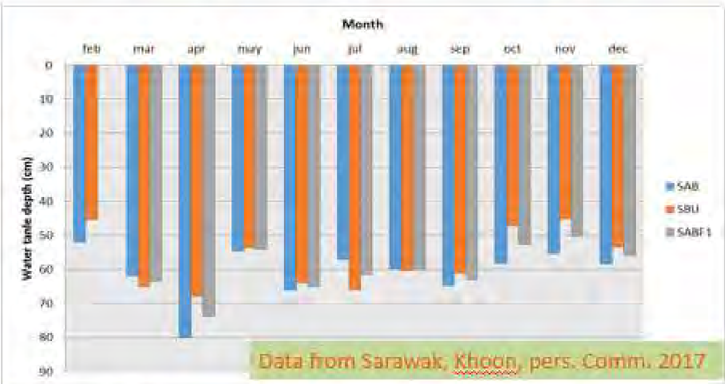
Other land uses with relatively high water table

To be verified in 2017-2019:

- Water table fluctuation
- FFB yield
- CO_2 emissions

10

How does the water table fluctuates ?



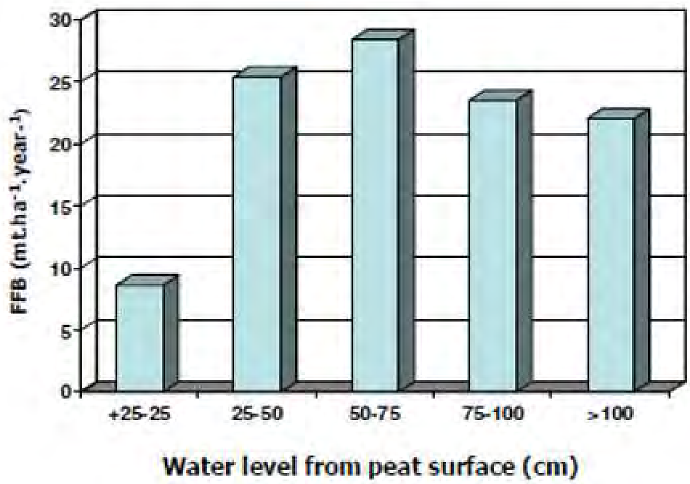
- Muka air tanah naik dan turun pada perkebunan **kelapa sawit** dan di **HTI** mengikuti dinamika musim hujan dan musim kemarau
- Selama beberapa tahun pengamatan, muka air tanah selalu lebih dalam dari 0,4 m, termasuk di lahan hutan (SABF1)

→ Fluktuasi muka air tanah sangat ditentukan oleh **curah hujan** dan pada batas tertentu dipengaruhi oleh **sistem pengelolaan**

11

Water table vs oil palm FFB yield

(RSPO, 2012)



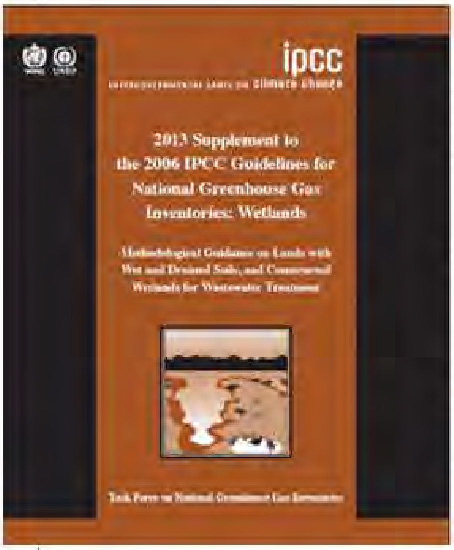
12

How much emissions from peat decomposition?

Do we have enough data of water table vs OP yield?

13

Annex 03



Contents

Tabel 2.1 Faktor Emisi CO_2 Tier 1/Tier 2 (ton CO_2-C ha^{-1} $tahun^{-1}$) untuk tanah organik tropis yang didrainase (IPCC, 2013)

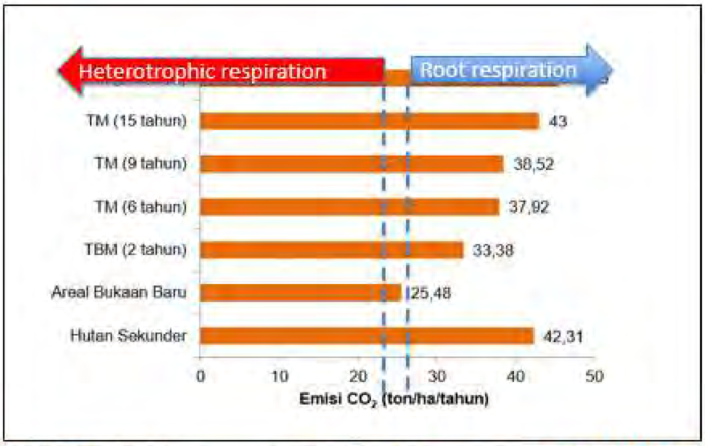
Kelas Penutupan lahan	FE	Selang kepercayaan 95%		Jl. lokasi
Hutan terpengaruh drainase atau belukar	5,3	-0,7	9,5	21
Perkebunan, rotasi panjang	15	10	21	t.t.
Perkebunan, rotasi pendek, seperti Acacia	20	16	24	13
Perkebunan kelapa sawit	11	5,6	17	10
Perkebunan, drainase <0,3 m, seperti sagu	1,5	-2,3	5,4	5
Tanaman semusim, bera	14	6,6	26	10
Tanaman semusim, sawah	9,4	-0,2	20	6
Padang rumput	9,6	4,5	17	t.t.
Permukiman	Disarankan untuk menggunakan FE penggunaan lahan yang paling mirip. Misalnya di perkotaan paling mirip dengan padang rumput.			

Annex 03

Penyesuaian Faktor Emisi Tier 1/Tier 2 (IPCC 2013) dengan kelas penutupan lahan Indonesia (Sekretariat REDD+, 2014)

No.	Penggunaan lahan	Emisi (t CO_2 ha^{-1} th^{-1})	Keterangan
1	Hutan Lahan Kering Primer	0	Tanah mineral, diasumsi nol
2	Hutan Lahan Kering Sekunder	0.	Tanah mineral, diasumsi nol
3	Hutan Mangrove Primer	0	Tanah mineral, diasumsi nol
4	Hutan Mangrove Sekunder	0	Tanah mineral, diasumsi nol
5	Hutan Rawa Primer	0	IPCC (2006)
6	Hutan Rawa Sekunder	19	IPCC (2013)
7	Hutan Tanaman	73	IPCC (2013)
8	Perkebunan (kepala sawit)	40	IPCC (2013)
9	Pertanian Lahan Kering/tegalan	51	IPCC (2013)
10	Pertanian Lahan Kering Campuran (Agroforest)	51	IPCC (2013)
11	Semak Belukar	19	IPCC (2013)
12	Belukar Rawa	19	IPCC (2013)
13	Padang rumput (savanna)	35	IPCC (2013)
14	Sawah	34	IPCC (2013)
15	Rawa	0	Tergenang, diasumsi emisi nol
16	Tambak	0	Tergenang, diasumsi emisi nol
17	Transmigrasi	51	Diasumsi serupa dengan tegalan dan pertanian campuran
18	Permukiman	35	Diasumsi serupa dengan padang rumput
19	Bandara/Pelabuhan	0	Sebagian besar permukaan tertutup beton
20	Pertambangan	51	Diasumsi serupa dengan lahan bera
21	Tanah Terbuka	51	IPCC (2013)
22	Badan air	0	Dalam keadaan reduksi , diasumsi emisi nol
23	Awan	?	Minimalkan dengan menggunakan citra dari tahun-tahun yang berdekatan.

Kementerian Pertanian



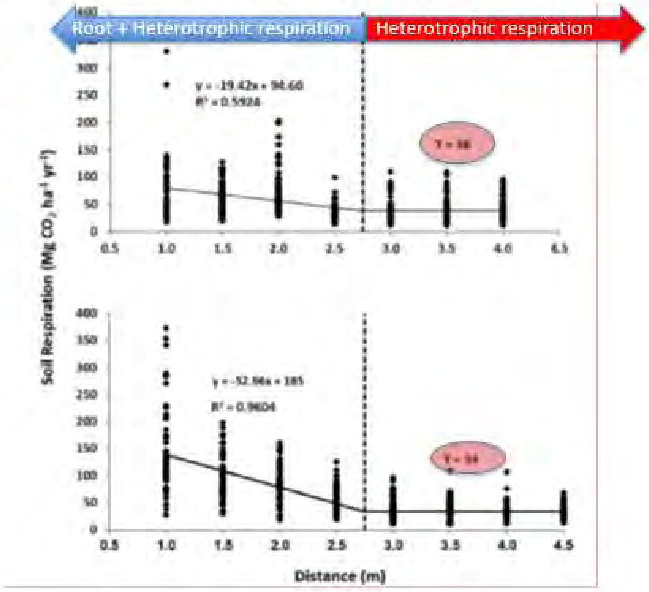
- → Emisi CO2 dari dekomposisi gambut di Sumut sekitar **25 t CO2/ha/th**
- → Respirasi akar meningkat dengan bertambahnya umur kelapa sawit, namun respirasi akar tidak seharusnya diperhitungkan sebagai faktor emisi (IPCC 2014) karena CO2 dalam jumlah yang hampir sama dengan yang keluar melalui respirasi, diserap oleh tanaman melalui proses fotosintesis

(Reinterpretasi data IOPRI. 2009. CO2 emission on oil palm plantation: field observation. Paper on Indonesian Palm Oil)

Emisi pada perkebunan sawit (Dariah et al. 2014)

→ Emisi CO2 dari dekomposisi gambut di Riau sekitar **38** t CO2/ha/th, di Jambi sekitar **34** t/ha/th

→ Respirasi akar meningkat semakin dekat ke pohon. Respirasi akar merupakan error yang harus dikeluarkan dari factor emisi



Emissions estimate using subsidence sticks

(Maswar et al. unpub., based on 37 *subsidence sticks*)

Lokasi	Laju Subsiden	Emisi	Oksidasi/subsiden
	cm/tahun	t CO2/ha/tahun	Mg CO (ha·yr)
Kalbar, tan pangan	4.71±1.26	42.6±11.4	40%
Riau, sawit 10 th	**2.78±0.37**	**37.7±3.3**	60%
Riau, belukar	5.15±2.48	46.72±26.1	40%
Jambi, sawit 9 th	**2.49±0.19**	**33.8±2.6**	60%
Kalteng, Karet	4.89±1.45	44.3±13.1	40%

- Laju subsiden pada perkebunan sawit relatif lebih rendah, mungkin karena pengaruh pemadatan oleh bulldozer sewaktu persiapan lahan
- Laju subsiden pada perkebunan kelapa sawit berkisar antara 2.5-2.8 cm/tahun pada perkebunan kelapa sawit, 9-12 tahun sejak bangun saluran drainase
- Emisi pada perkebunan sawit sekitar 34-38 t CO2/ha/tahun

Annex 03

Conventional agriculture or Paludiculture?

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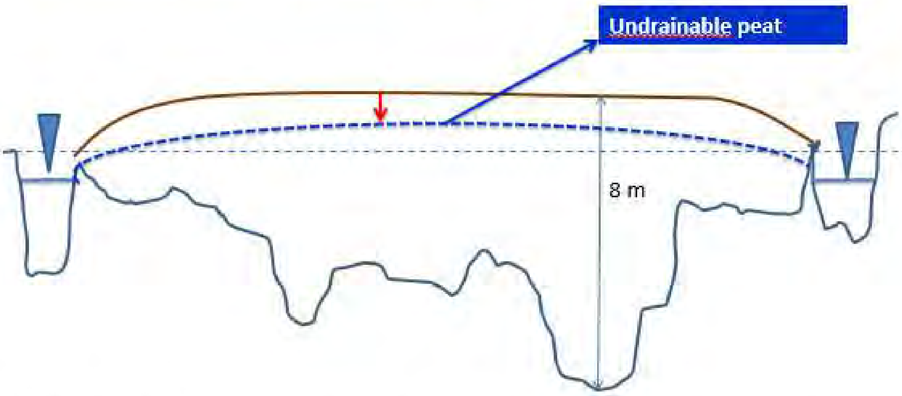
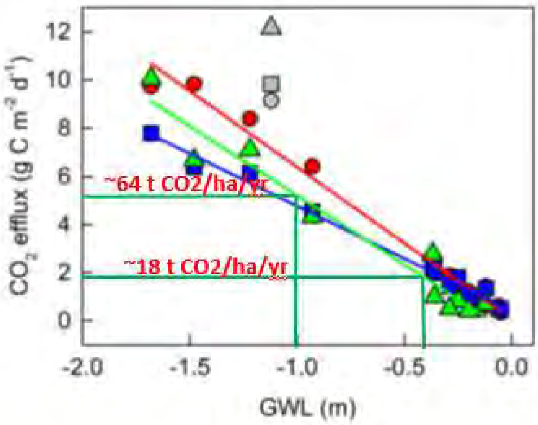
When Paludiculture can be implemented?



1. When we can find economically competitive crops that tolerate high water table
2. When funds are available to compensate farmers for practicing the system
3. When the water table reaches **undrainable level**

21



Source: Nur Wakhid (2017), Jabiren, Kalteng, di bawah tegakan karet rakyat

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Modified Hooijer (2012):
Emisi (t CO_2/ha/tahun) = 0.7 *0.91 * cm

Water table 0.4 m:
Emission = 0.4*67.3 = 25.5 t CO_2/tahun

Water table 1.0 m T
Emission = 0.7*0.91*100=63,7 t CO_2/tahun

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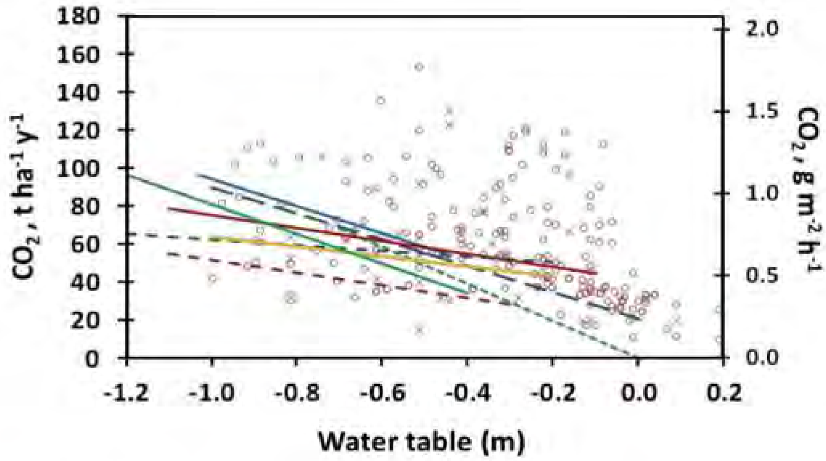
Annex 03



Jauhiainen (2016), belum memisahkan respirasi akar :

1 m ➔ Emission = 80 t CO2 ha^{-1}

0.4 m ➔ Emission = 40 t CO2 ha^{-1}

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Relative advantages and disadvantages of land cover types

Indocator	Peat forest	Plantation/Agriculture	Degraded peat
C Stock	High	Low – moderate	Low-moderate
Emisi GRK	Nil/very low	Moderate-high	Sedang-tinggi
Fire risk	Low	Rendah	Tinggi
Biodiversity	High	Low	Low-moderate
Manfaat sosial	Low	Moderate-high	Low
Provitability	Low	Low-very high	Nil-negative

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Annex 03

Conclusions

- Almost consistent positive trend of water table depth and CO_2 emissions
- Data is lacking to show high water table vs crop yield and GHG emissions → Calls for establishment of several pilots to address this issue
- Pay more attention for restoration of peat shrub

Annex 03

Keynote Speaker : Dr. Kusumo Nugroho (BBSDLP, Indonesia)
Title : Monitoring Water Table in Peatland Between Theory and Practice (#08)

MONITORING WATER TABLE IN PEATLAND BETWEEN THEORY AND PRACTICE

KUSUMO NUGROHO

INDONESIAN CENTER FOR LAND RESOURCES RESEARCH AND DEVELOPMENT
AGENCY FOR AGRICULTURAL RESEARCH AND DEVELOPMENT
MINISTRY OF AGRICULTURE

1

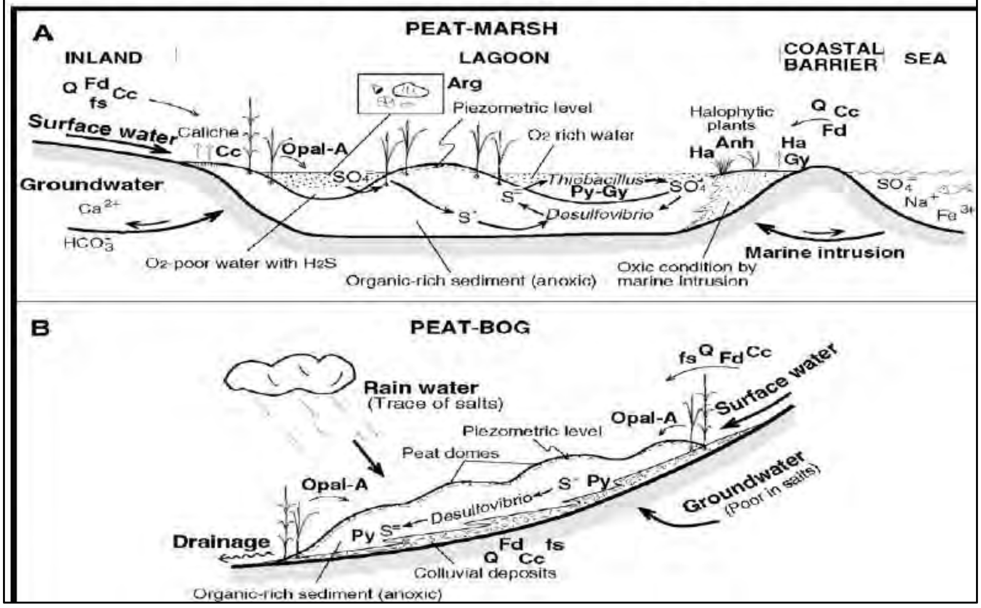
OUTLINE

- Introduction
- Model conception
- Role of physical properties of peat
- Monitoring by measurement
- Model validation
- Practical Scenarios application

2

INTRODUCTION

Peatland and the hydrological unit



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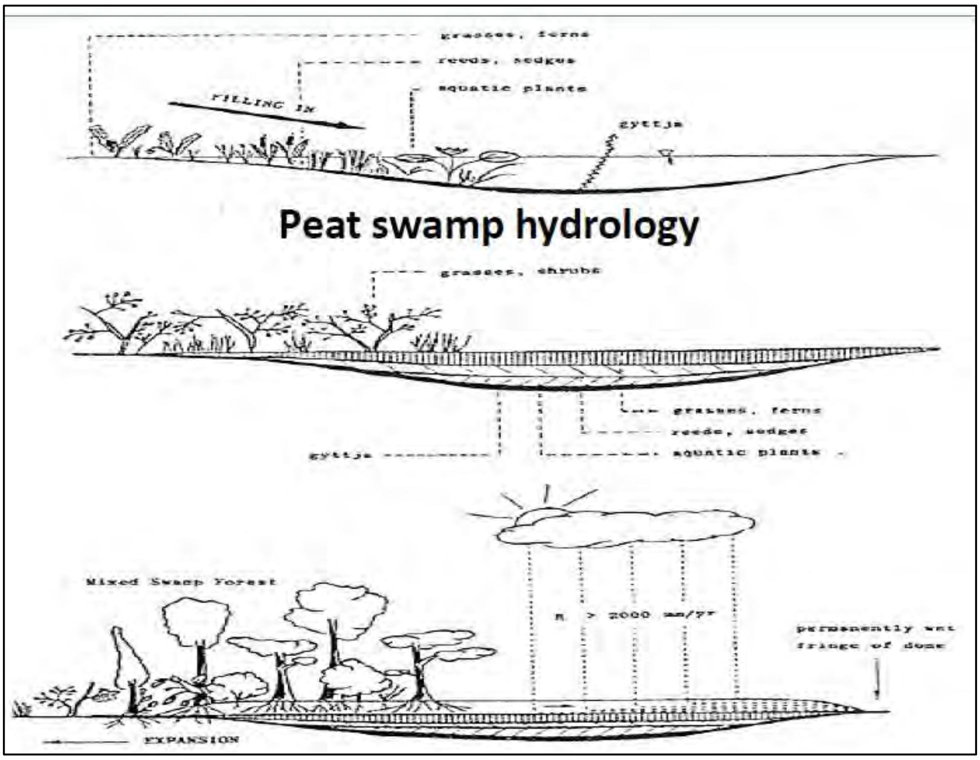
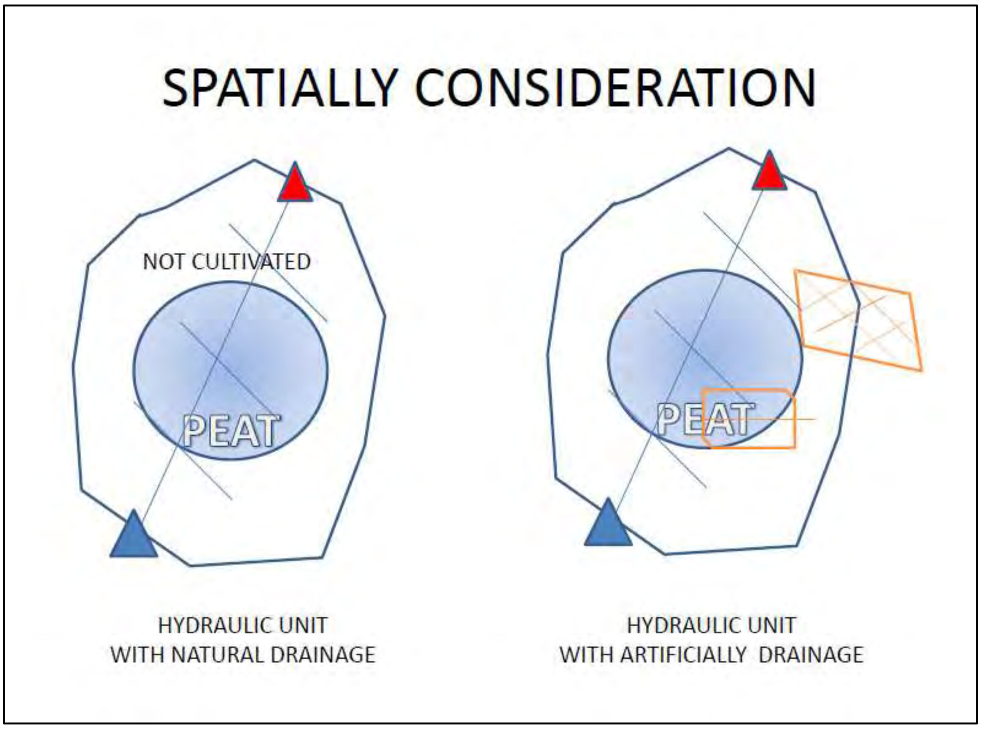

grasses, ferns
reeds, sedges
aquatic plants
FILLING IN
gyttja
Peat swamp hydrology
grasses, shrubs
grasses, ferns
reeds, sedges
gyttja
aquatic plants
Mixed Swamp Forest
permanently wet
fringe of dome
EXPANSION

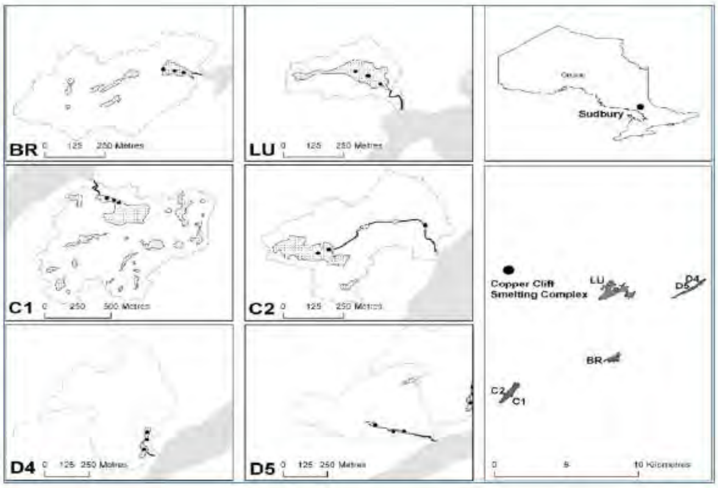
5


SPATIALLY CONSIDERATION
NOT CULTIVATED
PEAT
PEAT
HYDRAULIC UNIT
WITH NATURAL DRAINAGE
HYDRAULIC UNIT
WITH ARTIFICIALLY DRAINAGE

6

Annex 03

Spatial consideration



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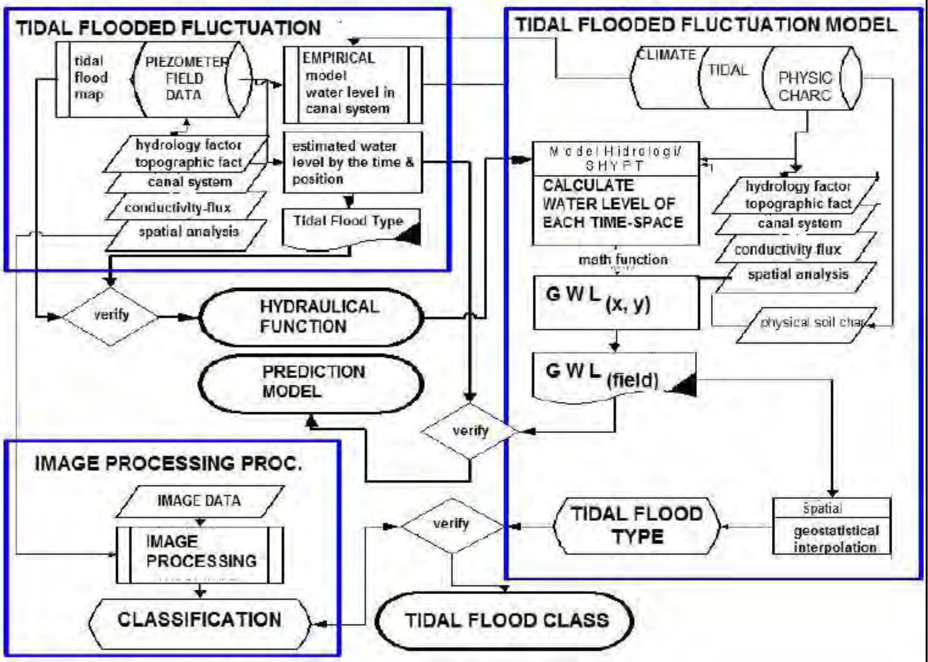
HYDRAULICAL MODEL CONCEPTION



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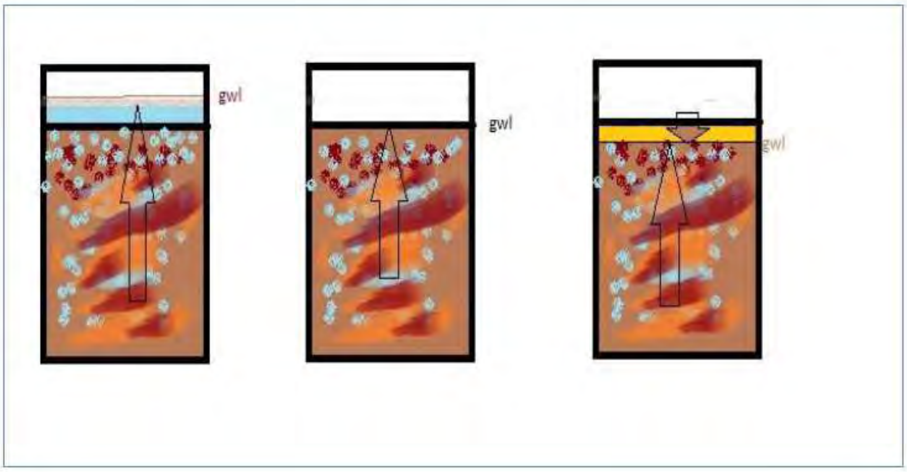
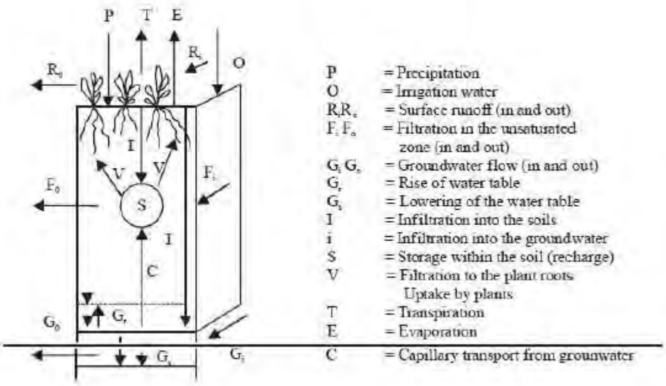
Annex 03

Common Water Table problem in swampy area



SOIL - HYDRAULIC MODEL PARAMETER



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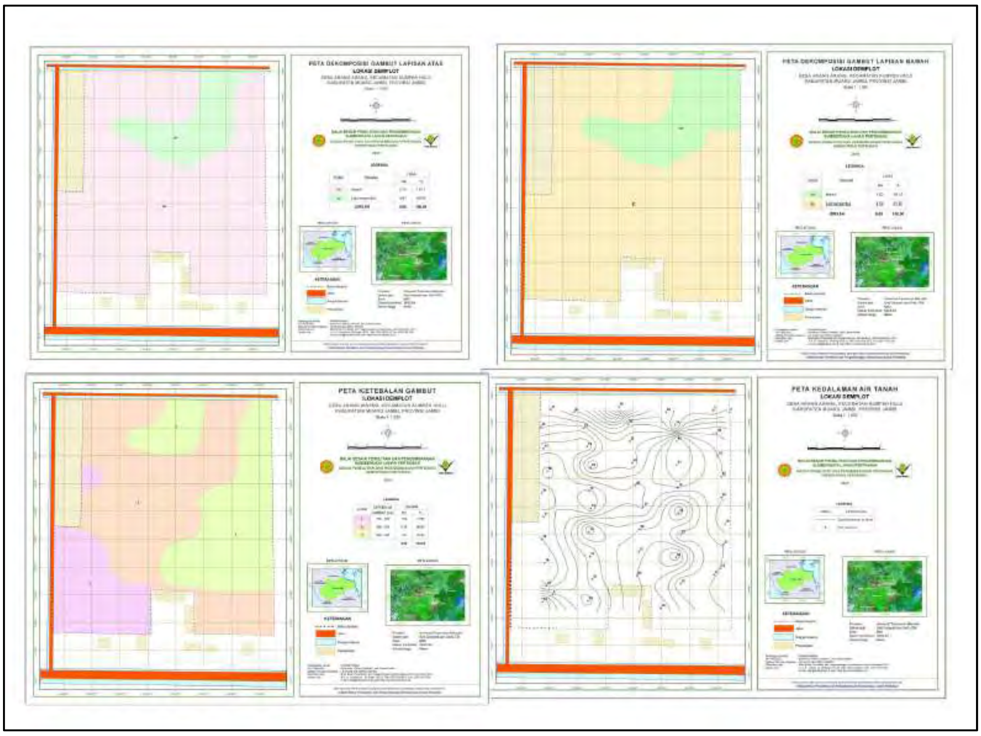

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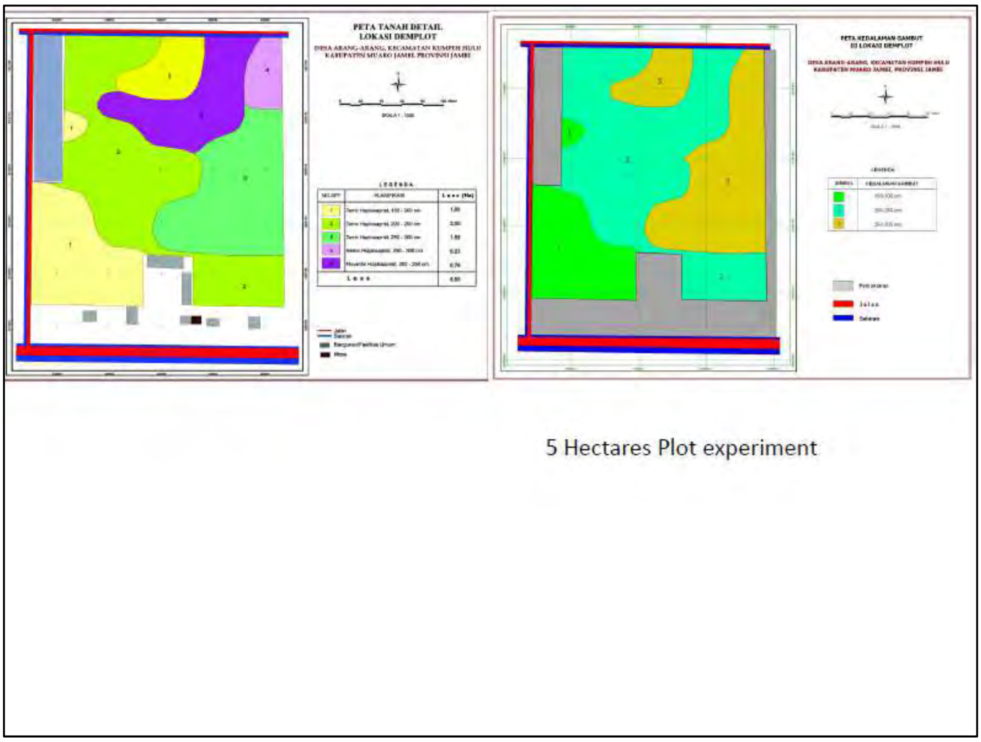

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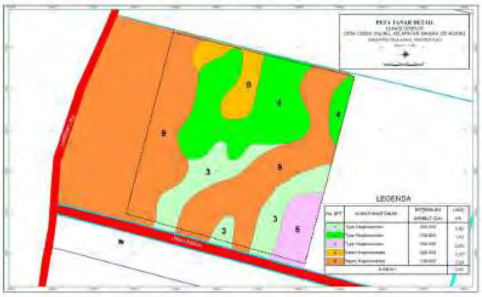
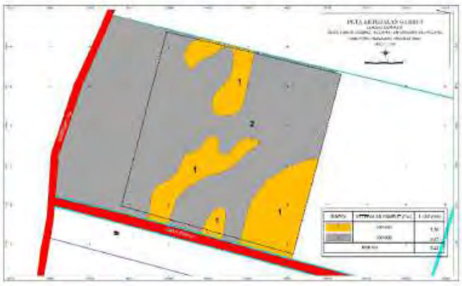
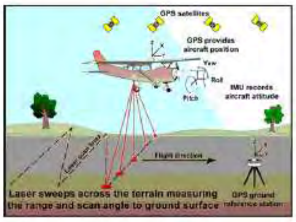


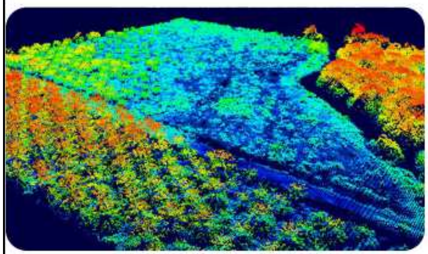


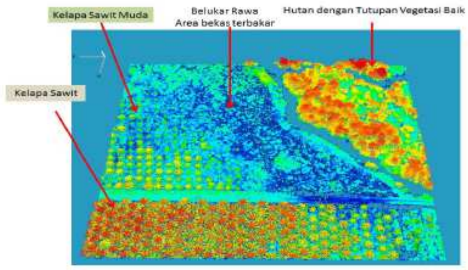
Teknologi LiDAR dan Foto Udara

*"**LIDAR** (**Li**ght **D**etection **a**nd **R**anging) adalah metode penginderaan jauh yang menggunakan cahaya laser untuk mengukur jarak ke permukaan bumi."*



Three dimension model





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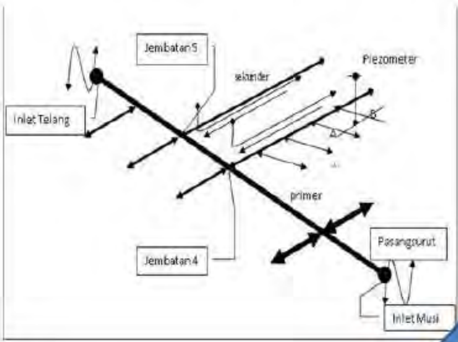
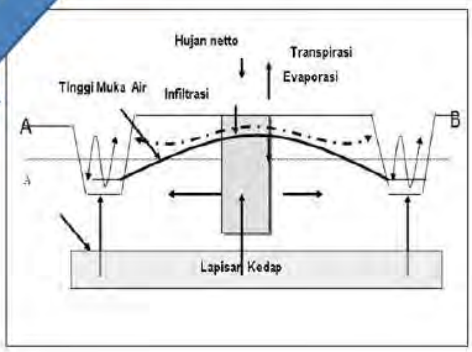


Canals scheme

Ground water level in field



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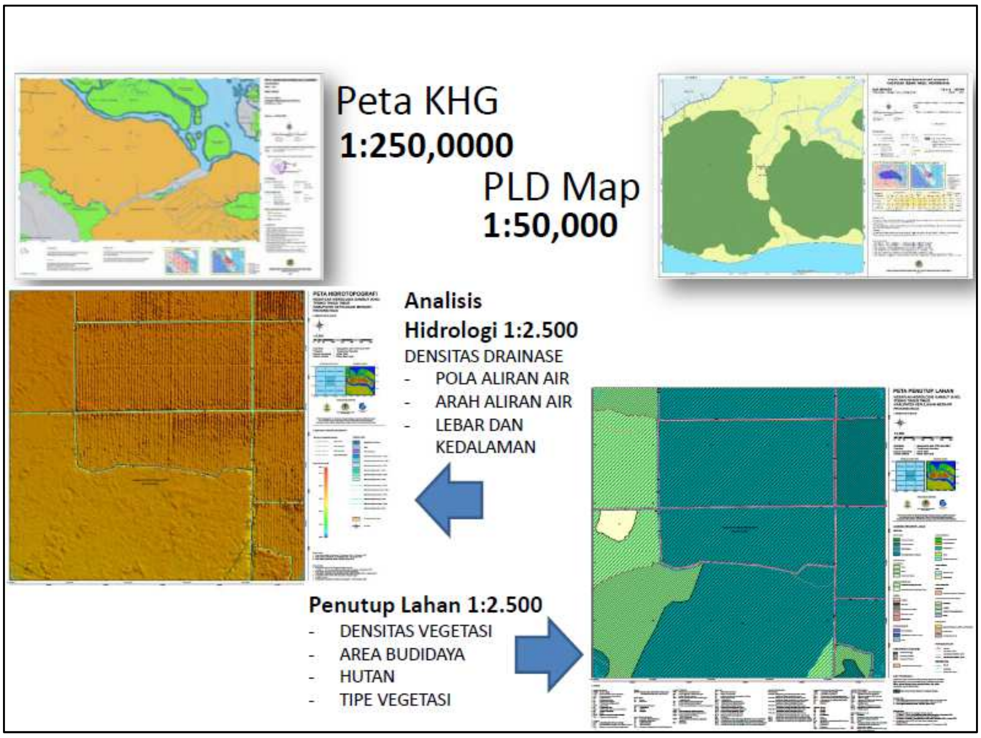

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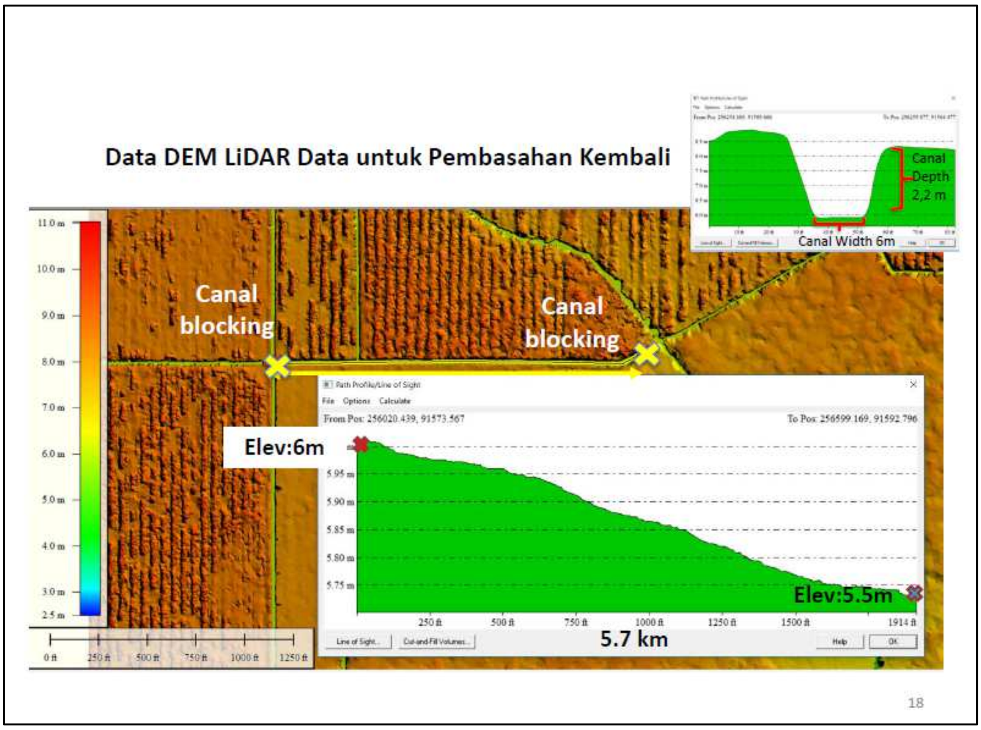

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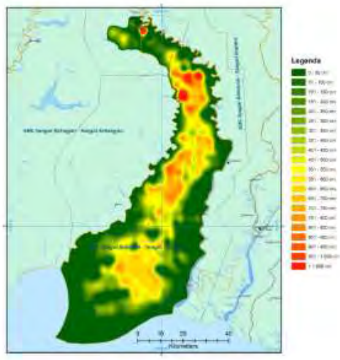
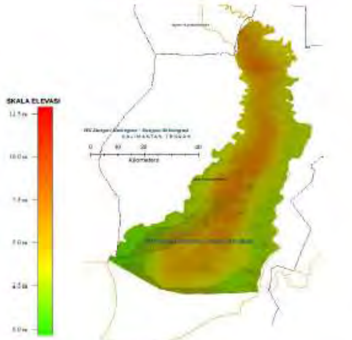
Annex 03

DTM PULANG PISAU

KHG Sungai Kahayan – Sungai Sebangau





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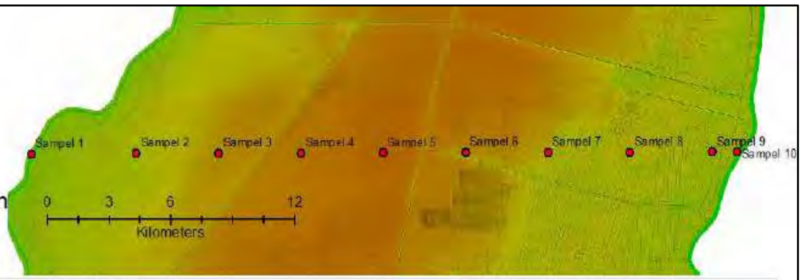
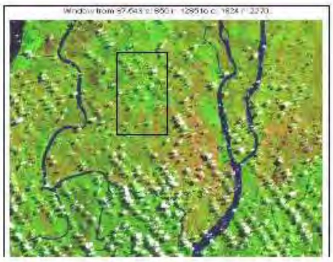
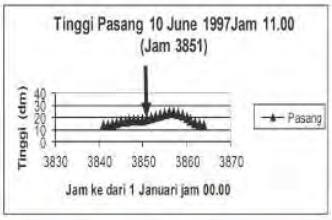
Grafik Perbandingan DTM dan Kedalaman



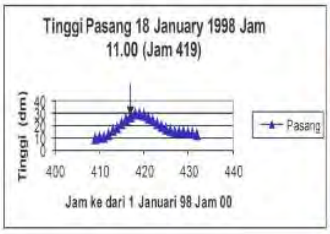
	Sampel 1	Sampel 2	Sampel 3	Sampel 4	Sampel 5	Sampel 6	Sampel 7	Sampel 8	Sampel 9	Sampel 10
Tinggi DTM	0,00	3,00	5,48	6,88	7,53	5,09	3,48	3,48	3,31	0,00
Kedalaman Gambut	0	-2,01	-6,64	-6,37	-7,49	-7,27	-1,75	0	-0,3	0

20





Gambar 27 Landsat Band 543 dan Kondisi Pasang 1997 waktu Pengambilan Citra



Gambar 28 Landsat Band 543 dan Kondisi Pasang 1998 waktu Pengambilan Citra

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DIGITAL ELEVATION MODEL DI KHG CAWANG – AIR LALANG

Tata kelola air di ekosistem gambut penting untuk mencegah kebakaran dan penurunan muka tanah yang dapat mengakibatkan banjir

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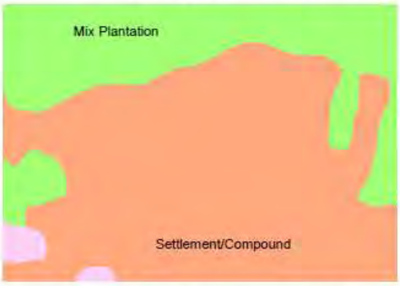
Annex 03

Proses Multi Tahap Penutup Lahan Skala Kecil ke Skala Sedang dengan Data dari Foto Udara dan LiDAR

Lokasi Kecamatan Meranti Barat, Kabupaten Kepulauan Meranti, Riau



Generalisasi / Agregasi

Detailing

Sumber: Peta Penutup Lahan Skala 1:250.000
Sumber: Landsat 8 OLI, 2014

Sumber: Peta Penutup Lahan Skala 1:2.500
Sumber Data: Foto Udara, 2017

Analisis Penutup Lahan yang berhirarki sudah disusun dalam SNI dan RSNI (Skala 1:1.000.000 hingga skala 1:1.000), sehingga proses untuk Agregasi dan pendetilan sudah terakomodir

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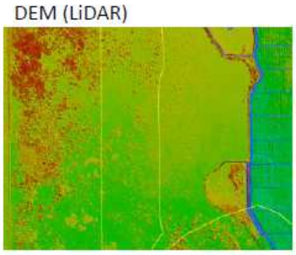
Pemanfaatan Teknologi Penginderaan Jauh dan Pemetaan untuk Analisis Spasial Perencanaan Restorasi Gambut

Foto Udara

INTERPRETASI VISUAL (Landscape Ecology Approach)

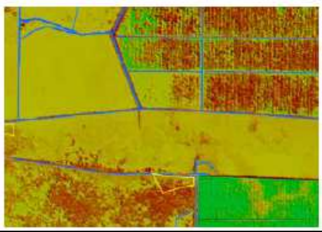
Peta Penutup Lahan

DEM (LiDAR)



Analisis Spasial, Analisis Hidrologi

Peta Hidrotopografi (Kanal)



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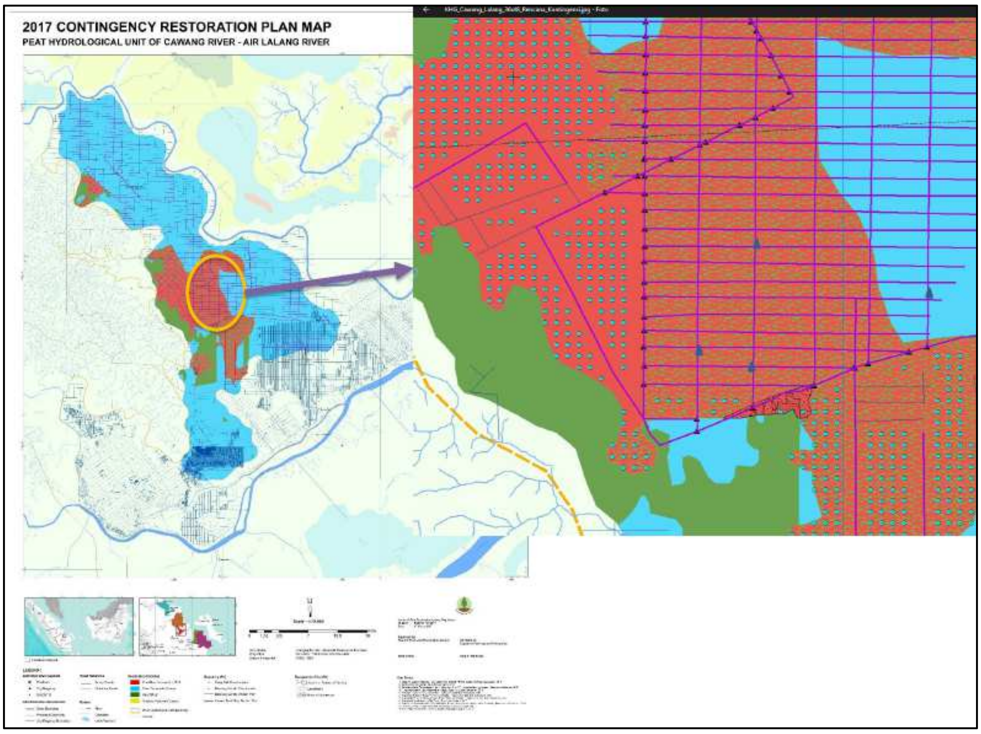
Annex 03



DIGITAL ELEVATION MODEL DI KHG CAWANG – AIR LALANG

Tata kelola air di ekosistem gambut penting untuk mencegah kebakaran dan penurunan muka tanah yang dapat mengakibatkan banjir

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Annex 03

Evett and Cheng Liu (1987), provides a formulation for calculating the achievement of flood waters from open channels (from Primary to tertiary Channel location), in conjunction with flood discharge, using the following equation;

v	**= (1.486/n)*((R**(2/3))*(s**(1/2)))**
v	**: flow velocity (length unit /time unit)**
n	**: manning coefficient**
R	**: radius hydraulic radian**
S	**: energy gradient slope**

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The flow changes gradually as defined by Ranga Raju (1986). This equation takes into account the flow:

dh/dx	$= (S_0 - S_f)/(1 - F^2)$
F	= U/sa gd or U/sqrt(gd)

F	: Force due to gradients
S_0	: slope of base .
S_f	: slope of energy
U	: Kinetic Energy
h	: depth of flow => depth of channel water surface
x	: length or accounted space (channel)

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Annex 03

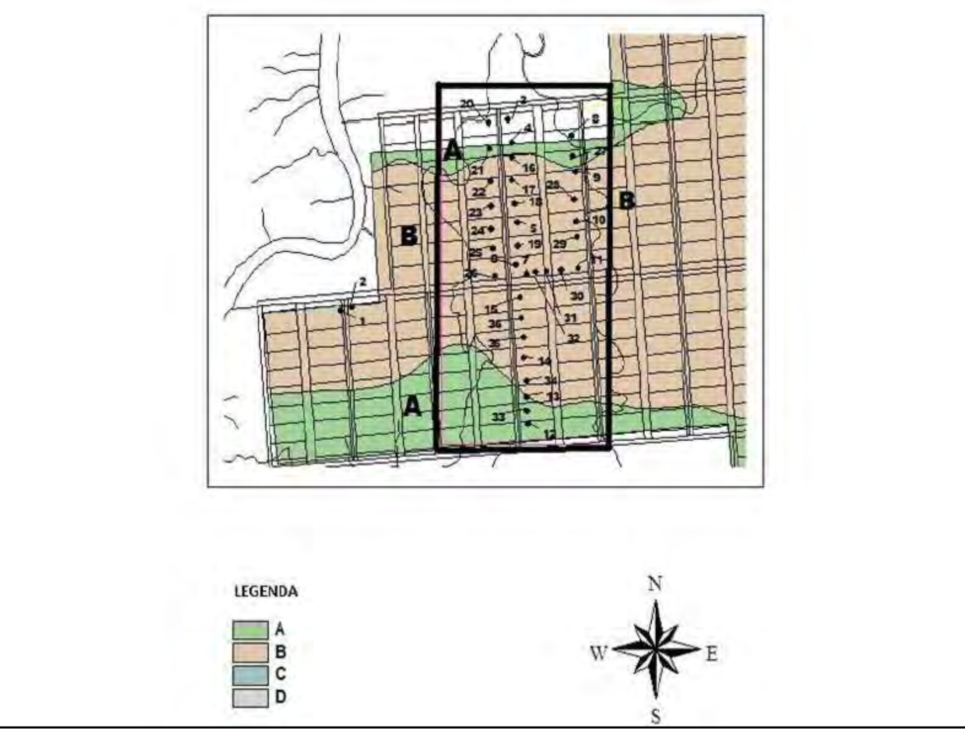
Chandra (1986) Calculate the influence of tidal in the tertiary channel against the water table level with the formula:

h(x,t)	= hm + A e^{-px} Sin (wt - qx)
h (x,t)	: Ground water level at distance x and time t
t	: time (hour)
hm	: ground water level t x (cm)
A	:Amplitude (cm)
w	: 2p/T = frequenty (Rad/hour)
T	: Time period of one wave cycle (hour)
px = qx	: $(w/2u)^{0.5}$
x	: phase shift (Rad)

The calculation is described in the following equation:

DV/Dt	= $P_n + S_i + G_i - ET - S_o - G_o \pm T$
DV/Dt	: Volume of water stored in the wetlands
DV	: Changes in water savings per unit time
Dt	: Time changes
P_n	: Net precipitation
S_i	: Surface flows include flood flows
G_i	: Underground water flow
ET	: Evapotranspiration (based on calculation of climate data)
S_o	: Flow through the surface
G_o	: Outflow from underground water
T	: Inflow (+) and outflow (-)
DV	:Pt (Total pore in water-saturated time, or part of the cross-sectional area filled with water) + Q (On the unsaturated soil)
ET	:Calculated on block bounded by path,
S_o & G_o	Calculated from the outflow / incoming stream is calculated using the correlation result of current meters measurement and the water level observed
T	:Inflows (+) and outflows (-) of the tidal calculations.

Annex 03



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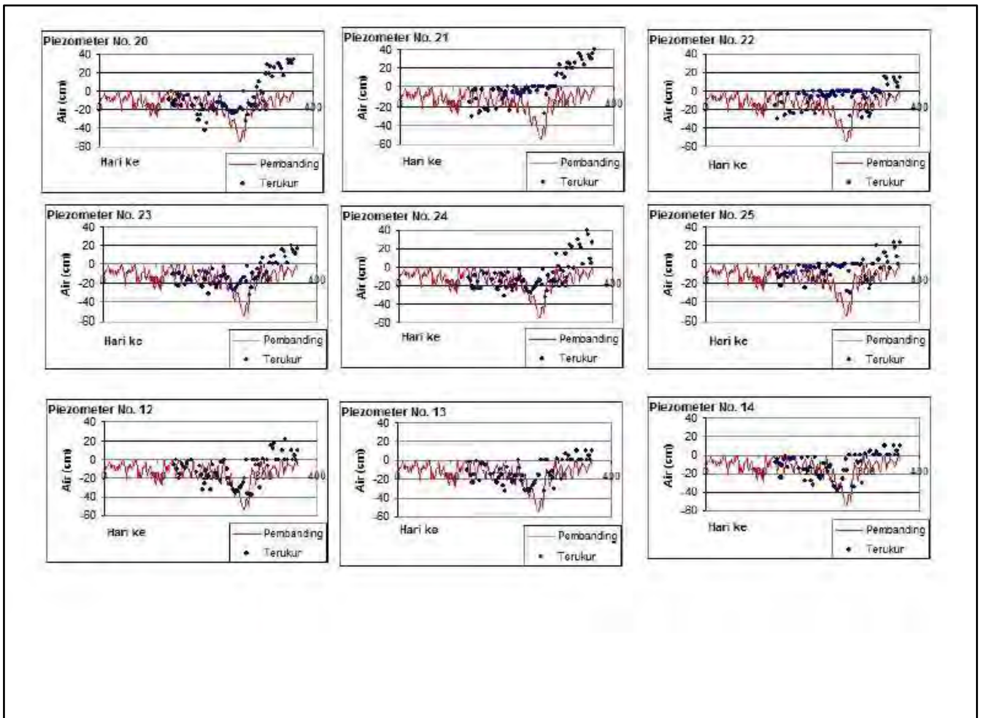

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Annex 03

ORGANIC POOL LINE

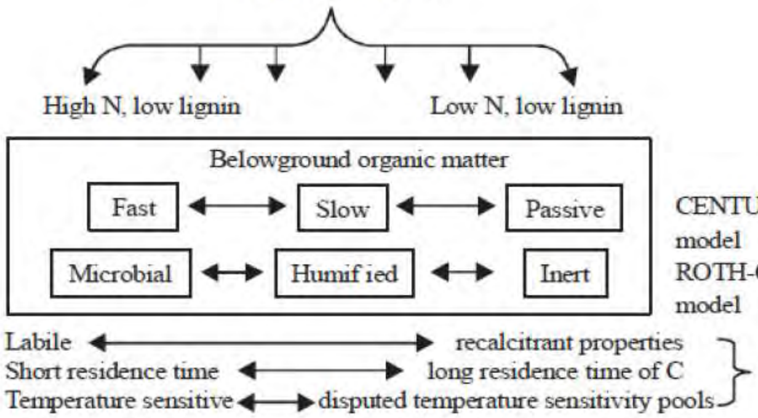
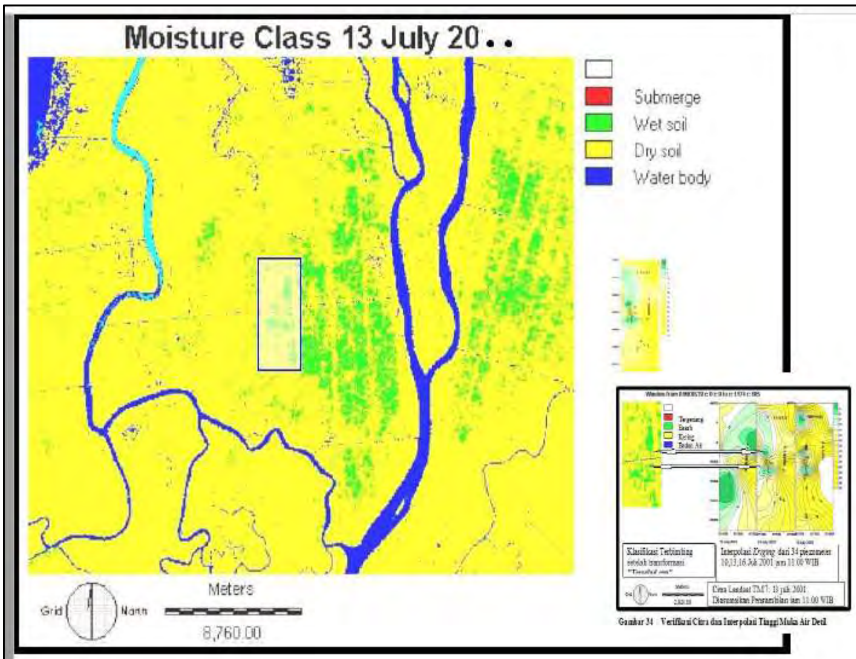
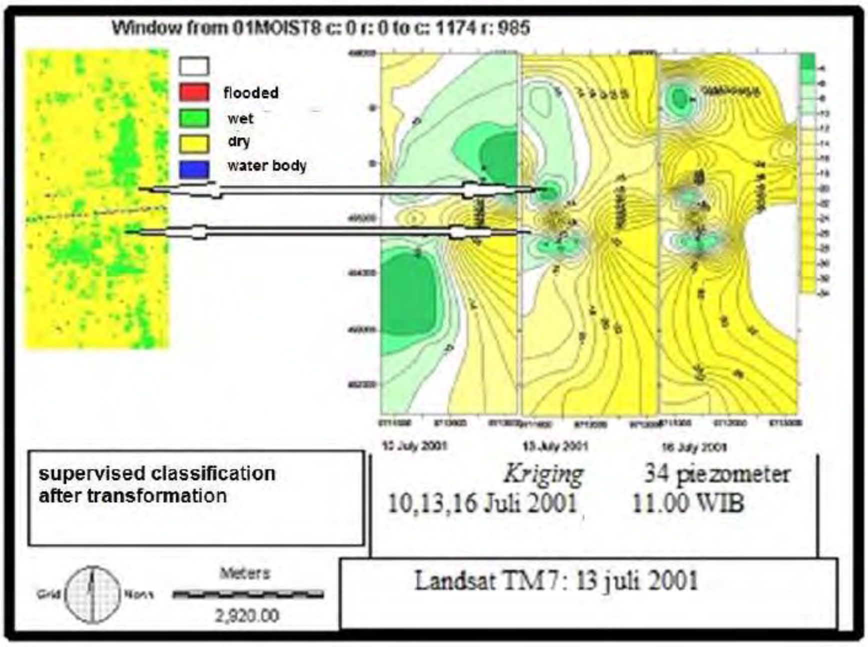


Fig. 10: Properties of conceptual pools of belowground carbon stocks in two well-known models[44]

35



36


Window from 01MOIST8 c: 0 r: 0 to c: 1174 r: 985
flooded
wet
dry
water body
10 July 2001
13 July 2001
16 July 2001
supervised classification
after transformation
Kriging
10,13,16 Juli 2001
34 piezometer
11.00 WIB
Landsat TM7: 13 juli 2001
Meters
2,920.00
Grid
North

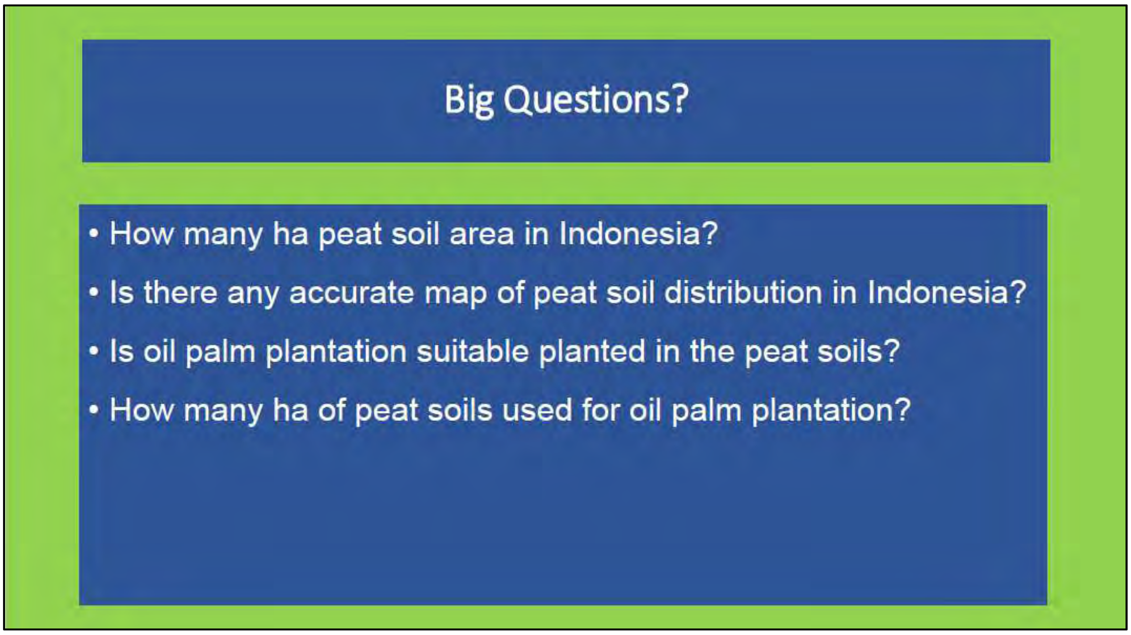
37

THANK YOU

Annex 03

Keynote Speaker : Suwardi (HITI, Indonesia)
Title : Cultivation of Oil Palm Plantation in the Peatland (#09)

1



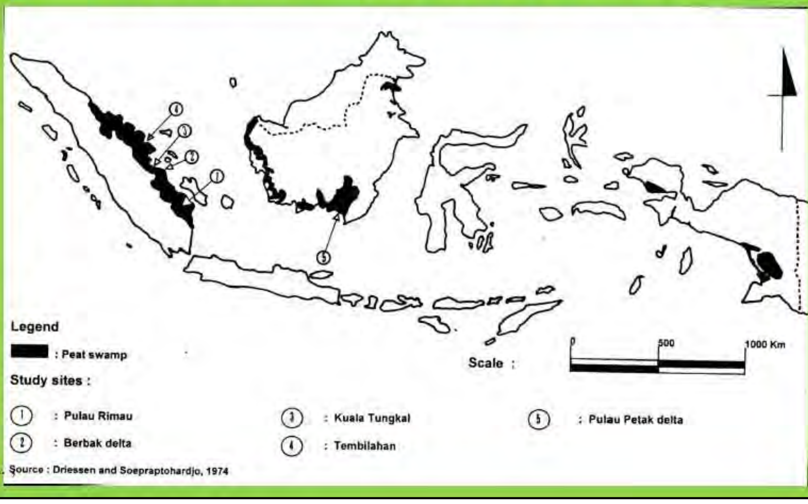
2

Definition of Peat Soil

- Definition of Peat Soil is soil composed of natural plant residues formed in the long period of time in a spesific environment. Requirement depth for peat soil by Soil Taxonomy is 50 cm.
- Characteristic of peat soil depends on the sediment under the peat and the characteristic of sediment depends on the environment process of sedimentation such as terrace, coastal sand, or mangrove sediment.
- In Indonesia, peat soil distributes in Sumatera, Kalimantan and Papua.

3

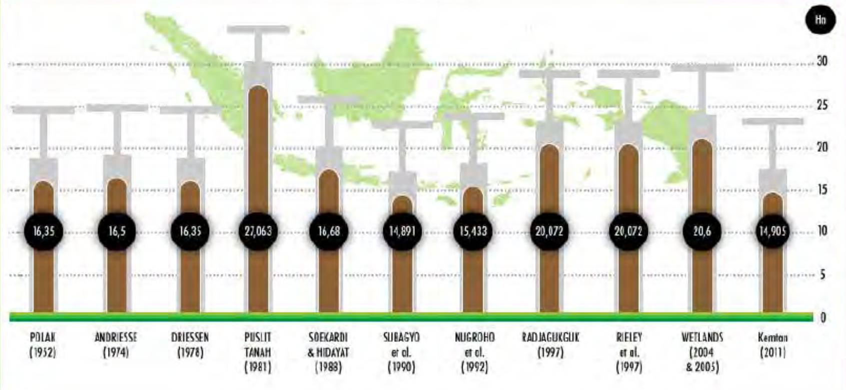
Indonesian Peat soils Distribution



Total area 14-18 juta ha.

Annex 03

Peatland in Indonesia



Tabel 1. Luas dan sebaran lahan gambut menurut kedalaman pada masing-masing provinsi di Sumatera, Kalimantan dan Papua

PROVINSI/PULAU					LUAS	
	D1	D2	D3	D4	Ha	%
ACEH	144.274	71.430			215.704	3,35
SUMATERA UTARA	209.335	36.472		15.427	261.234	4,06
SUMATERA BARAT	11.454	24.370	14.533	50.329	100.687	1,56
RIAU	509.209	908.553	838.538	1.611.114	3.867.413	60,08
KEPULAUAN RIAU	103	8.083			8.186	0,13
JAMBI	91.816	142.716	345.811	40.746	621.089	9,65
BENGKULU	3.856	802	2.451	944	8.052	0,13
SUMATERA SELATAN	705.357	515.400	41.627		1.262.385	19,61
KEPULAUAN BANGKA BELITUNG	42.568				42.568	0,66
LAMPUNG	49.331				49.331	0,77
SUMATERA	***1.767.303***	***1.707.827***	***1.242.959***	***1.718.560***	***6.436.649***	***100,00***
KALIMANTAN BARAT	421.697	818.460	192.988	246.989	1.680.135	35,16
KALIMANTAN TENGAH	572.372	508.648	632.989	945.225	2.659.234	55,66
KALIMANTAN SELATAN	10.185	21.124	74.962		106.271	2,22
KALIMANTAN TIMUR	44.357	41.582	171.830	74.597	332.365	6,96
KALIMANTAN	***1.048.611***	***1.389.813***	***1.072.769***	***1.266.811***	***4.778.004***	***100,00***
PAPUA	1.506.913	817.651	319.874		2.644.438	71,65
PAPUA BARAT	918.610		127.873		1.046.483	28,35
PAPUA	***2.425.523***	***817.651***	***447.747***	***0***	***3.690.921***	***100,00***
TOTAL	**5.241.438**	**3.915.291**	**2.763.475**	**2.985.371**	**14.905.574**	

Source: BBSDLP, 2011

Peat soil at Riau: 3.67 M ha, 60% Riau land

Peat soil is very imporant

D1: Peat depth (50-100)cm
D2: Peat depth (100-200)cm
D3: Peat depth (200-300)cm
D4: Peat depth >300cm

REPPProT: Regional Physical Planning Programme For Transmigration, 1990:
Soil map based on land system Scale 1:2.500.000

Soil map: Atlas Exploration of Soil Resources of Indonesia Scale 1: 1.000.000, Puslitanak, 2000.

Peat Soil Distribution Scale 1:250.000 BBSDLP, 2011

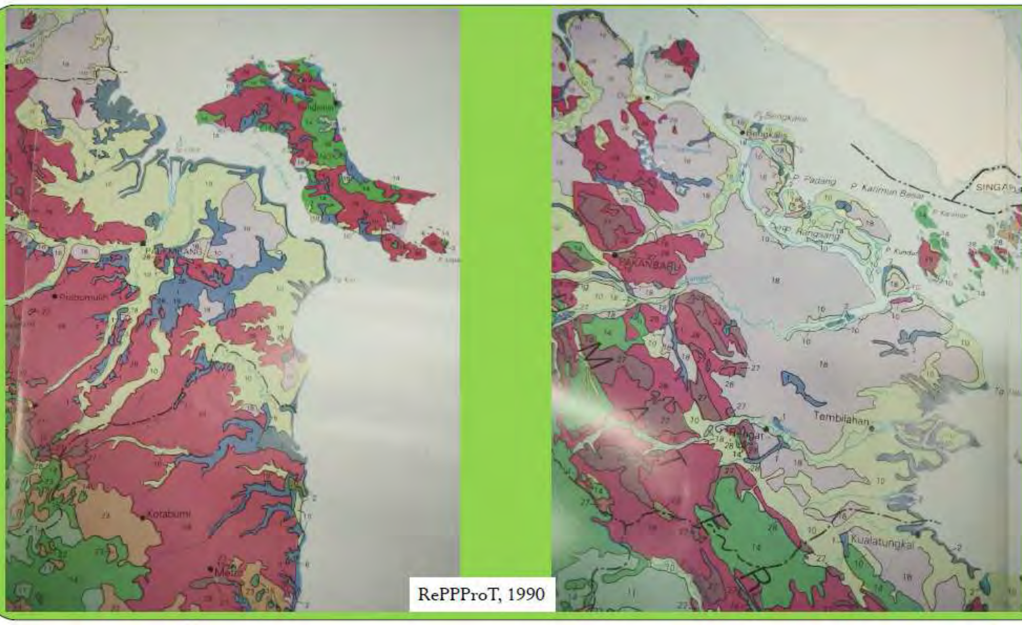
Example Problem:
Delta Upang, Saleh, Sugihan, Telang, P. Rimau at South Sumatra mostly are not peat soils (Tropaquept), in the REPPProT year, 1990,

In those areas, only small areas are defined as peat soils. The other areas are Alluvial Soils (Sulfaquept, Endoaquept, mapped by PUSLITANAK 2000,

In Peat soil mapping of BBSDLP, 2011 most of the area are peat soils with the depth of >1m.

Now Areas of Telang –Tanjung Api Api, Upang, Air Kumbang at South Sumatra are not found peat soils. Now there is new definition of KHG dan FLEG, most of that area are difined as peatland. Therefore the peat soil map should be revised based on the fiels condition.

7



RePPProT, 1990

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Annex 03

Puslitanak tahun 2000

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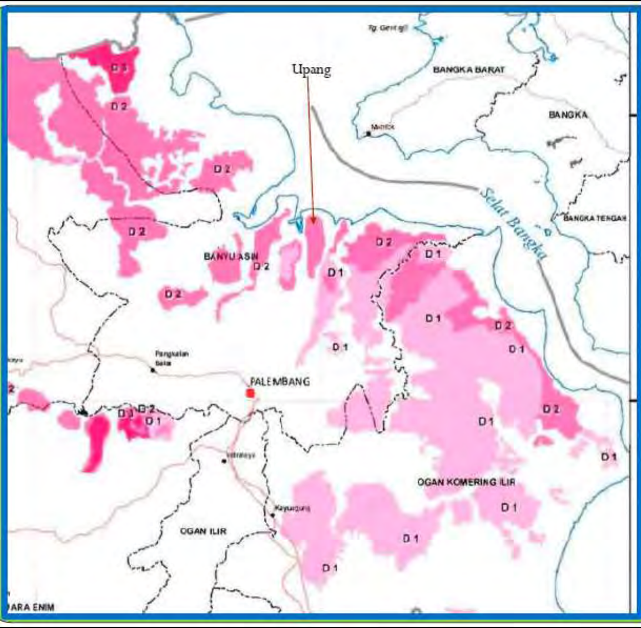

Peat Soil Distribution BBSDLP, 2011.

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Annex 03

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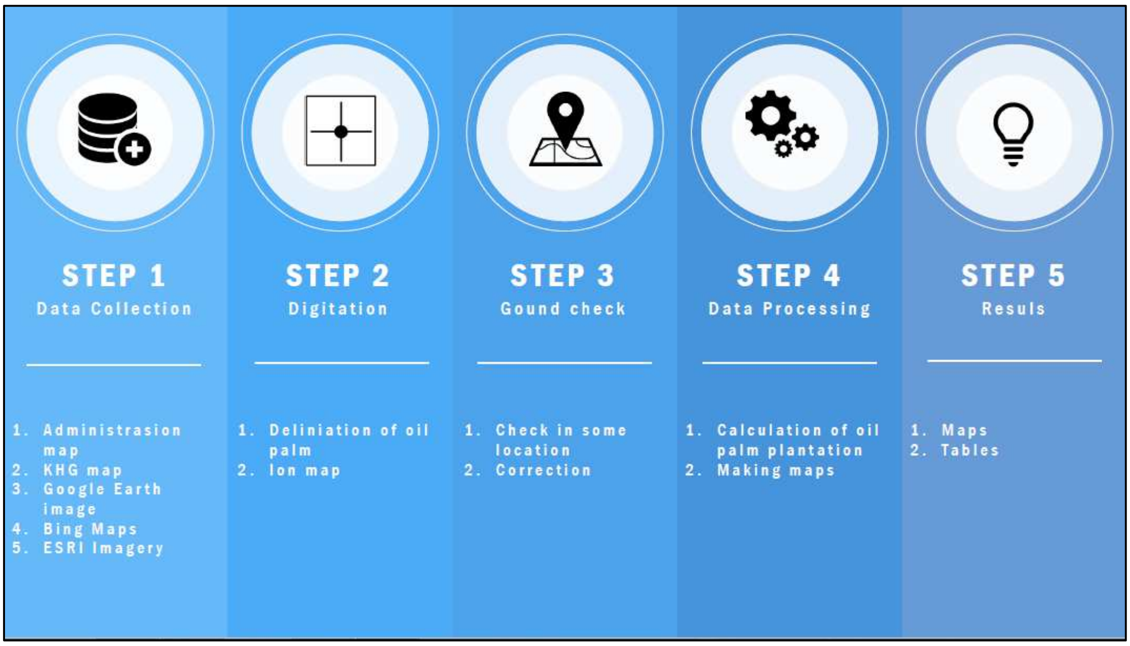

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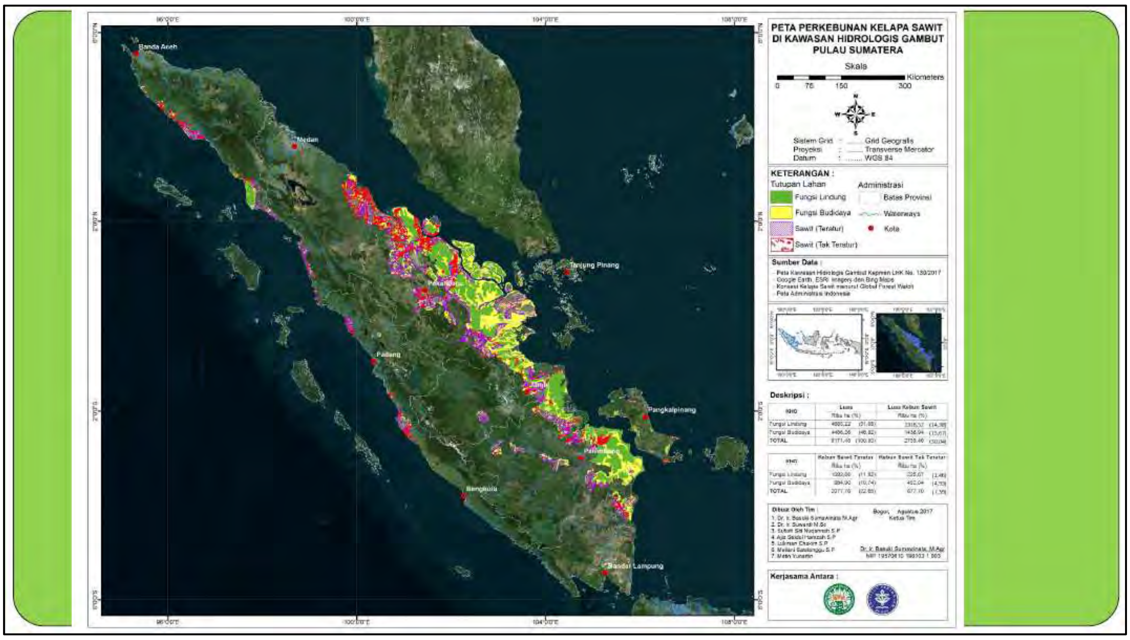
Annex 03



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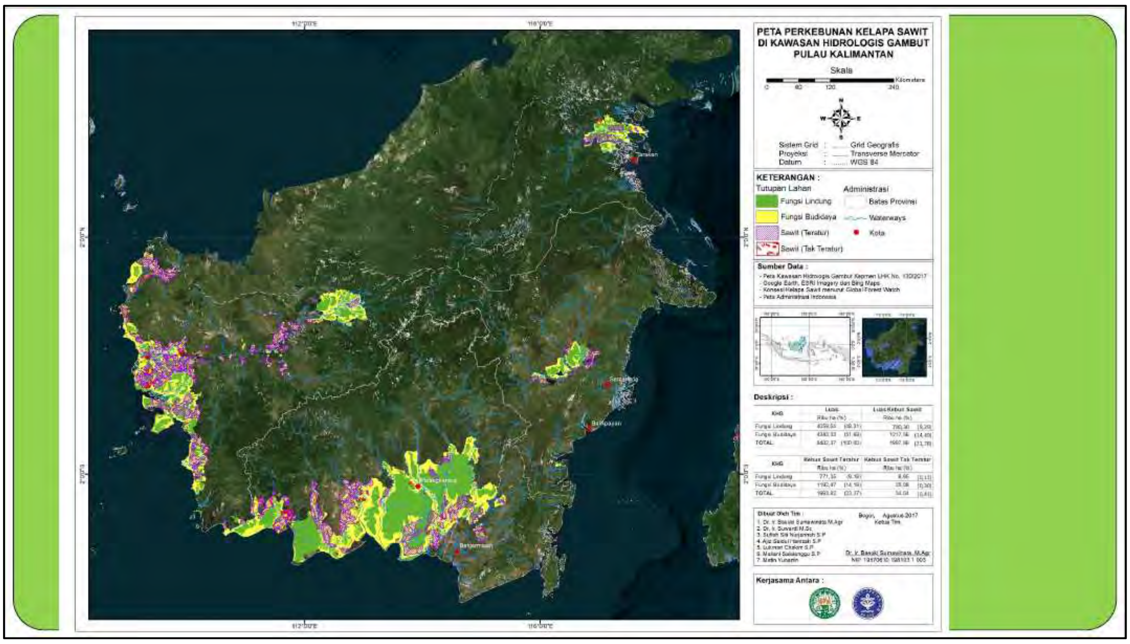

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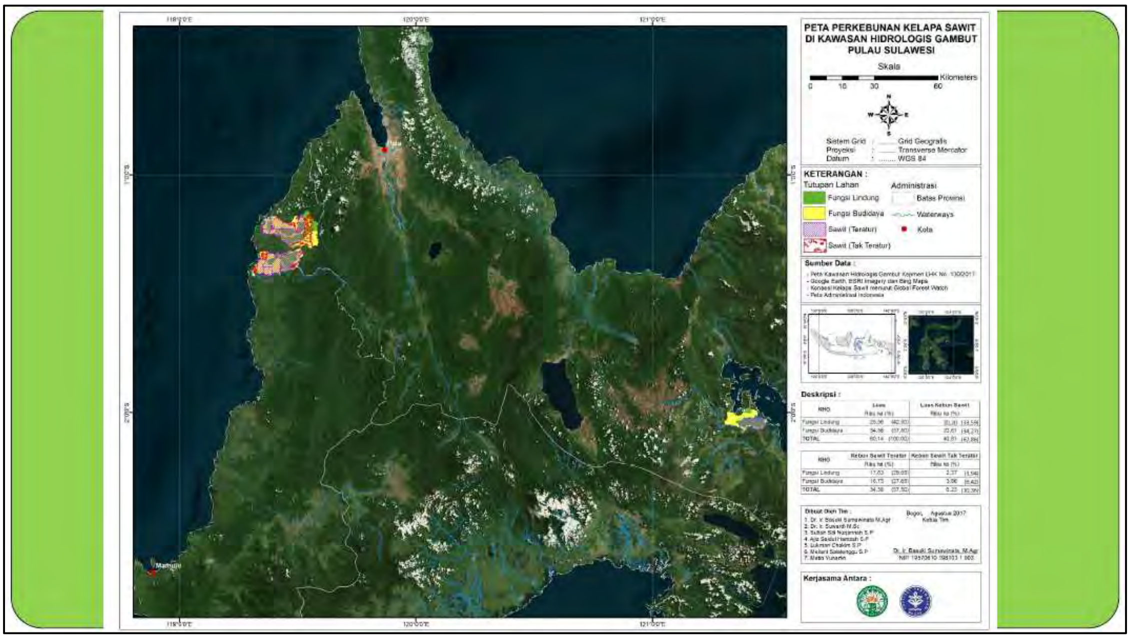
Annex 03



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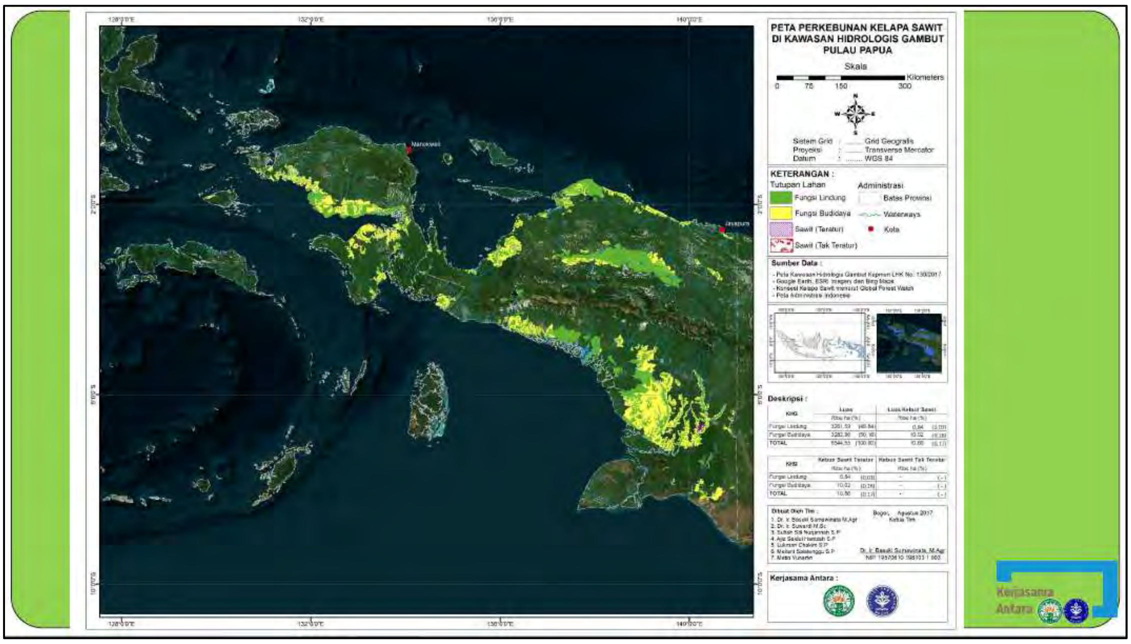

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Annex 03

Tabel 5 Luas perkebunan kelapa sawit pada KHG Seluruh Indonesia

No	Provinsi	KHG		Perkebunan Kelapa Sawit					
				Teratur		Tidak Teratur		Total Sawit	
		----------Ribu ha (%)----------							
1	Sumatera	9 171.47	(37.93)	1 878.79	(8.59)	722.57	(2.80)	2 755.46	(11.40)
2	Kalimantan	8 402.37	(34.75	1 963.82	(8.12)	34.04	(0.14)	1 997.86	(8.26)
3	Sulawesi	60.14	(0.25)	34.58	(0.14	6.23	(0.03	40.81	(0.17)
4	Papua	6 544.55	(27.16)	10.86	(0.04)	-	-	10.86	(0.04)
	TOTAL	24 178.53	(100.00)	4 087.02	(19.90)	717.97	(2.97)	4 821.90	(19.94)

17

Tabel 10 Luas perkebunan kelapa sawit pada fungsi lindung ekosistem gambut di KHG Seluruh Indonesia

No	Provinsi	Fungsi lindung ekosistem gambut		Perkebunan Kelapa Sawit					
				Teratur		Tidak Teratur		Total Sawit	
		----------Ribu ha (%)----------							
1	Sumatera	4 685.23	(38.94)	1 092.86	(9.08)	225.67	(1.88)	1 318.52	(10.96)
2	Kalimantan	4 059.05	(33.74)	771.35	(6.41)	8.95	(0.07)	780.30	(6.49)
3	Sulawesi	25.56	(0.21)	17.83	(0.15)	2.37	(0.02)	20.2	(0.17)
4	Papua	3 261.59	(27.11)	0.84	(0.01)	-	-	0.84	(0.01)
	TOTAL	12 031.43	(100.00)	1 882.87	(15.65)	236.99	(1.97)	2 119.86	(17.62)

Tabel 15 Luas perkebunan kelapa sawit pada fungsi budidaya ekosistem gambut di KHG Seluruh Indonesia

No	Provinsi	Fungsi budidaya ekosistem gambut		Perkebunan Kelapa Sawit					
				Teratur		Tidak Teratur		Total Sawit	
		----------Ribu ha (%)----------							
1	Sumatera	4 486.26	(36.92)	984.90	(8.11)	452,04	(3.72)	1436.9	(11.83)
2	Kalimantan	4 343.33	(35.75)	1192.47	(9.82)	25,08	(0.21)	1217.5	(10.02)
3	Sulawesi	34.58	(0.28)	16.75	(0.13)	3.86	(0.03)	20.61	(0.17)
4	Papua	3 282.96	(27.03)	242.85	(2.00)	-	-	242.85	(2.00)
	TOTAL	12 147.13	(100.00)	2204.15	(18.15)	480,98	(3.96)	2685.13	(22.11)

18

Conclusions

- The area of peat soil in Indonesia is less than 14.9 M ha and the peat soil map should be revised based on the field condition.
- The Peat Hidrological Area (Kawasan Hidrologi Gambut/KHG) difined by Ministry of Environment and Forestry 24.2 M ha is not reflected the peatland area becauce around half of the area is mineral soils.
- Oil palm plantation area at KHG is 4.8 M ha or 19.87% of KHG 24. 2 M ha.
- Oil Palm area at conservation function of peat ecosystem (Fungsi Lindung Ekosistem Gambut/FLEG is 2.1 M ha or 17.62% of FLEG 12.0 M ha.

Kerjasama
Antara

Annex 03

Appendix III

Keynote Speaker : Dr. Hideyuki Kubo (IJ-REDD, Japan)
Title : Action Plan for Minutes of Meetings (MoM) between BRG and JICA on the Elaboration of Peatland Restoration (#10)

Action Plan

for Minutes of Meetings (MoM) between BRG and JICA on the Elaboration of Peatland Restoration

As of 4 September 2017

1

Agenda 1: Satellite based model on ground water level monitoring

Actual Output	Who	Remark
Integrated real-time GWL data from both satellite and field (SESAME)	Sulaiman, Awal, Haris, Hamada	The work will be done by the end of September.
Fire prediction model that is the combination of Rainfall prediction model, GWL model and Canal density map	Sulaiman, Bryan, Kozan, Oide, Yamanaka, Takahashi	1) Develop three month rainfall prediction model 2) Convert data 1) into GWL 3) Overlay with canal density map
SESAME version-up	Sulaiman, Awal, Haris, BRG's university network, Takahashi	Current data are limited to climatic ones. Biological (oxygen content in the soil) and chemical data (EC content) as well as peat subsidence monitoring will be added to the current system. Starting from two SESAME in Riau and Central Kalimantan.
Data management system	Sulaiman, Awal, Takahashi, Hirano	Put data on GWL, Climate and CO2/NEE into BPPT server.

Overall coordination by Osaki / Haris / Kubo

2

Annex 03

Agenda 2: Peatland restoration actions

Actual Output	Who	Remark
Basic information for peat profile, GWL, water/nutrient, vegetation and topography (length 15-20 km with 1 km interval)	Haris, Alue, Soil Research Institute, Matsui, Kozan, Oide	Research design and survey planning by the end of September
Topography map with vegetation and phenology data by using drones and hyper data	Sulaiman, Kozan, Satori	The site is the same as the above
Analysis on local socio-economic, political and institutional situation	Hasegawa	The survey site is the same as the above
Action plan for each zone with the idea of nutrition supply methods	Haris, Alue, Osaki	

Overall coordination by Osaki / Haris / Kubo

3

Agenda 3: Capacity building of Indonesian officials and universities

Actual Output	Who	Remark
Design of the proposed Center for Restoration Information	Bambang, Haris, BRG's university network, Osaki	

Overall coordination by Osaki / Haris / Kubo

4

Agenda 4: Knowledge inputs nationally and internationally

Actual Output	Who	Remark
Roundtable is held and Advisory Committee is established	Osaki, Haris	
Event is held at COP23	Kubo, Osaki, Haris	

Overall coordination by Osaki / Haris / Kubo

Annex 03

Appendix IV

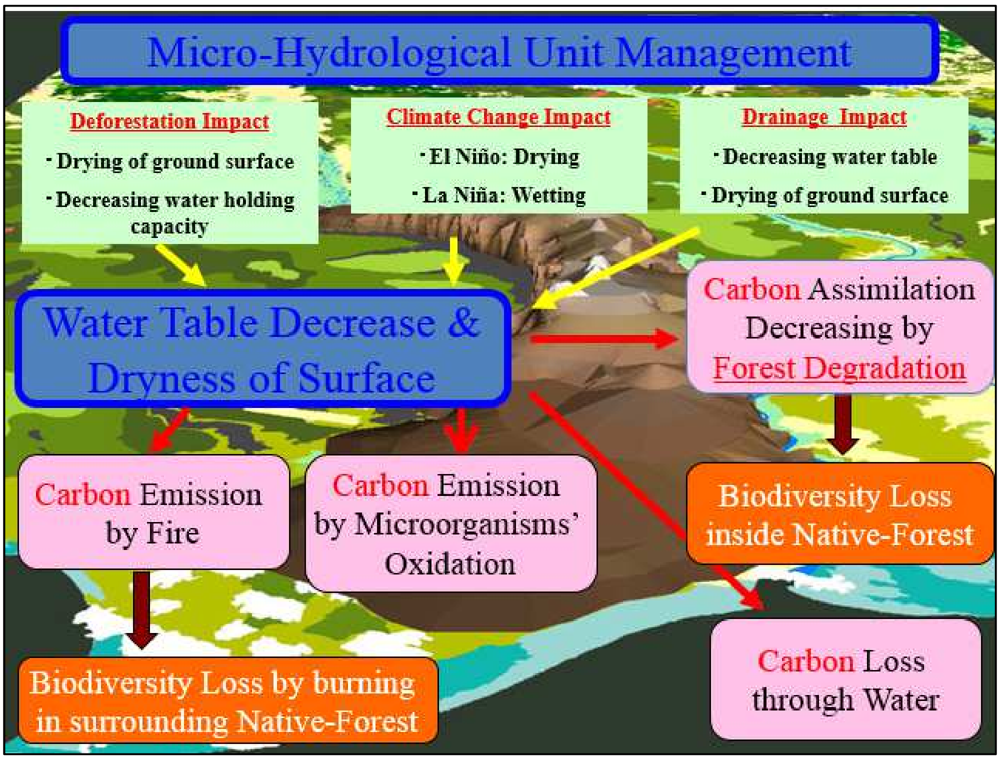
Keynote Speaker : Dr. Mitsuru Osaki (Hokkaido University, Japan)
Title : Gold Carbon Mechanism (#11)

1

Annex 03

Agenda 1: Integrated MRV System

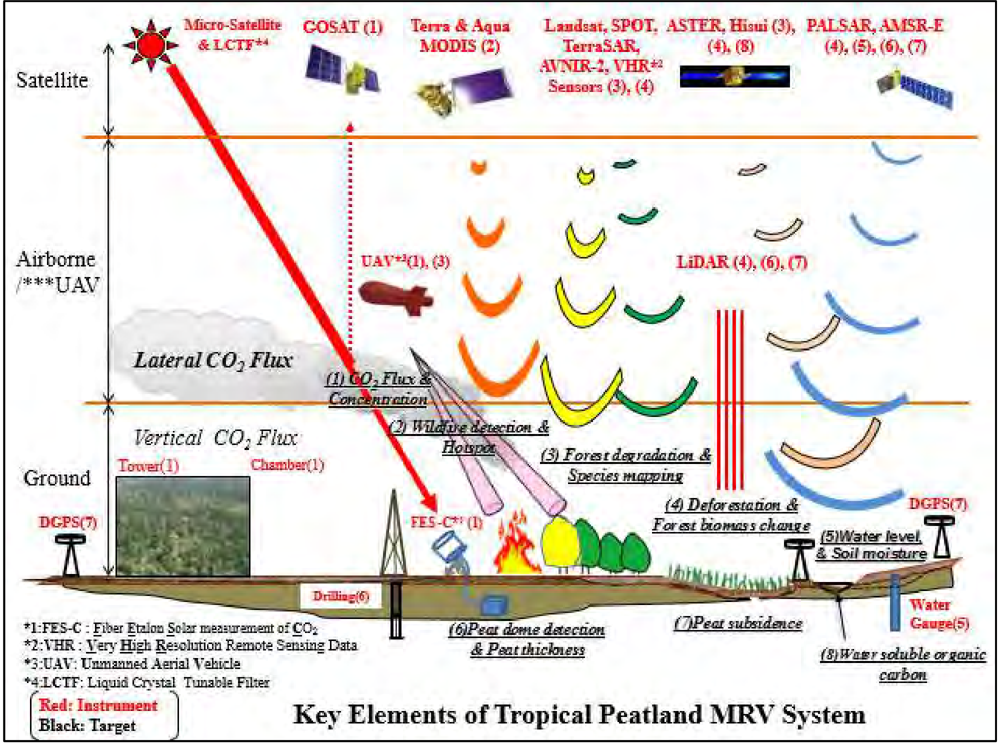
2



3

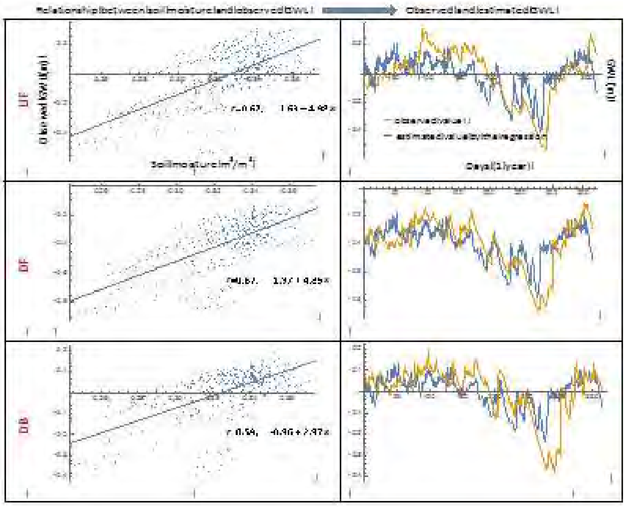
Agenda 1: Integrated MRV System

(1) Real time mapping on groundwater table

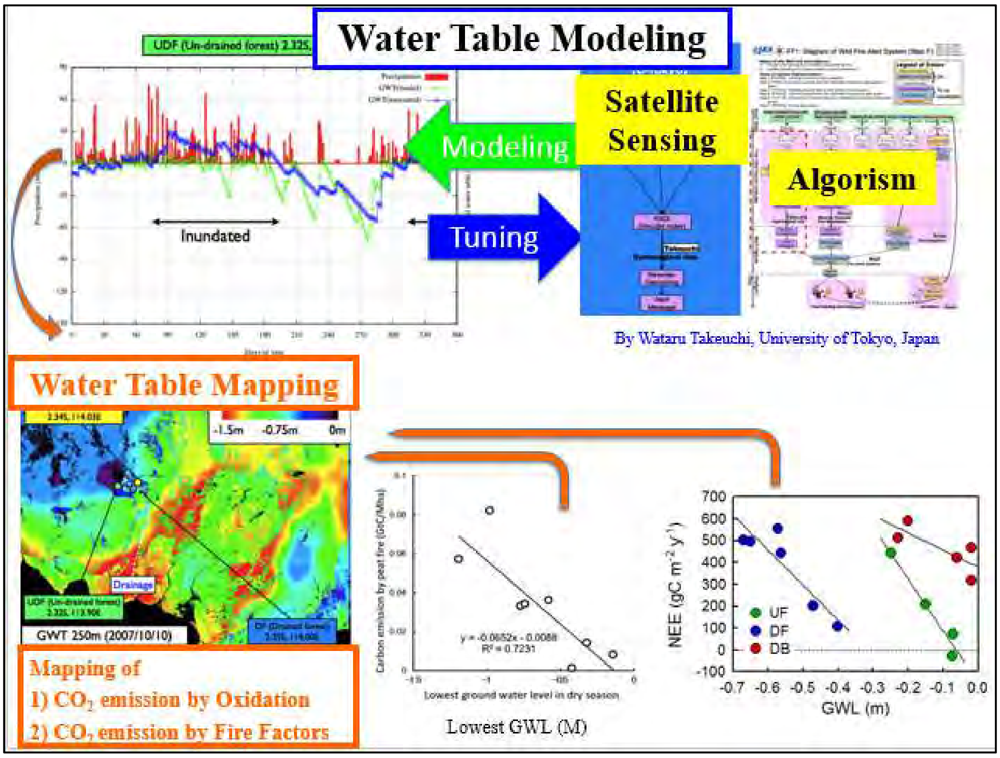


Key Elements of Tropical Peatland MRV System

Annex 03

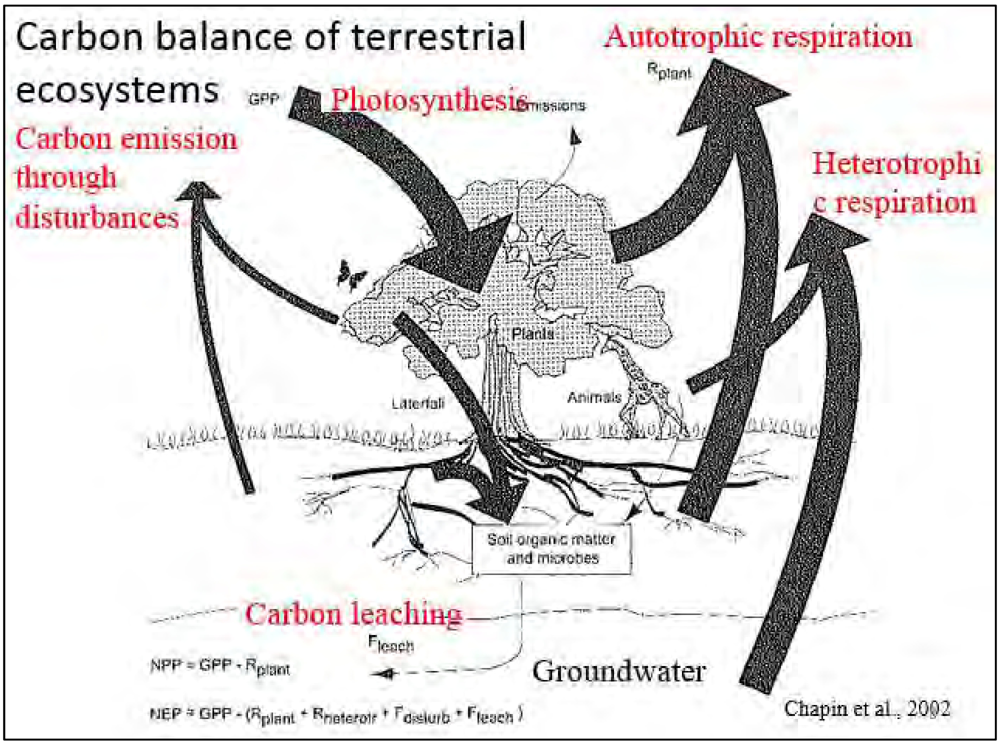

UF
DF
DB
observed value
estimated value by the regression

6

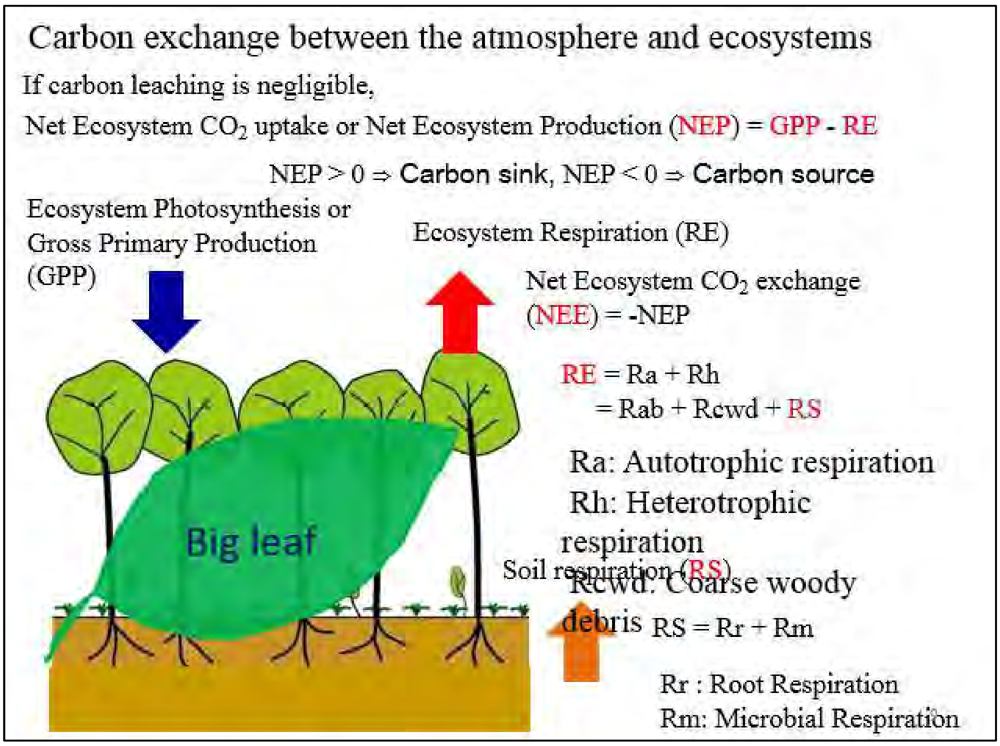

Water Table Modeling
UDF (Un-drained forest) 2.325,
Inundated
Modeling
Tuning
Satellite Sensing
Algorism
By Wataru Takeuchi, University of Tokyo, Japan
Water Table Mapping
-1.5m -0.75m 0m
Drainage
GWT 250m (2007/10/10)
Mapping of
1) CO_2 emission by Oxidation
2) CO_2 emission by Fire Factors
y = -0.0652x - 0.0088
R² = 0.7231
Lowest ground water level in dry season
Lowest GWL (M)
NEE (gC m⁻² y⁻¹)
UF
DF
DB
GWL (m)

7

Annex 03


Carbon balance of terrestrial ecosystems
Autotrophic respiration
R plant
GPP
Photosynthesis
Emissions
Carbon emission through disturbances
Heterotrophic respiration
Plants
Litterfall
Animals
Soil organic matter and microbes
Carbon leaching
F leach
NPP = GPP - R plant
Groundwater
NEP = GPP - (R plant + R heterotr + F disturb + F leach)
Chapin et al., 2002

8


Carbon exchange between the atmosphere and ecosystems
If carbon leaching is negligible,
Net Ecosystem CO2 uptake or Net Ecosystem Production (NEP) = GPP - RE
NEP > 0 ⇒ Carbon sink, NEP < 0 ⇒ Carbon source
Ecosystem Photosynthesis or Gross Primary Production (GPP)
Ecosystem Respiration (RE)
Net Ecosystem CO2 exchange (NEE) = -NEP
RE = Ra + Rh
= Rab + Rcwd + RS
Ra: Autotrophic respiration
Rh: Heterotrophic respiration
Rcwd: Coarse woody debris
Big leaf
Soil respiration (RS)
RS = Rr + Rm
Rr : Root Respiration
Rm: Microbial Respiration

9

Annual CO_2 fluxes of PSF in C Kalimantan (Undrained site)

(Mean ± SD, $gC\ m^{-2}\ yr^{-1}$)

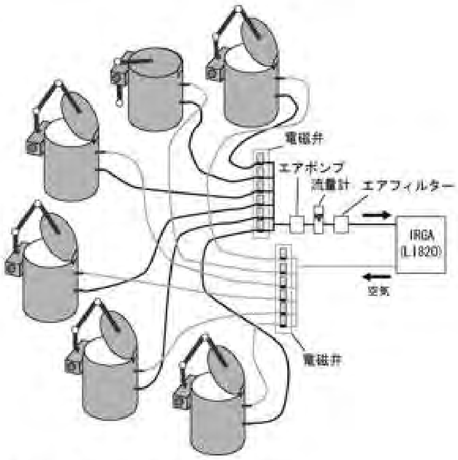
NEE[1)]	GPP[1)]	RE[1)]	RS[2)]	Rh[3)]
174±203	3468±118	3642±115	1347	722

1) Measured by the eddy covariance technique for 4 years from 2004 to 2008 (Hirano et al., 2012)

2) Measured using an automated chamber system in 2005 (Sundari et al., 2012).

3) Measured manually in trenched plots by the chamber method in 2014 and 2015 (Itoh et al., 2017). This is equivalent to peat decomposition.

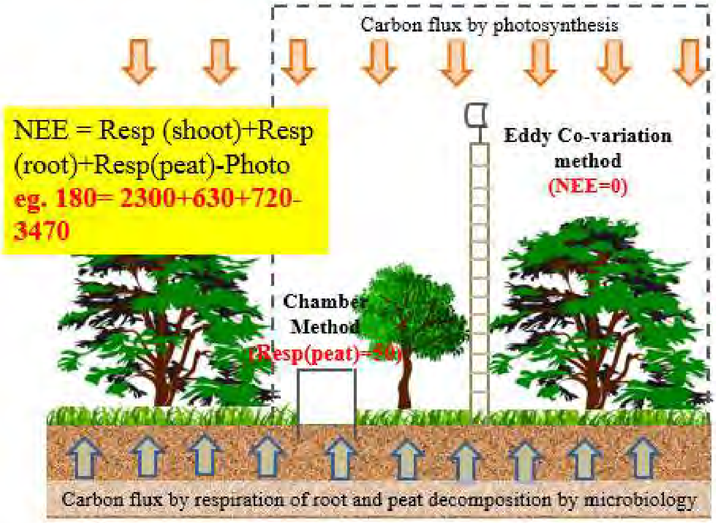
Continuous measurement of soil CO_2 efflux (total soil respiration) using automated chamber systems in Central Kalimantan



UF: Undrained forest
DF: Drained forest

Annex 03

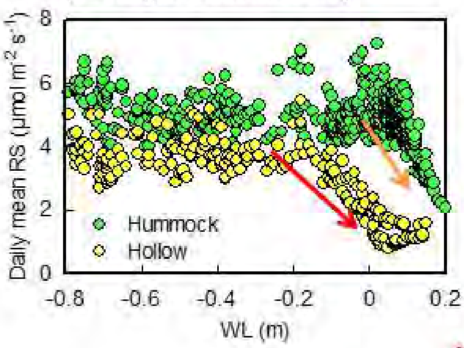
Difference of carbon flux components by the eddy co-variation method and the chamber method



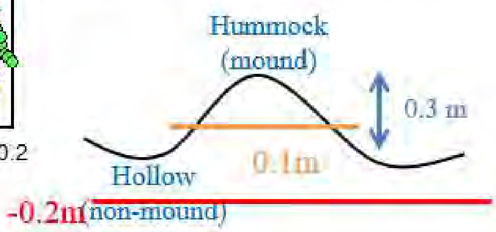
12

Daily mean soil CO_2 efflux vs. groundwater level (WL)

at UF (undrained forest) site
(Sebangau National Park)



Microtopography on the forest floor



Hirano et al., 2009

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Annex 03

Agenda 1: Integrated MRV System

(2) Fire Prediction Model

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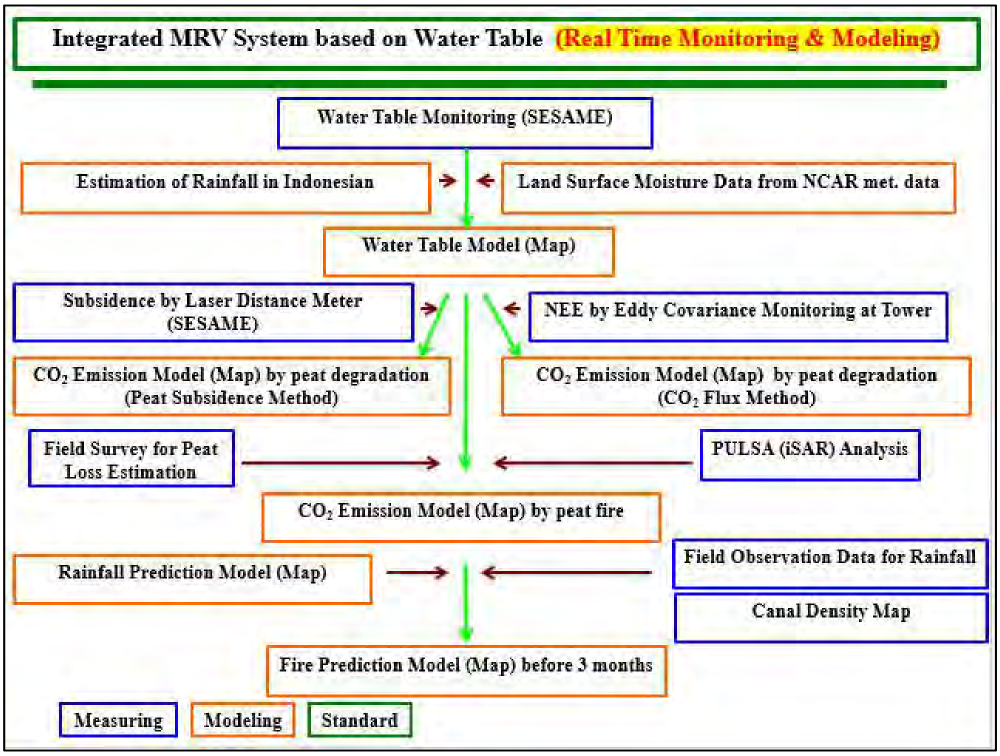

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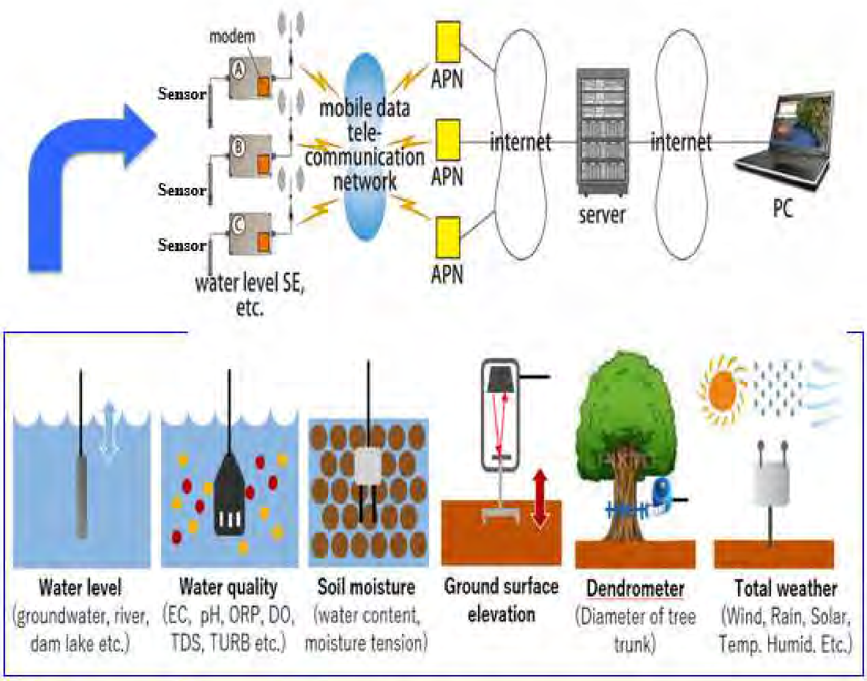
Agenda 1: Integrated MRV System

(3) Version-up of SESAME



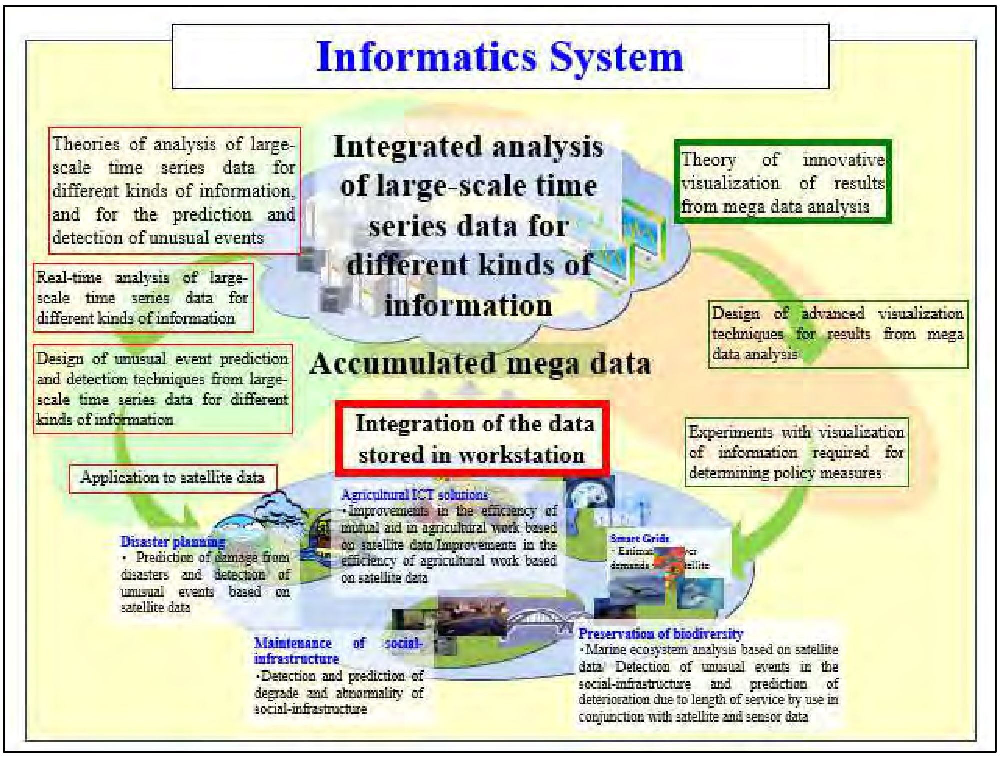
Chemical Sensor: EC, pH

Biological Sensor: ORC

Annex 03

Agenda 1: Integrated MRV System

(4) Data Management



Agenda 2. Peatland Restoration Design

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Agenda 2. Peatland Restoration Design

(1) Targeting area

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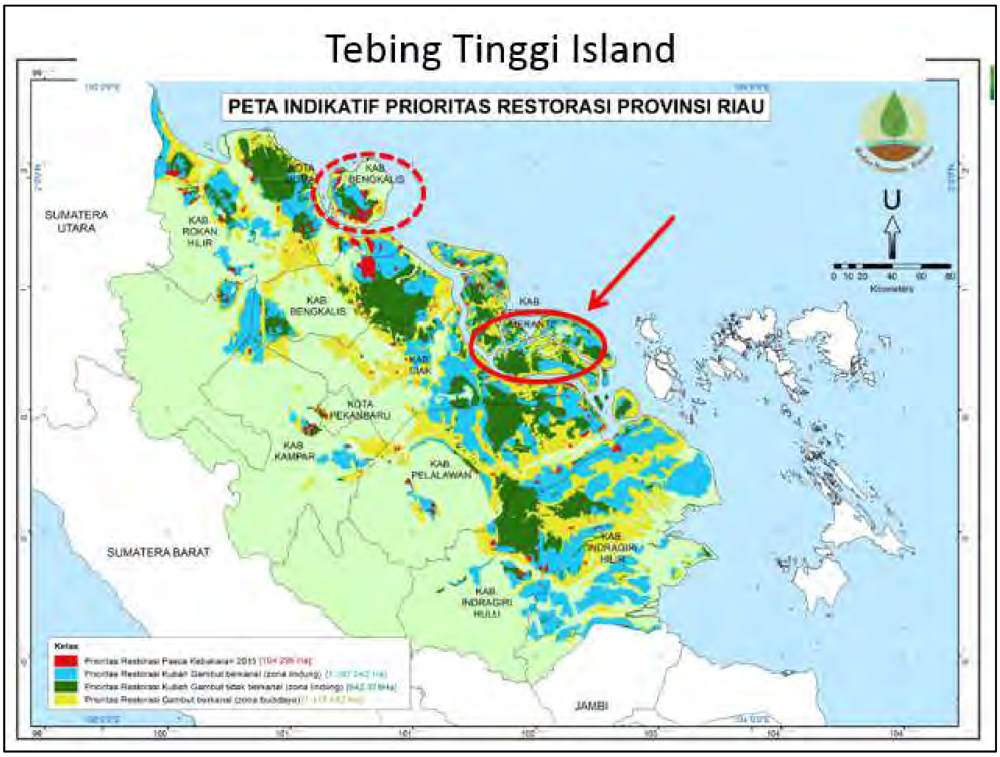

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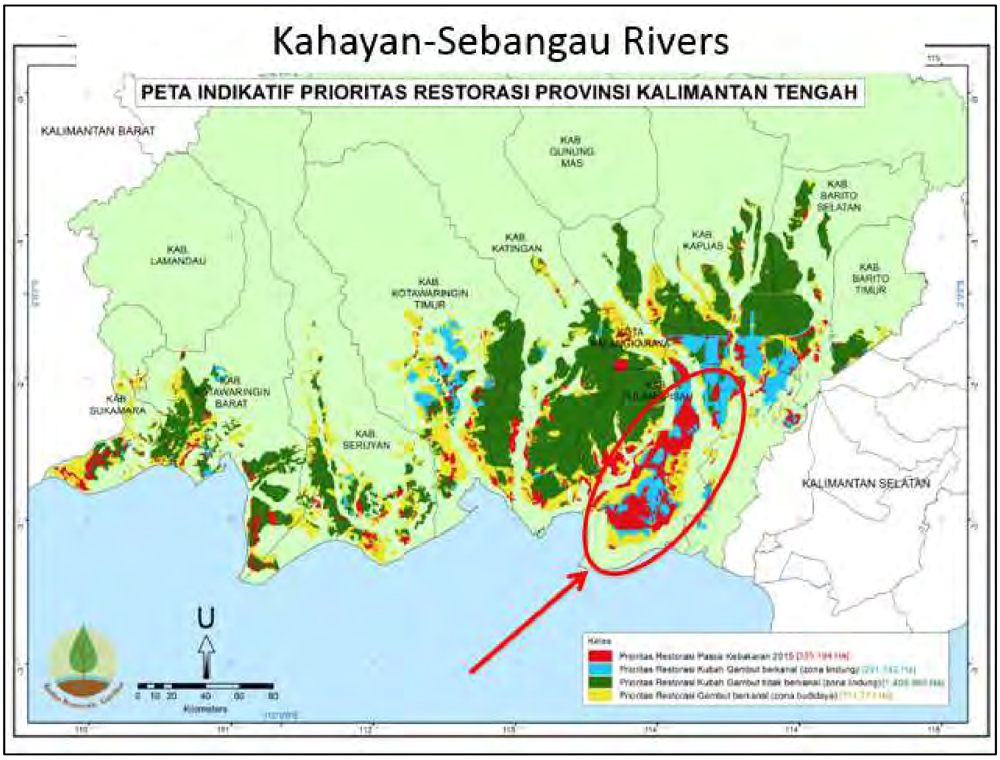

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Agenda 2. Peatland Restoration Design

(2) Zoning

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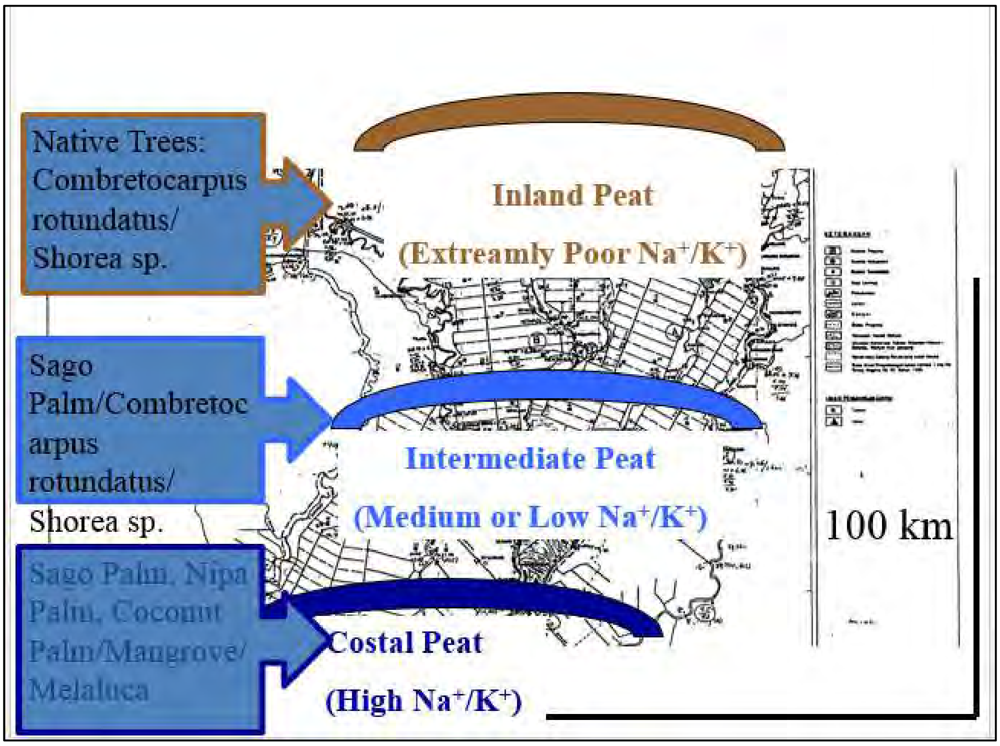

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Annex 03

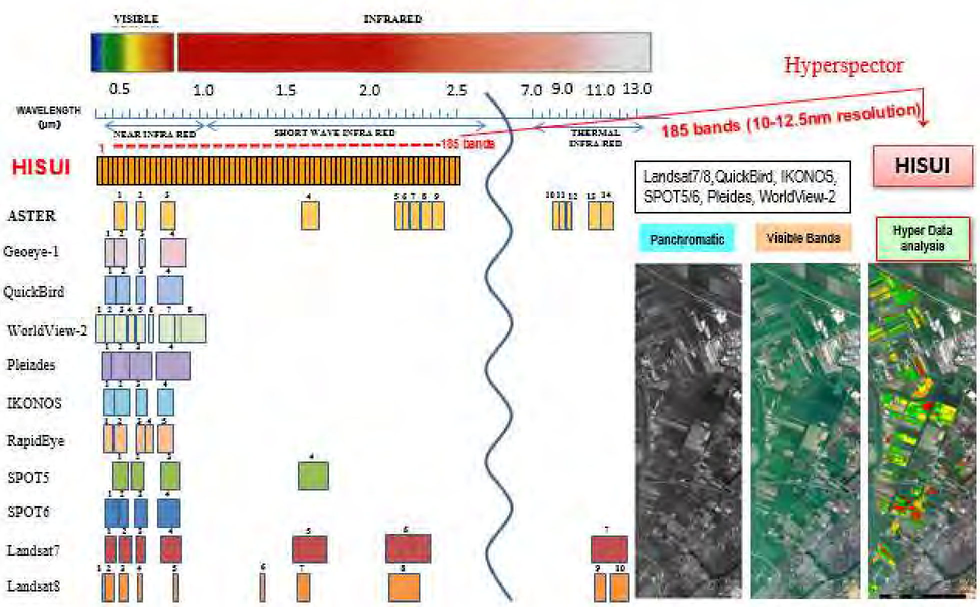
Peatland Profiling by Line Survay

<u>Peatland Monitoring</u>
Peat depth
Peat quality
Peat water

<u>Peatland Sensing</u>
Vegetation
Phenology
Topography

26

Hyperspector sensor



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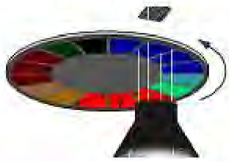
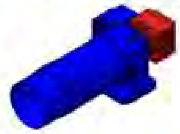
Principal of Hyperspectro Sensor

Prism Type Spectroscope



VS

LCTF Type Spectroscope



Various spectrum (wave length) obtaining from one beam (dot)

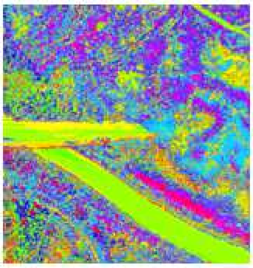
→ **Line (dot) sensing**

One spectrum (wave length) covering large area

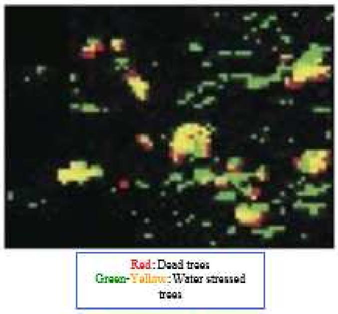
→ **Area sensing**, but weak relationship among spectrum

→ **New Mode Hyperspectro Sensing**

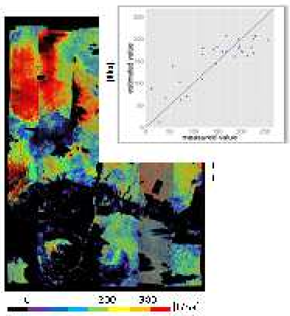
28



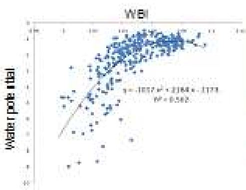
Biodiversity Mapping (one tree mapping) (Y. Takahashi et al) (1)



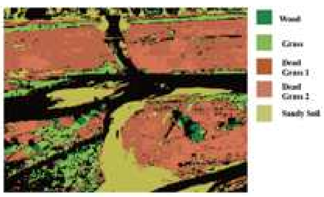
Forest Degradation Mapping (JSS & JAXA) (1)



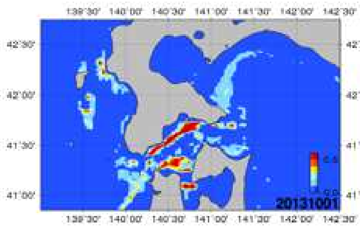
Biomass Mapping (JSS & JAXA) (1)



Leaf Water Potential Mapping (JSS & JAXA) (2)



Land Cover and Land Cover Changing (Shin Satori) (3)



Fishery (4)

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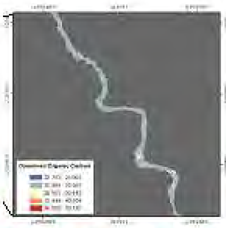
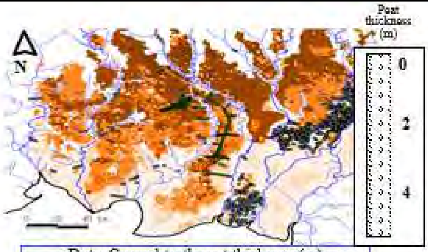
Annex 03

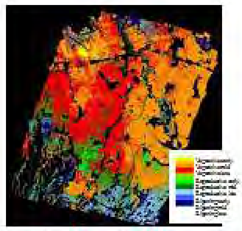


Dissolved Organic Carbon (DOC) Mapping (JSS & JAXA) (5)

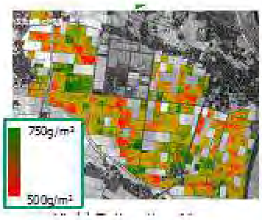


Dots: Ground-truth peat thickness (m)

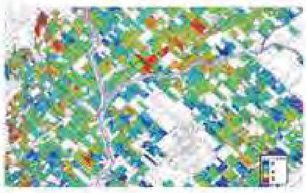
Peat Depth Mapping applied by Plant Phenology (Sawahiko Shimada) (6)



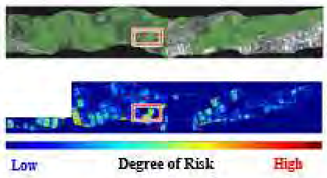
Rice Growth Stage Mapping (JSS & JAXA) (7)



Crop Yield Mapping (JSS & JAXA) (8)



Leaf Protein Content of Rice at Flowering Stage (Shin Satori from Fujitsu Hokkaido systems) (9)

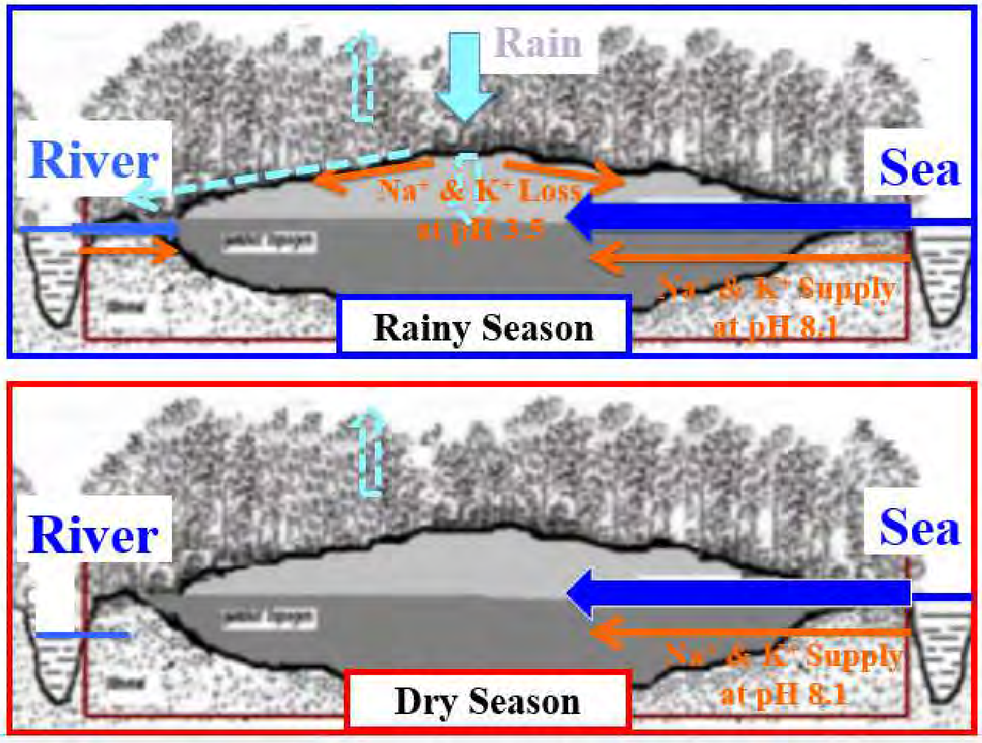


Disease Mapping (Early detection of rice blast) (JSS & JAXA) (10)

Agenda 2. Peatland Restoration Design

(3) Nutrients Supplying Model

Annex 03



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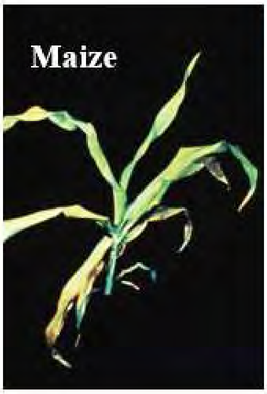
Typical K⁺ Deficiency Symptom

33

Long term experimental plot (from 1914)

Mg deficiency



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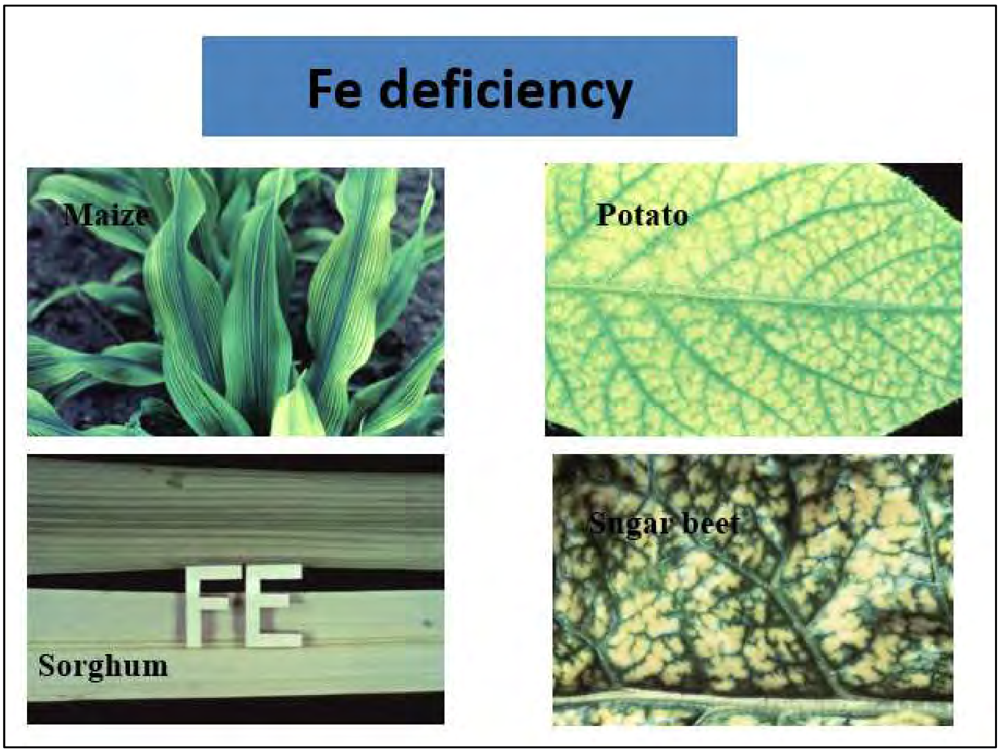

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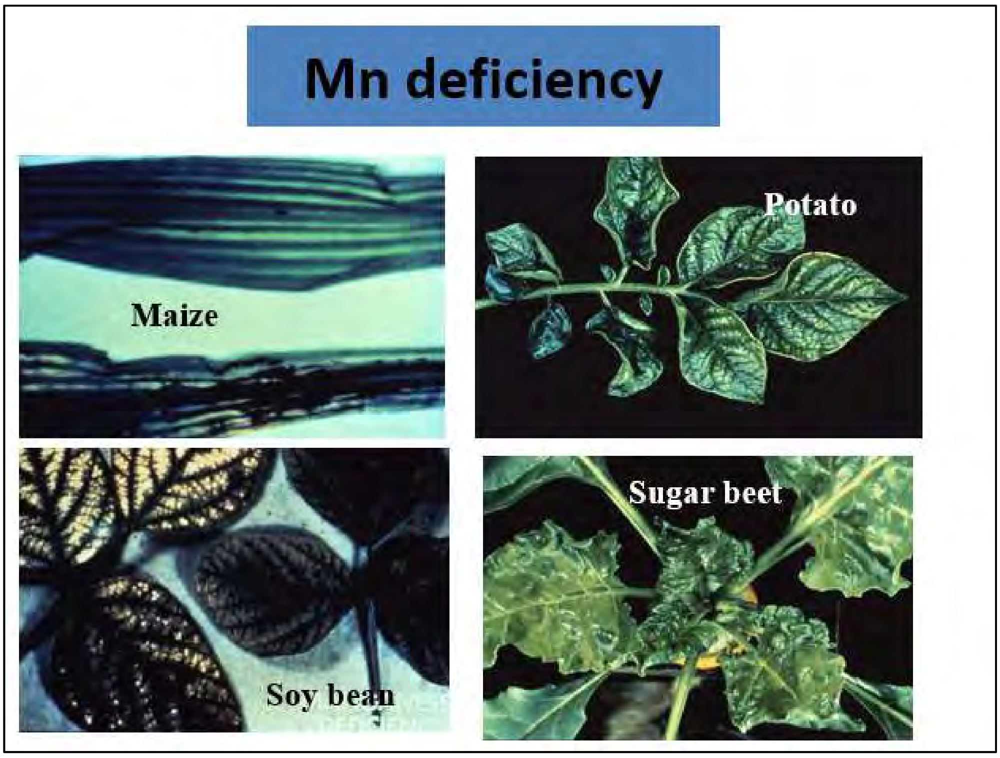

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Zn deficiency

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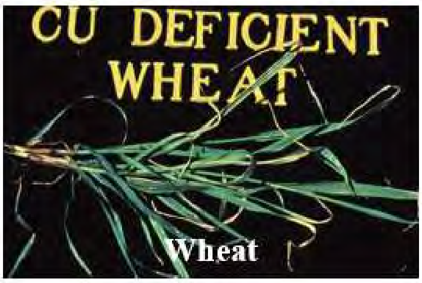
Cu deficiency



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Oil Palm grown at 50~70 cm water table @PT Meskom Agro Sarimas, RIAU PROVINCE
30 August 2017

1) From 2002
2) Land area: Inti (HGU) seluas 3.705 Ha + Plasma seluas 3.889 Ha.
3) Productivity (FBB): 17t /ha/year
4) Peat depth: ?
5) Water table: 50-70 cm
6) Tidal effect: small (6.5 km)
7) Fertilizer: FBB ash (7 kg/year/stand) & compound fertilizer (N:P:K=7:6:36)(6 kg/year/stand)
8) Weeds: high competition with weeds

Recommendation
1) Water table management: more than 40 cm water table
2) Fertilizer application: K^+/Na^+
3) Land surface management: Weed control

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Small Root Zone

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High root matt of weeds

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Poor root growth (poor root matt)

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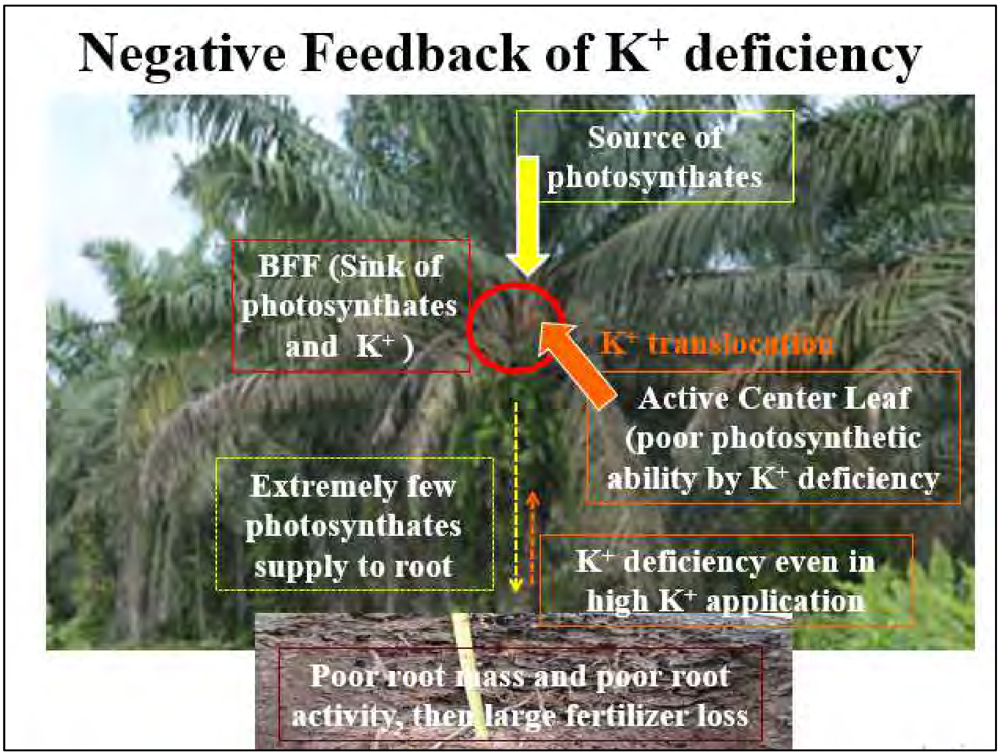

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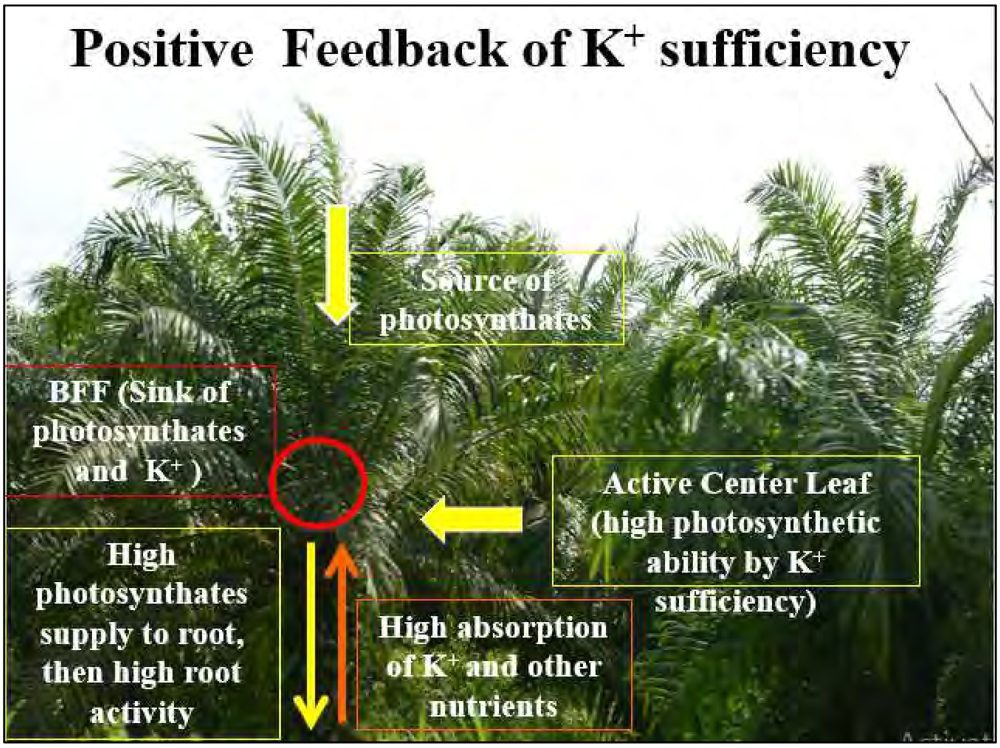

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Activate root function related with photosynthates distribution

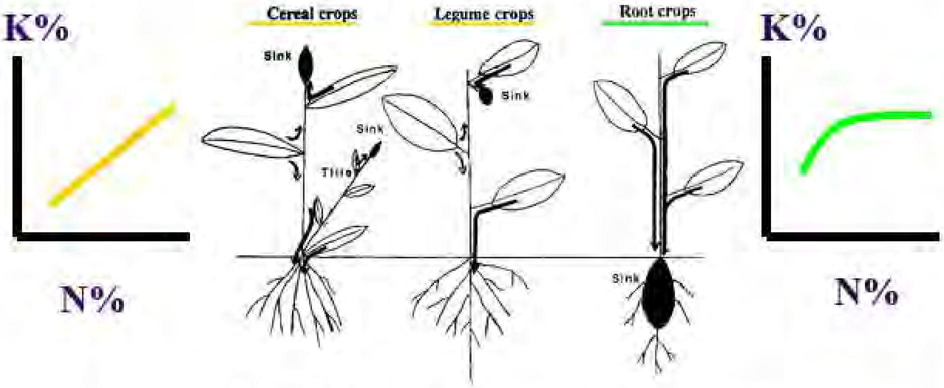

Fig. 5. Scheme of photosynthates distribution into roots. Scheme is described according to the results of Tanaka (1961) for rice, Tanaka and Fujita (1979) for field bean, Osaki et al. (1991a) for potato, and unpublished data.

K^+ of oil palm is key to maintain high root activity by photosynthates translocation like a root crops because of no lower position leaf in oil palm

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Recommendation

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Fire Blocking by Plants

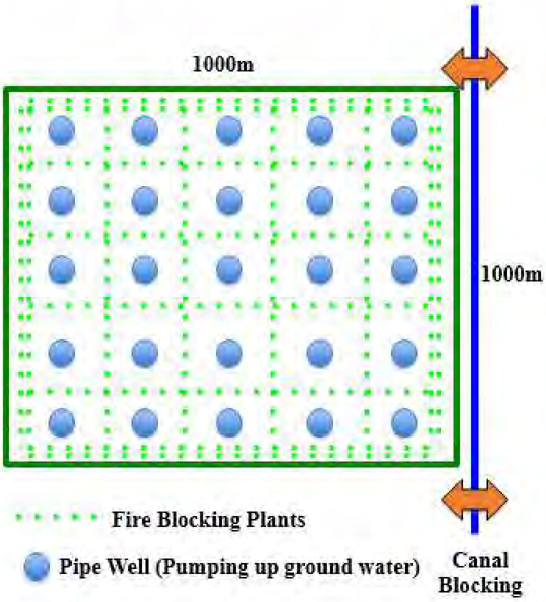
Fire Blocking Plants by rooting system & making Biochar
- *Combretcarpus rotundatus* (*Tumi* or *Perepat* in local)
- Bamboo
- Melastoma for N_2 fixing

↓

- Biochar (C. *rotundatus* & Bamboo) with K^+
- Natural compost by weeds
- Cover crop/pasture

↓

- Economic Plants: Sago, Coffee, Cacao, Fruits, etc.
- Animal Husbandry: Cow, Goat, Sheep



Agenda 2. Peatland Restoration Design

(4) Economic Implementation

Annex 03

Relationship between Nutrients and Chemical Components

Cellulose	Fern and Grass	High nutrients cycling, low-nutrients tolerance
Lignin	Tree	medium nutrients requirement, slow growth rate
Starch (net-type)	Sago	high requirement of K for sucrose translocation, N from N_2 fixing, low P requirement
Lipid	Oil Palm	high requirement of K for fatty acids translocation and high requirement of N for high photosynthesis
Starch (bowl-type)	Rice	extremely high requirement of N, P and K [no choice in peatland, only for mineral soil]

K^+ leach easily from peat, because peat has low CEC (poor absorption and adsorption) and K^+ do not compose into chemical compounds

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Sago based- Peatland Restoration
@
SEI TOHOR VILLAGE, MERANTI DISTRICT, RIAU PROVINCE

Ideal Sago Production

1) Semi-natural Conditions
*High Water Table
*Mixed Forest
*Production of 100 sago stand/ha/year

2) High Starch Production
300kg starch/ sago stand, then 30ton starch /ha/year (more than 10 time of rice)

3) High Biomass Productivity
1 ton biomass/ sago stand, then 100 ton biomass/ ha/year

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Sago based- Peatland Restoration
@
SEI TOHOR VILLAGE, MERANTI DISTRICT, RIAU PROVINCE

Sago Characteristics

1) Submerge Tolerance
2) N_2 Fixing
3) Low P
4) Na Tolerance (saline tolerance)
5) Acid Soil Tolerance
6) Perennial Crop

7) K^+ Nutrient Required, but <u>very K^+ poor</u> in pure peatland except of riverside and tidal effect area

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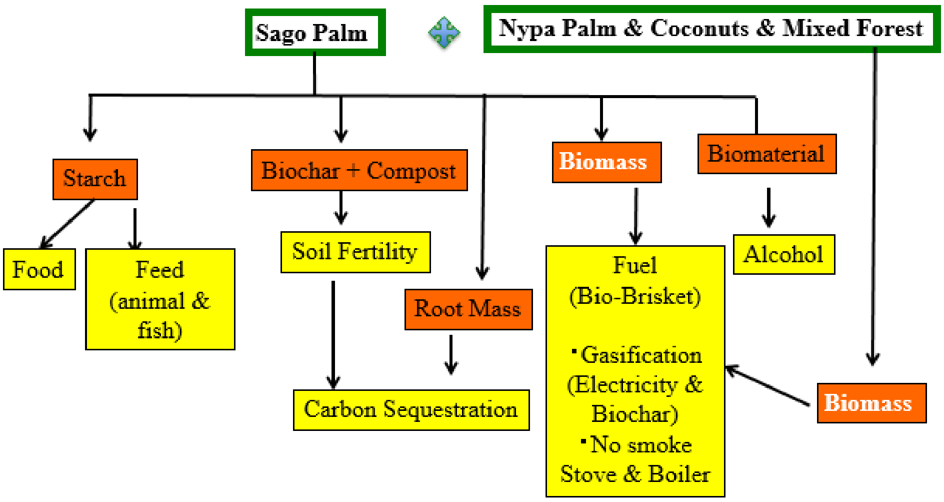
Whole Usage of Biomass in "Sago based Ecosystem"



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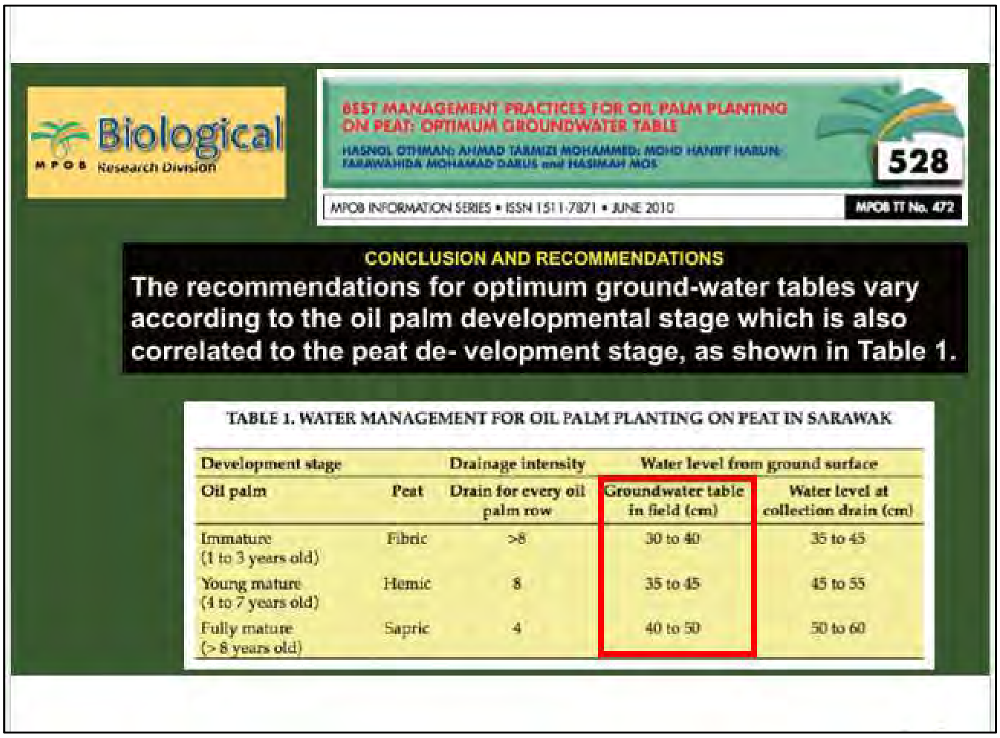

CONCLUSION AND RECOMMENDATIONS

The recommendations for optimum ground-water tables vary according to the oil palm developmental stage which is also correlated to the peat de- velopment stage, as shown in Table 1.

TABLE 1. WATER MANAGEMENT FOR OIL PALM PLANTING ON PEAT IN SARAWAK

Development stage		Drainage intensity	Water level from ground surface	
Oil palm	Peat	Drain for every oil palm row	Groundwater table in field (cm)	Water level at collection drain (cm)
Immature (1 to 3 years old)	Fibric	>8	30 to 40	35 to 45
Young mature (4 to 7 years old)	Hemic	8	35 to 45	45 to 55
Fully mature (> 8 years old)	Sapric	4	40 to 50	50 to 60

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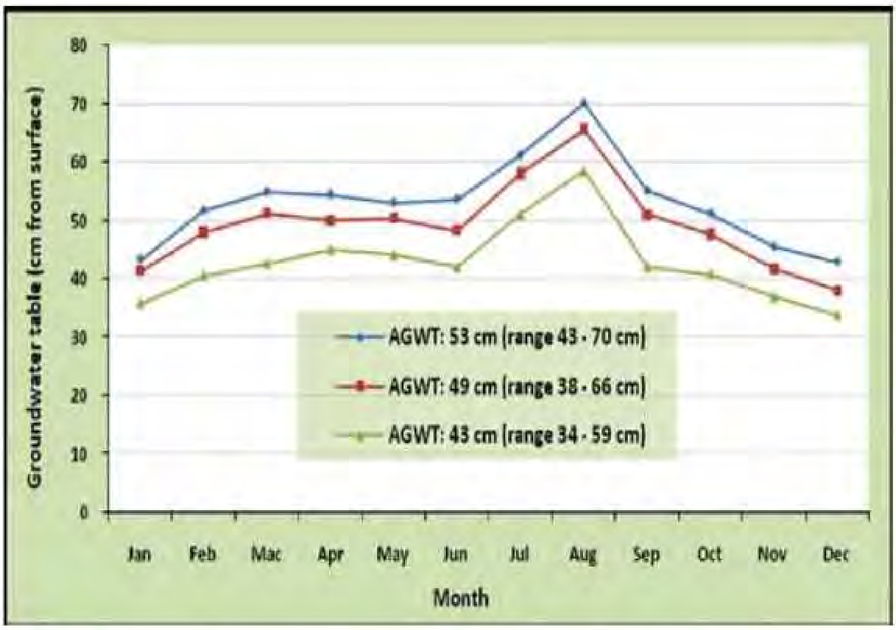

Figure 1. Monthly mean groundwater table in three different blocks planted with oil palm (AGWT: average groundwater table).

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Annex 03

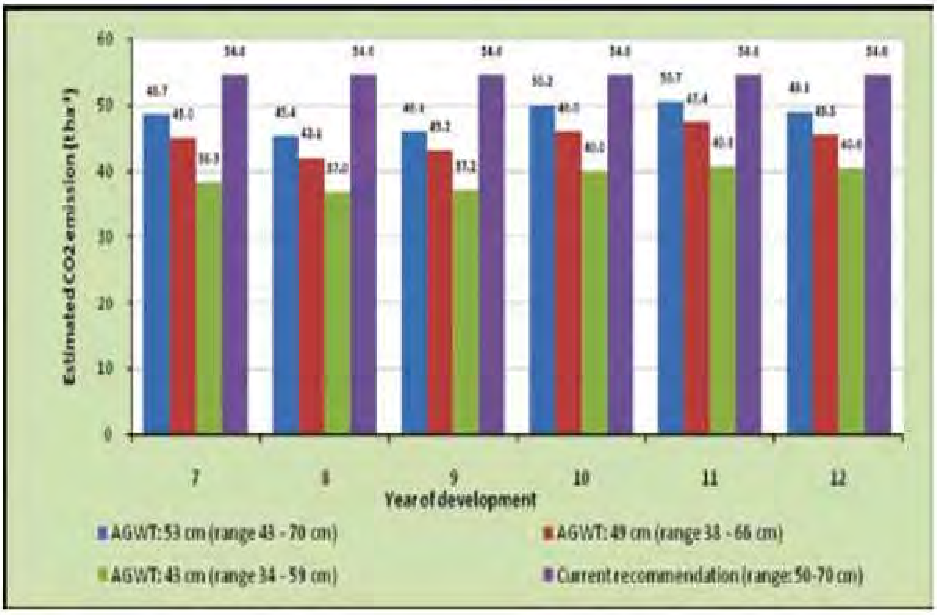


Figure 7. Estimated CO_2 emission at different groundwater tables after 7 to 12 years of peat development.

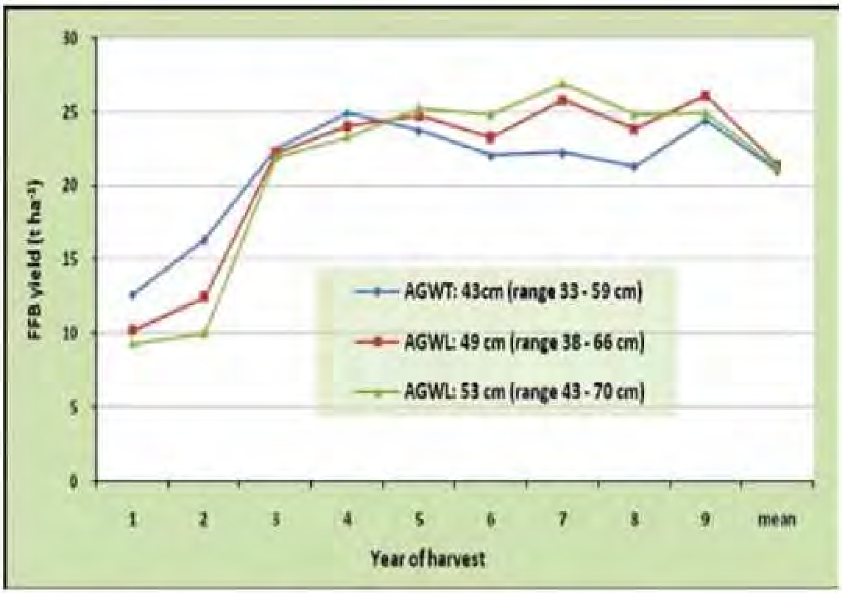


Figure 8. Fresh fruit bunches (FFB) yield profile of three blocks with different groundwater tables.

Oil Palm grown in High Water Table

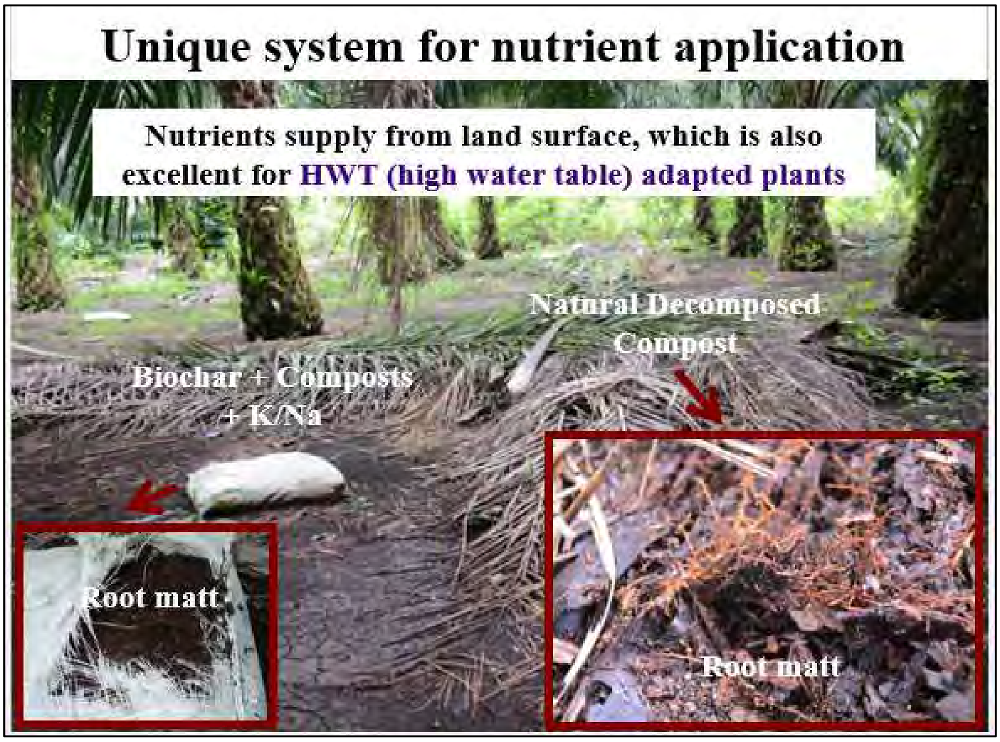
Oil Palm grown high water table @Mega Timur Village, Sungai Ambawang Distric, Kubu Raya Regency, Pontianak

1) 8 years palm for 14 ha by Mr. Suparjo (farmer)
2) High productivity: 40 ton/ha/year (very high productivity)
3) Sallow peat (1~2 m depth)
4) High water table (10~20 cm from surface)
4) Final stage of peat
5) Tidal effect
6) Soil surface management by organic matters

Research Topics

1) Root matte distributed at only surface (shallow peat, organic matter application), which is main reason of high water table tolerance
2) Tidal effect (keeping wet, supplying O_2, nutrients supply (K/Na or micro nutrients)

Annex 03



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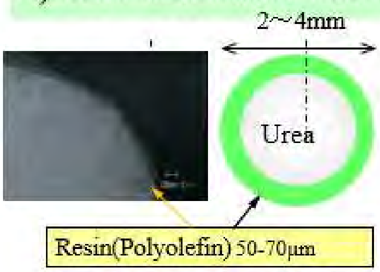
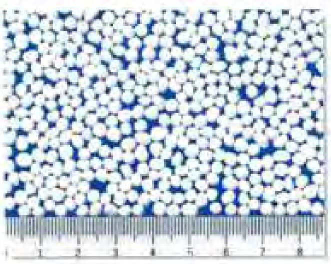
1) Biochar (or Coal), Composts (Weeds), Rock Phosphates

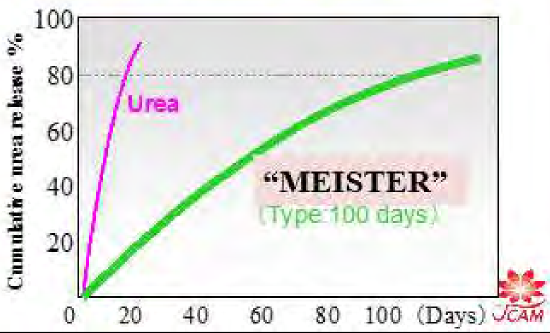
2) Microorganisms: N_2 fixing bacteria, VAM (Mycorrhiza)

3) Slow release K^+ nutrients by the coated fertilizer



- Total N Contents: 41-42%(Urea:46%)
- Particle Size: 2-4mm(5-8 Mesh)
- Water Absorption: No
- Hardness: 2-3kg/particle
- Various urea-releasing patterns





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Energy Profit Ratio (EPR) =Derived Energy/Invested Energy

Rabbit Limit:
An Indian cannot survive even if he can catch many rabbits, when energy derived from the caught rabbits is smaller than energy required to catch the rabbits.

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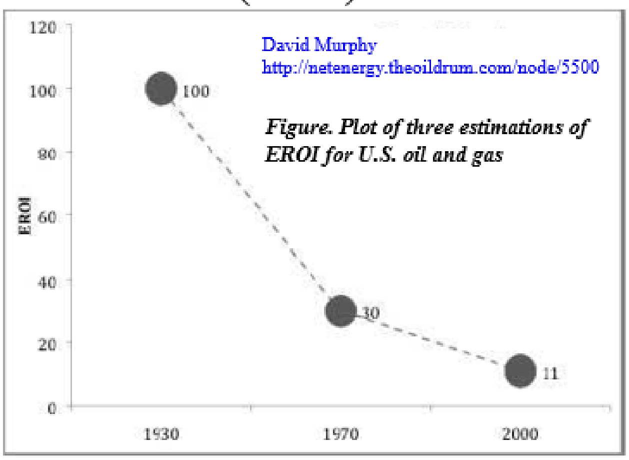
Energy Return on (Energy) Investment (EROI)



The Net Hubbert Curve: What Does It Mean?
Posted by David Murphy on June 22, 2009 - 10:30am in The Oil Drum: Net Energy

Cutler Cleveland of Boston University has reported that the EROI of oil and gas extraction in the U.S. has decreased from 100:1 in the 1930's to 30:1 in the 1970's to roughly 11:1 as of 2000 (Figure 1). But beyond the fact that society receives currently around 11 barrels of oil for every 1 barrel that it spends getting that oil. **What does this mean?**

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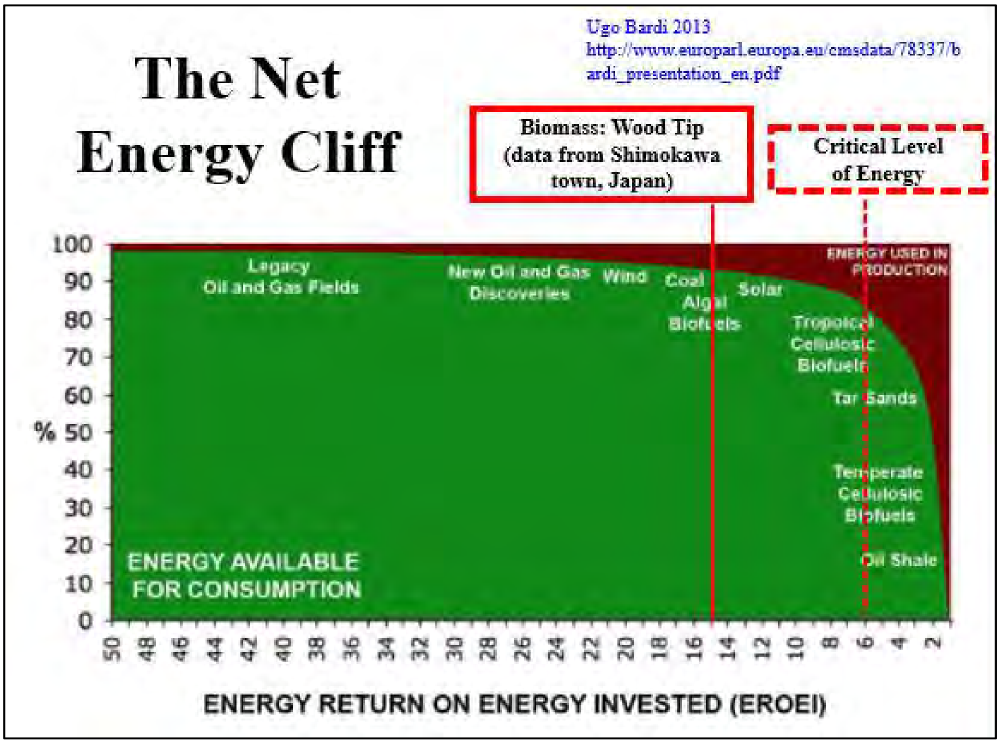

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Table. Energy Profit Ratio (EPR) of Various Energy Sources

Generation type	EPR	Location	Reference
Coal thermal power generation	6.6	Japan	Amano, 2008
Oil thermal power generation	7.9	Japan	Amano, 2008
LNG thermal power generation	2.1	Japan	Amano, 2008
Atomic power generation	6.7-16.9	Japan	Amano, 2008
Small/ medium size hydro power generation	15.3	Japan	Amano, 2008
Geo thermal power generation	6.8	Japan	Amano, 2008
Solar power generation	5.2	Japan	Amano, 2008
Wind-mill power generation	3.9-11	Japan	Amano, 2008
Wood energy for Boiler or CHP* power generation	20.5	Finland	NEDO oversea report, 2006 No.983
Wood energy for Boiler or CHP* power generation	15.5	Sweden	NEDO oversea report, 2006 No.983
Wood energy for Boiler or CHP* power generation	4.5	Date, Japan	Tsuji,2009
Wood energy for Boiler or CHP* power generation	10	Akagi, Japan	Tsuchiya & Karasawa, 2009
Wood energy for Boiler or CHP* power generation	5.8	Ashoro, Japan	Tsuji,2009
Refused-Derived Fuel (RDF) for Boiler or CHP* power generation	10	Furano, Japan	Tsuji,2009

*CHP: combined heat & power

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Agenda 3. Capacity Building

(1) Peatland Restoration Center

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Kalimantan University Consortium

Education, Capacity Building, and Networking

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Sumatra University Consortium

Education, Capacity Building, and Networking

Riau University (UNRI)
Jambi University (UNJA)
Lampung University (UNILA)
Sriwijaya University (UNSRI)

Agenda 4. Knowledge input nationally and internationally

Annex 03

SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD

Goal 1. End poverty in all its forms everywhere
Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
Goal 3. Ensure healthy lives and promote well-being for all at all ages
Goal 4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
Goal 5. Achieve gender equality and empower all women and girls
Goal 6. Ensure availability and sustainable management of water and sanitation for all
Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10. Reduce inequality within and among countries
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12. Ensure sustainable consumption and production pattern
Goal 13. Take urgent action to combat climate change and its impacts*
*Acknowledging that the UNFCCC is the primary international, intergovernmental forum for negotiating the global response to climate change.
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

United Nations Department of Economic and Social Affairs, Division for Sustainable Development, "Outcome Document - Open Working Group on Sustainable Development Goals" URL:http://sustainabledevelopment.un.org/focussdgs.html

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ABCDEFGs Securities in Peatlands to Global Crisis

-Aquatic /water security: Water Reservoir Ecosystem
-Biodiversity security: High biodiversity by mix-planting and nature-conservation around peat dome
-Climate Change security: Mitigation as Carbon Emission Reduction & Adaptation as High Biomass Production (enough water) against El Niño
-Disaster security: Fire & Haze Protection
-Energy security: Biomass energy from sago starch and residuals, and other biomass materials in Sago based Ecosystem
-Food/Feed security: Sago starch for food and feed (animal husbandry and fish culture)
-Global Partnership as global security: International safety networks on Peatland/Wetland
-social security: REDD+, PES, CSR&CSV, and ESG&SRI

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The green bond program of the World Bank (International Bank for Reconstruction and Development, rated Aaa/AAA) supports the transition to low-carbon and climate resilient development and growth in client countries. This includes both mitigation of and adaptation to climate change—all while observing the World Bank's safeguard policies for environmental and social issues.

Green Bond:
10,000,000,000 (10B)
US dollars

http://treasury.worldbank.org/cmd/pdf/ImplementationGuidelines.pdf

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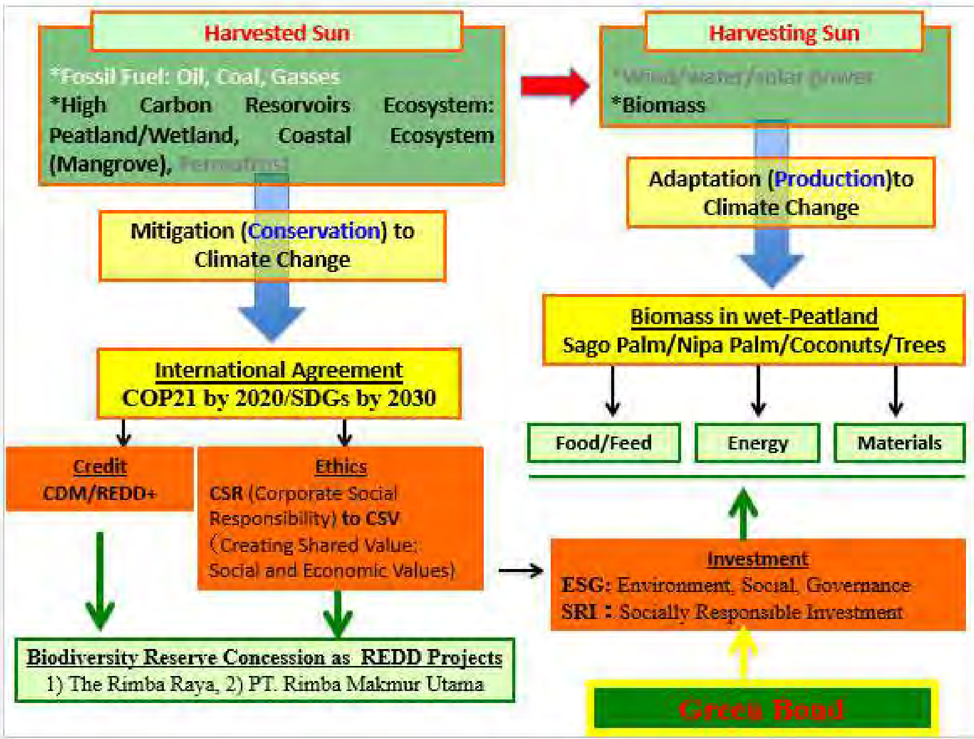

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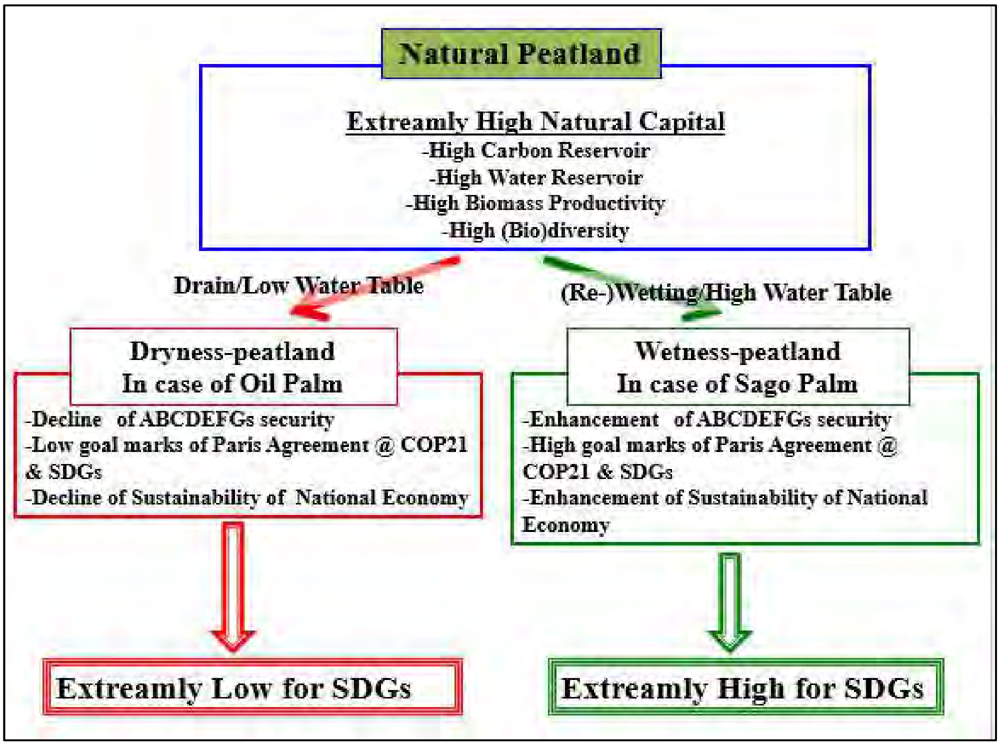


Natural Peatland
Extreamly High Natural Capital
-High Carbon Reservoir
-High Water Reservoir
-High Biomass Productivity
-High (Bio)diversity
Drain/Low Water Table
(Re-)Wetting/High Water Table
Dryness-peatland
In case of Oil Palm
-Decline of ABCDEFGs security
-Low goal marks of Paris Agreement @ COP21 & SDGs
-Decline of Sustainability of National Economy
Wetness-peatland
In case of Sago Palm
-Enhancement of ABCDEFGs security
-High goal marks of Paris Agreement @ COP21 & SDGs
-Enhancement of Sustainability of National Economy
Extreamly Low for SDGs
Extreamly High for SDGs

Annex 03

Appendix V

Keynote Speaker : Dr. Hideyuki Kubo (IJ-REDD, Japan)
Title : Building the Technical Capacity for Peatland Monitoring and Restoration: JICA's support for peatlands (#12)

1

Annex 03

Cooperation framework

- Technical Cooperation (TC)

Capacity building of concerned stakeholders

- Institutional arrangement

With Peatland Restoration Agency (BRG)

Minutes of Meeting (2017 –)

With Ministry of Environment and Forestry (KLHK)

TC Project on fire prevention (2017 –)

TC Project on mitigation in LULUCF sector (2018 –)

Areas of work

- Monitoring

Real-time Ground Water Level (GWL)

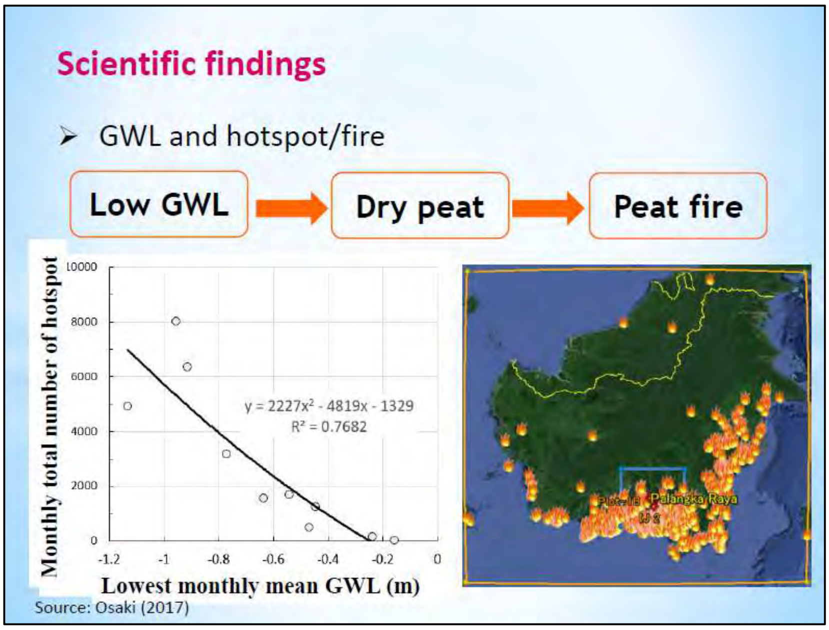
→ Fire risk alert

→ CO_2 emissions from peat decomposition

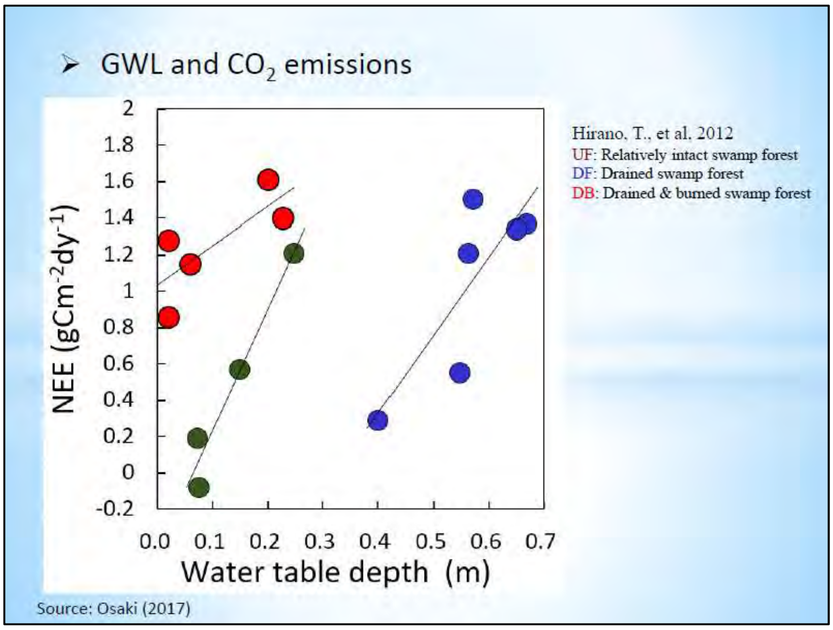
CO_2 Emission Mapping

- Restoration

Zoning and zone-based restoration


Scientific findings
GWL and hotspot/fire
Low GWL
Dry peat
Peat fire
Monthly total number of hotspot
10000
8000
6000
4000
2000
0
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
y = 2227x² - 4819x - 1329
R² = 0.7682
Lowest monthly mean GWL (m)
Palangka Raya
Source: Osaki (2017)

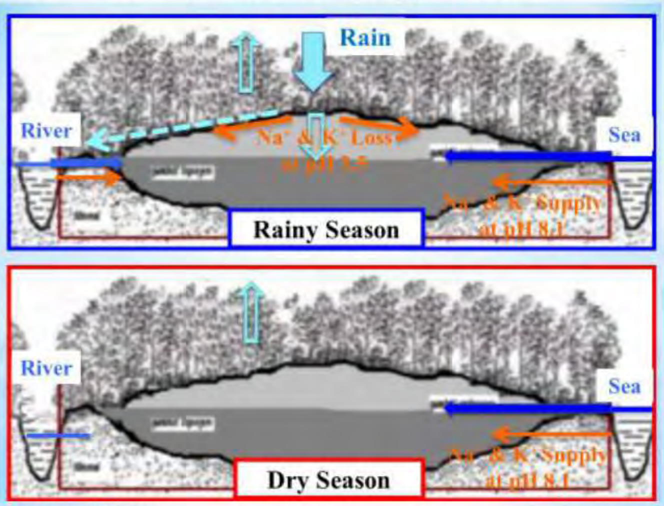
4


GWL and CO2 emissions
NEE (gCm-2dy-1)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Water table depth (m)
Hirano, T., et al, 2012
UF: Relatively intact swamp forest
DF: Drained swamp forest
DB: Drained & burned swamp forest
Source: Osaki (2017)

5

Annex 03

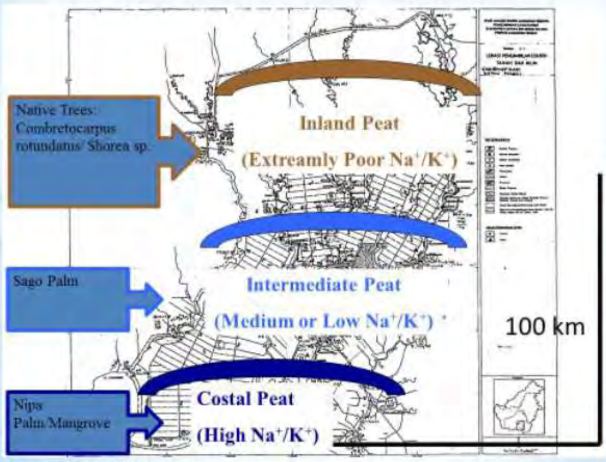
➢ Nutritional condition within a peat dome



Source: Osaki (2017)

6

➢ Nutritional condition within a peat dome
= A case of zoning in Central Kalimantan =



Source: Osaki (2017)

7

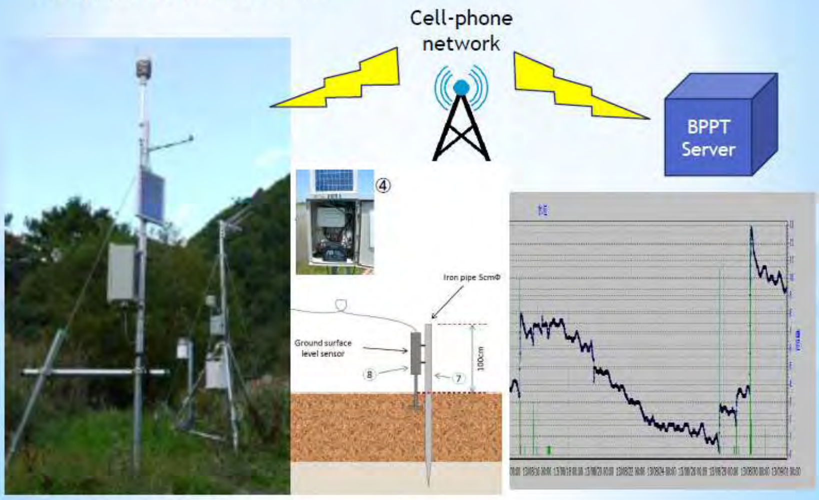
Our support: Monitoring work

Working with:

- Peatland Restoration Agency (BRG)
- Agency for the Assessment and Application of Technology (BPPT)
- Ministry of Environment and Forestry (KLHK)

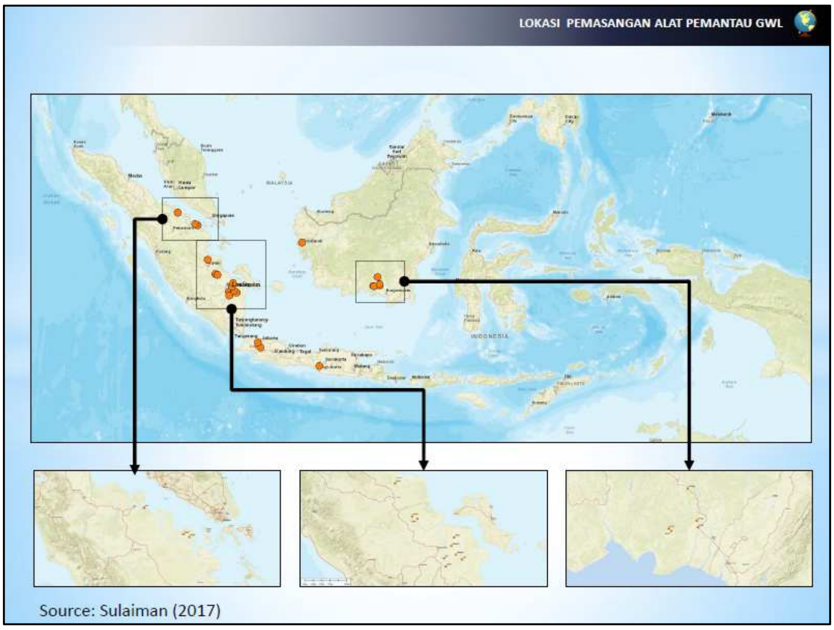
8

Field based GWL data

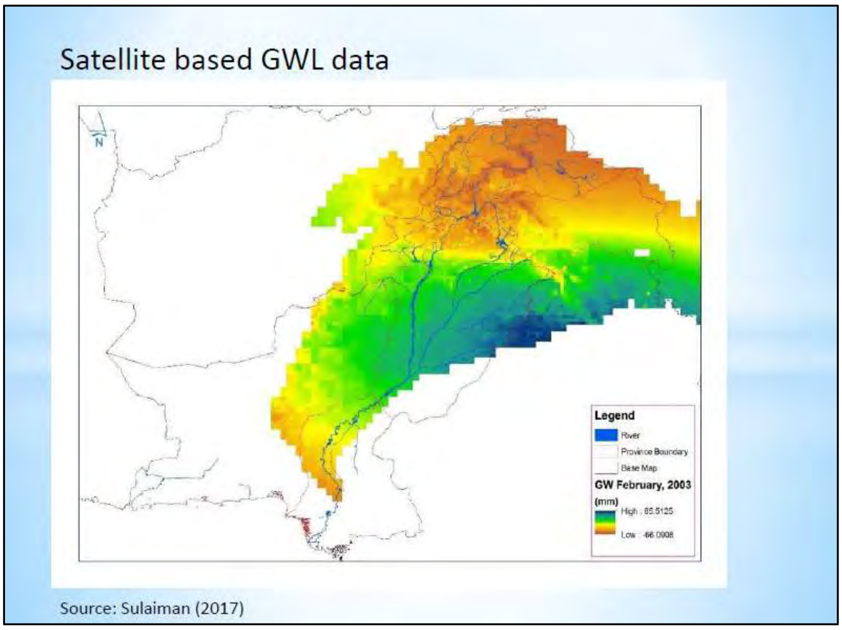


Source: Hamada (2016)

9


LOKASI PEMASANGAN ALAT PEMANTAU GWL
Source: Sulaiman (2017)

10


Satellite based GWL data
Legend
River
Province Boundary
Base Map
GW February, 2003
(mm)
High : 85.5125
Low : -66.0908
Source: Sulaiman (2017)

11

Annex 03

Immediate targets:

- Real-time GWL data throughout entire peatlands in Indonesia (Proto-type by the end of September)

  - Improved model of satellite data analysis by using field data (by early next year)

- Prediction of GWL data over the next three months

Mid-term target:

- CO_2 Emission Mapping (Peat Degradation)

- CO_2 Emission Mapping (Peat Loss by Fire)

12

Our support: Restoration work

Working with:

- Peatland Restoration Agency (BRG)

- Ministry of Environment and Forestry (KLHK)

- District and Provincial governments
  - Meranti (Riau)
  - Pulang Pisau (Central Kalimantan)
  - Ketapang (West Kalimantan)
  - Others

13

Annex 03

Immediate targets:

- Establish a "zoning" based designing for restoration (One KHG in Meranti and One KHG in Pulang Pisau)

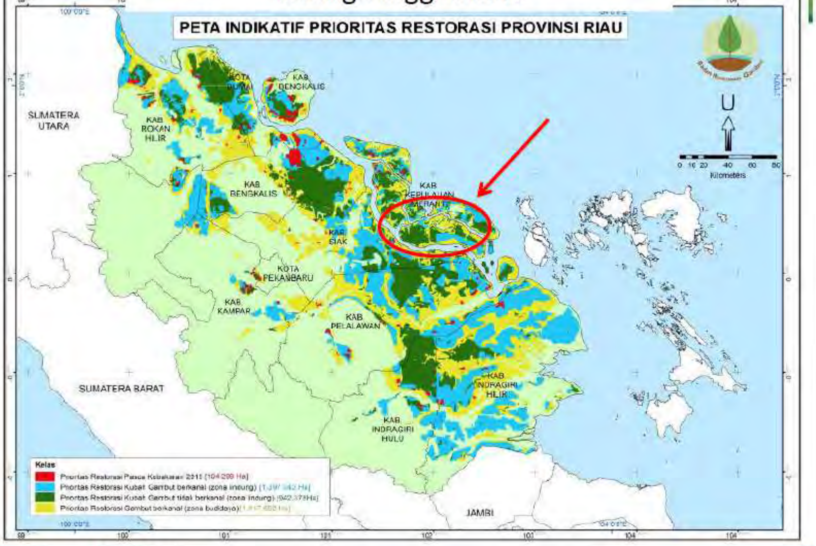
- Demonstrate a restoration approach at a intermediate peat zone (Small-scale pilot in Ketapang)

Mid-term targets:

- Apply successful approaches at a scale under new Technical Cooperation Project by KLHK/BRG/JICA

14

Tebing Tinggi Island

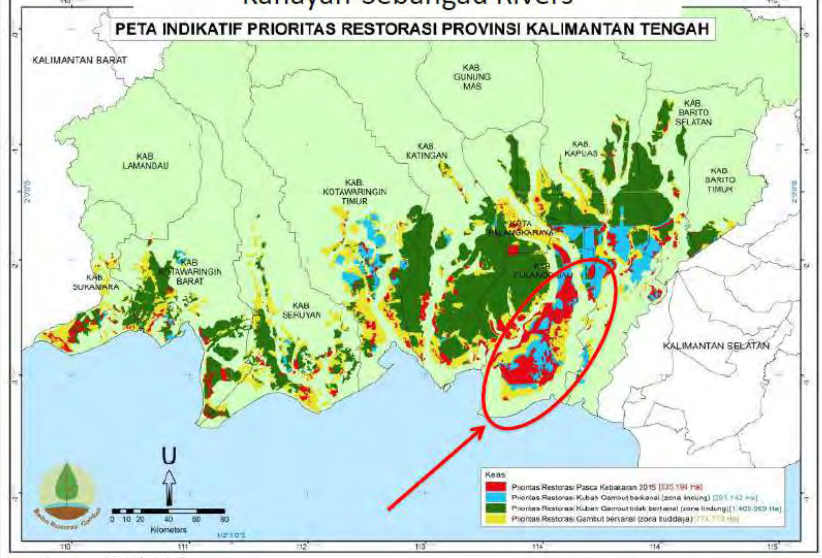


Source: BRG (2016)

15

Annex 03

Kahayan-Sebangau Rivers



Source: BRG (2016)

"Zoning" based designing for restoration

- Methodology development
  - Field based data
  - Remote sensing data
- Community based restoration
- Improving existing plantation management

Annex 03


Our support: Networking work
• Sharing Restoration Information – University network
• International Committee for Peatland Restoration Actions in Indonesia:
- Led by BRG and International Peatland Society (IPS)
- Establish a scientific and technical support system
- 1st Tropical Peatland Roundtable to be held in Oct.
- Welcome your support to the Int'l Committee!!!!!

Annex 03

Appendix VI

Title : "Jakarta Declaration" on Responsible Management of Tropical Peatland (#13)

1st Tropical Peatland Roundtable

2nd November 2017

"Jakarta Declaration" on
Responsible Management of Tropical Peatland

Truly effective Tropical Peatland Restoration in Indonesia will require substantial development of an integrated peatland management system based on scientific and technical knowledge and information. Achieving this requires the establishment of an International Committee for Technical Consultation to facilitate Tropical Peatland Restoration Action.

For this purpose, the IPS (International Peatland Society), BRG (Peatland Restoration Agency, Indonesia) and JPS (Japan Peatland Society) organized the 1st "Tropical Peatland Roundtable" on the 1st and 2nd November 2017 in Jakarta, supported by JICA (Japan International Cooperation Agency), Norwegian Embassy, UNDP (United Nations Development Programme), and BRG.

After two days of thorough discussion, a principal strategy of Responsible Management of Tropical Peatland was agreed. This includes five pillars of action:

- establish a "Tropical Peatland Center "
- organize an " International Committee for Technical Consultation"
- develop an "Integrated Monitoring System"
- conduct a "Model Project" for responsible management
- achieve capacity building

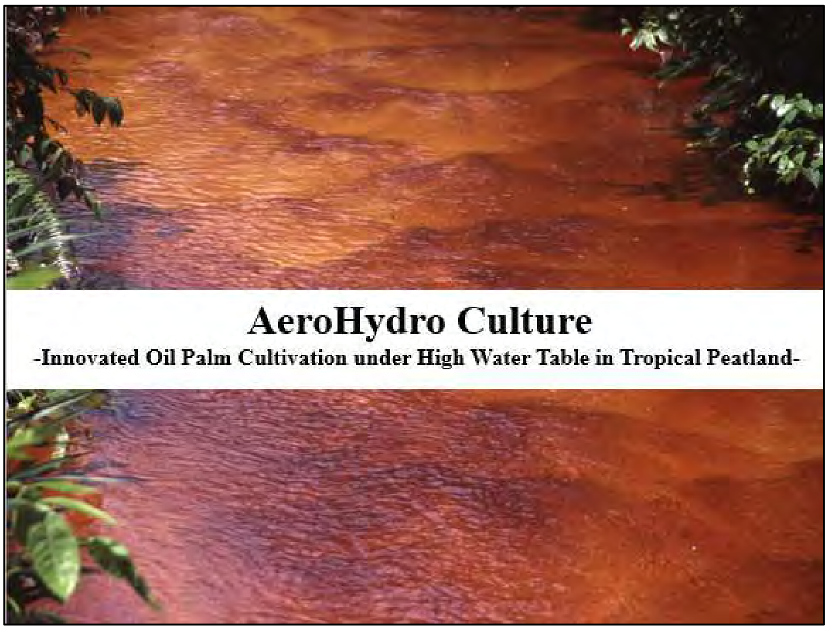
We release this "Jakarta Declaration" as a milestone for promoting action on "Responsible Management of Tropical Peatland", also as a basis for bridging Indonesian stakeholders and the international community.

Gerald Schmilewski	Nazir Foead	Mitsuru Osaki
The President of the International Peatland Society (IPS)	The Head of Peatland Restoration Agency (BRG)	The President of Japan Peatland Society (JPS)

Annex 03

Appendix VII

Keynote Speaker : Dr. Mitsuru Osaki (Hokkaido University, Japan)
Title : AeroHydro Culture: Innovated Oil Palm Cultivation under High Water Table in Tropical Peatland (#14)



1

2

Annex 03

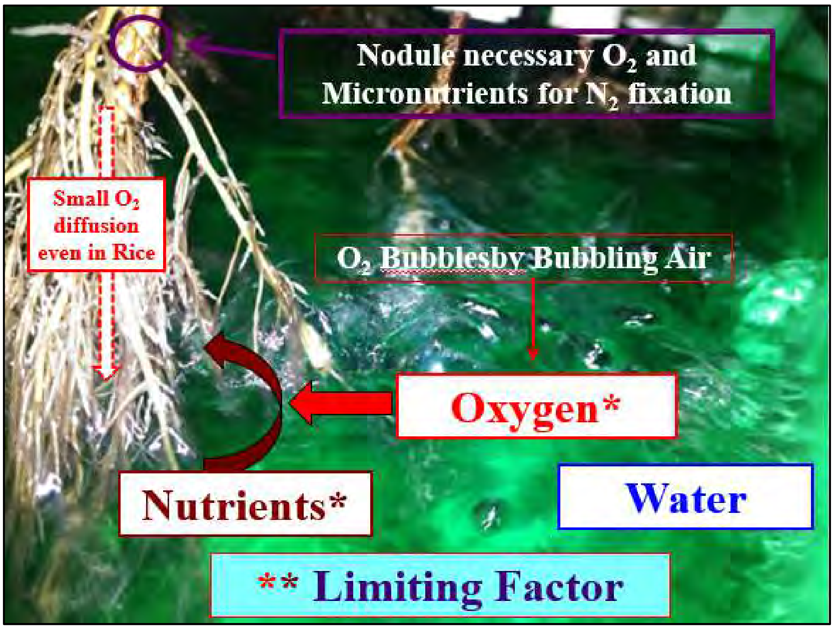
Proposal

AeroHydro Culture

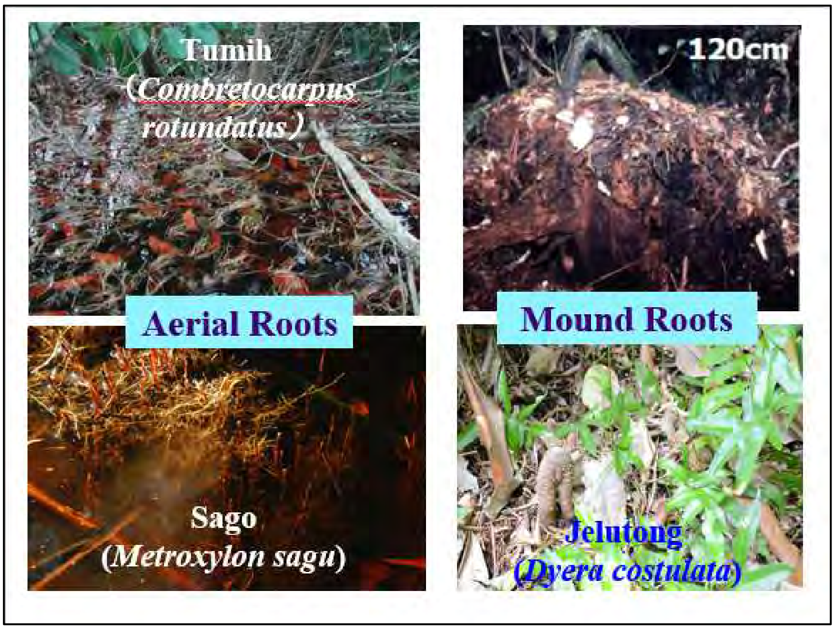
- Culture at High Water Table-

1. Principal

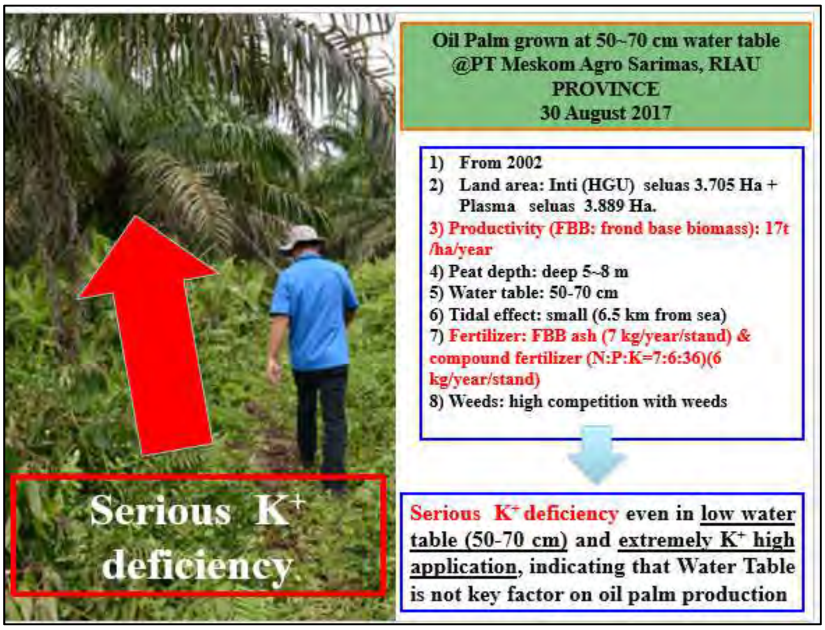
3



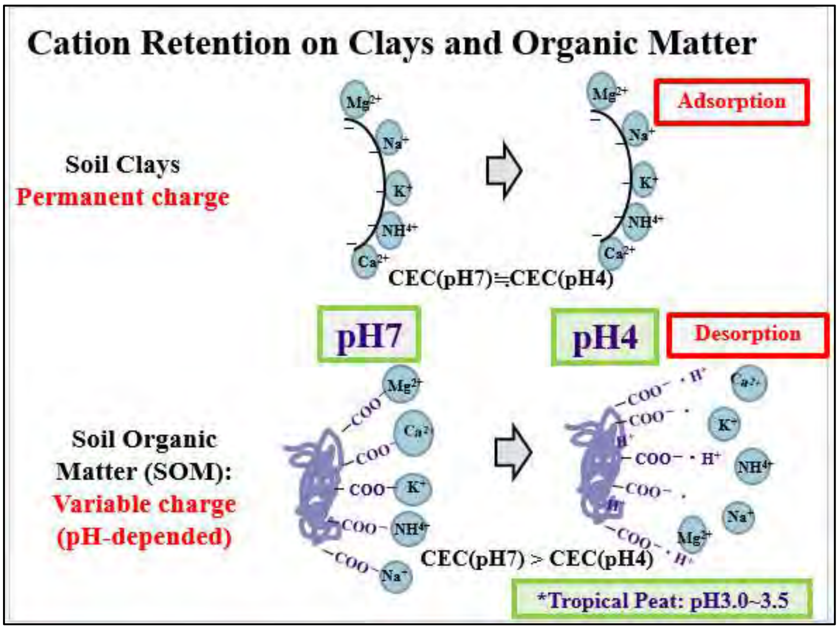
4


Tumih
(Combretocarpus
rotundatus)
120cm
Aerial Roots
Mound Roots
Sago
(Metroxylon sagu)
Jelutong
(Dyera costulata)

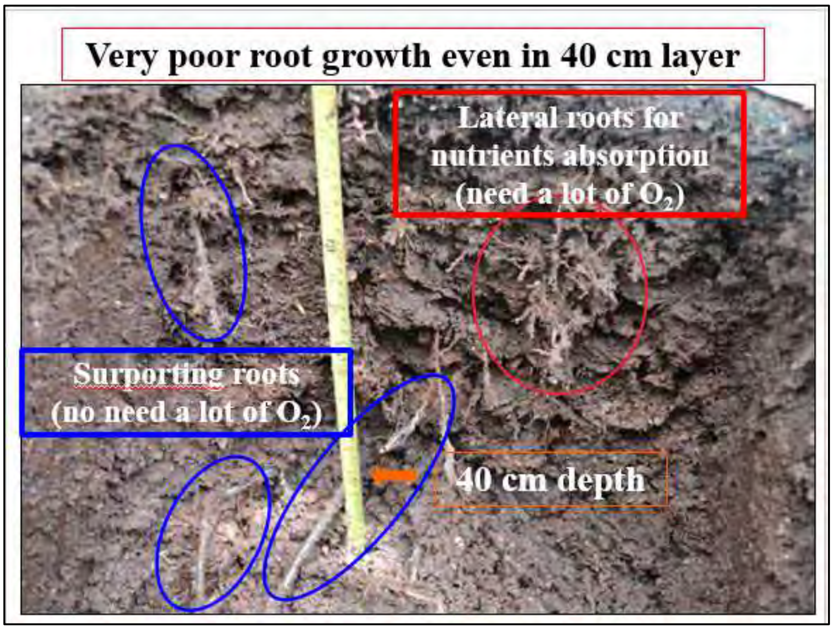
5


Oil Palm grown at 50~70 cm water table
@PT Meskom Agro Sarimas, RIAU
PROVINCE
30 August 2017
1) From 2002
2) Land area: Inti (HGU) seluas 3.705 Ha + Plasma seluas 3.889 Ha.
3) Productivity (FBB: frond base biomass): 17t /ha/year
4) Peat depth: deep 5~8 m
5) Water table: 50-70 cm
6) Tidal effect: small (6.5 km from sea)
7) Fertilizer: FBB ash (7 kg/year/stand) & compound fertilizer (N:P:K=7:6:36)(6 kg/year/stand)
8) Weeds: high competition with weeds
Serious K+ deficiency even in low water table (50-70 cm) and extremely K+ high application, indicating that Water Table is not key factor on oil palm production
Serious K+
deficiency

6


Cation Retention on Clays and Organic Matter
Soil Clays
Permanent charge
Adsorption
CEC(pH7)≒CEC(pH4)
pH7
pH4
Desorption
Soil Organic Matter (SOM):
Variable charge
(pH-depended)
CEC(pH7) > CEC(pH4)
*Tropical Peat: pH3.0~3.5

7


Very poor root growth even in 40 cm layer
Lateral roots for nutrients absorption (need a lot of O_2)
Surporting roots (no need a lot of O_2)
40 cm depth

8

Annex 03

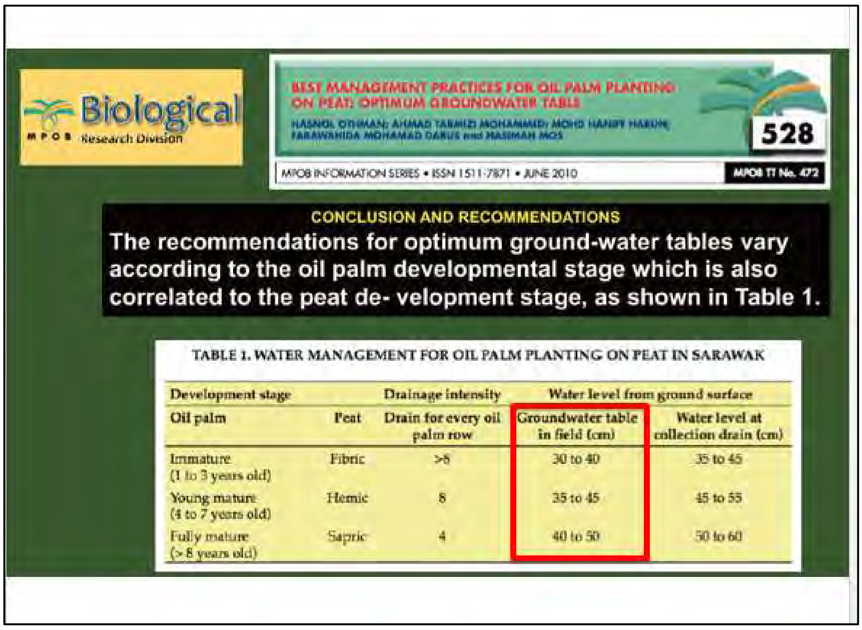
Proposal

AeroHydro Culture

- Culture at High Water Table-

2. Practice Evidence

9



Biological
MPOB Research Division

BEST MANAGEMENT PRACTICES FOR OIL PALM PLANTING ON PEAT: OPTIMUM GROUNDWATER TABLE

HASNOL OTHMAN; AHMAD TARMIZI MOHAMMED; MOHD HANIFF HARUN; FARAWAHIDA MOHAMAD DARUS and MASIMAN MOS

528

MPOB INFORMATION SERIES • ISSN 1511-7871 • JUNE 2010

MPOB TT No. 472

CONCLUSION AND RECOMMENDATIONS

The recommendations for optimum ground-water tables vary according to the oil palm developmental stage which is also correlated to the peat de- velopment stage, as shown in Table 1.

TABLE 1. WATER MANAGEMENT FOR OIL PALM PLANTING ON PEAT IN SARAWAK

Development stage		Drainage intensity	Water level from ground surface	
Oil palm	Peat	Drain for every oil palm row	Groundwater table in field (cm)	Water level at collection drain (cm)
Immature (1 to 3 years old)	Fibric	>8	30 to 40	35 to 45
Young mature (4 to 7 years old)	Hemic	8	35 to 45	45 to 55
Fully mature (> 8 years old)	Sapric	4	40 to 50	50 to 60

10


Good Growth of Oil Palm near Mangrove
(High Sea Water Level)
Oil Palm
Oil Palm
Nipa Palm
Mangrove

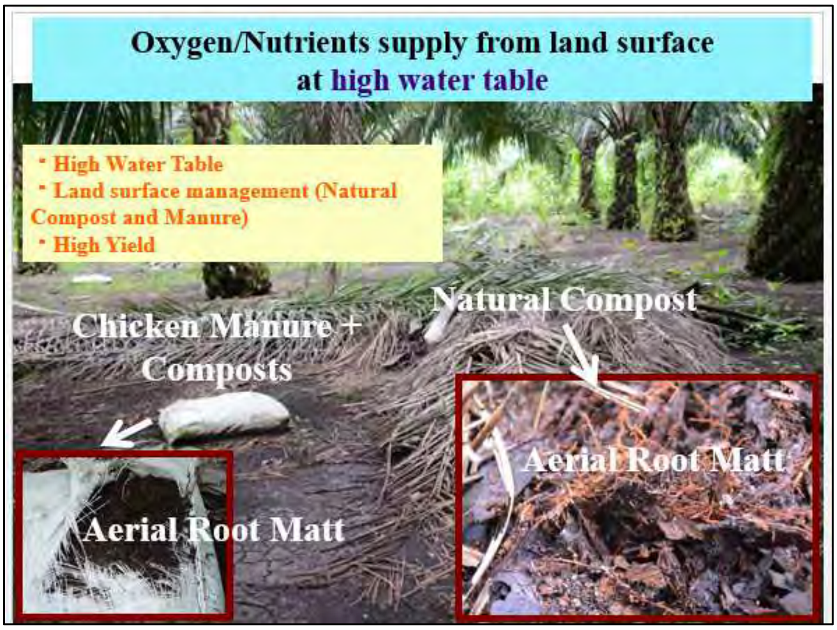
11


"United Plantations Berhad"
@ Oil Palm Plantation in Malaysia-
▪ High Water Table
▪ High Yield
▪ Land surface management (Natural Compost and Grass Multing)
▪ The world's first certified producer of sustainable palm oil by "The Roundtable on Sustainable Palm Oil (RSPO)" on the 26th August 2008
Natural Compost

12


Oil Palm grown high water table
@Mega Timur Village, Sungai Ambawang District, Kubu Raya Regency, Pontianak
1) 8 years palm for 14 ha by Mr. Suparjo (farmer)
2) High productivity: 40 ton/ha/year (very high productivity)
3) Sallow peat (1~2 m depth)
4) High water table (10~20 cm from surface)
4) Final stage of peat
5) Tidal effect
6) Soil surface management by organic matters

13


Oxygen/Nutrients supply from land surface at high water table
・High Water Table
・Land surface management (Natural Compost and Manure)
・High Yield
Chicken Manure + Composts
Natural Compost
Aerial Root Matt
Aerial Root Matt

14

Annex 03

Proposal
AeroHydro Culture
- Culture at High Water Table-

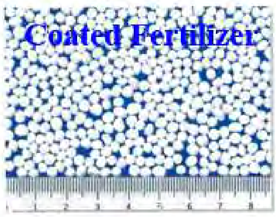
3. Proposal

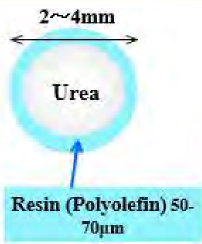
15

Proposal: AeroHydro Culture Technology

Nutrients/Oxygen Application from Land Surface

1) High Water Table
2) Natural Composts by Frond and Cover Crops
3) Slow Release K^+ Nutrients as the Coated Fertilizer
4) Biochar



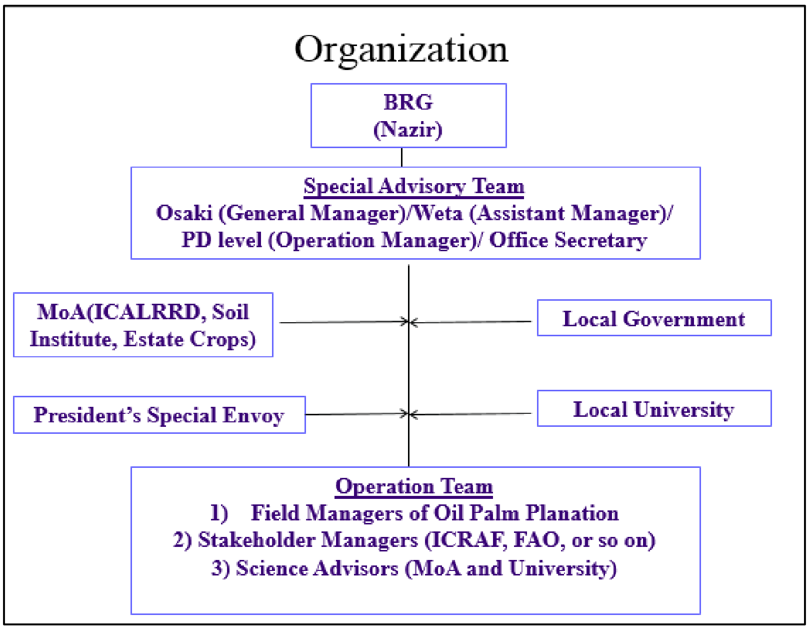


Film by Palm Oil Materials

16

Appendix VIII

Keynote Speaker : Dr. Mitsuru Osaki (Hokkaido University, Japan)
Title : AeroHydro Culture: Innovated Oil Palm Cultivation under High Water Table in Tropical Peatland (continue from Appendix VII) (#15)



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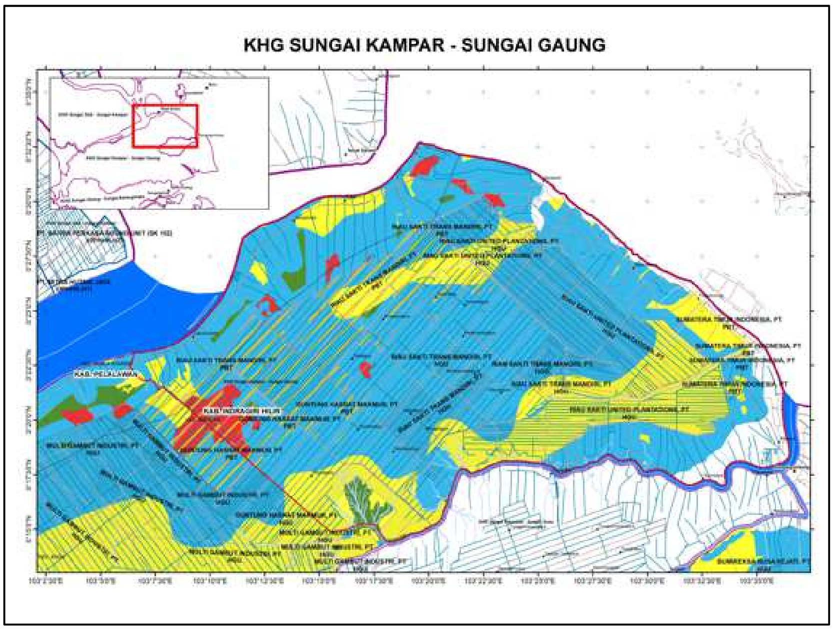
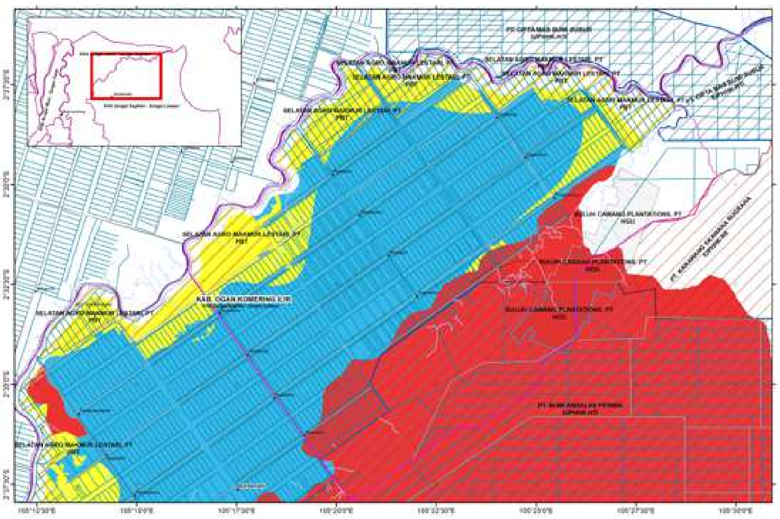


18

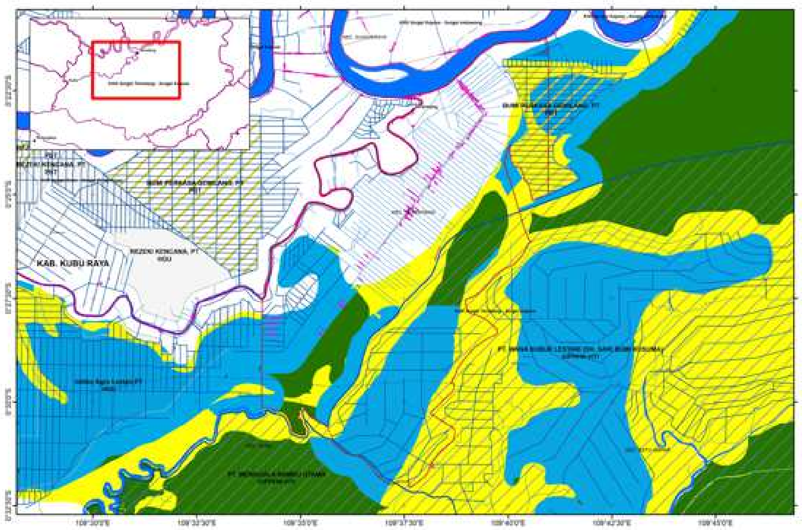
Annex 03

KHG SUNGAI SUGIHAN - SUNGAI LUMPUR



19

KHG SUNGAI TERENTANG SUNGAI KAPUAS



20

Annex 03

Appendix IX

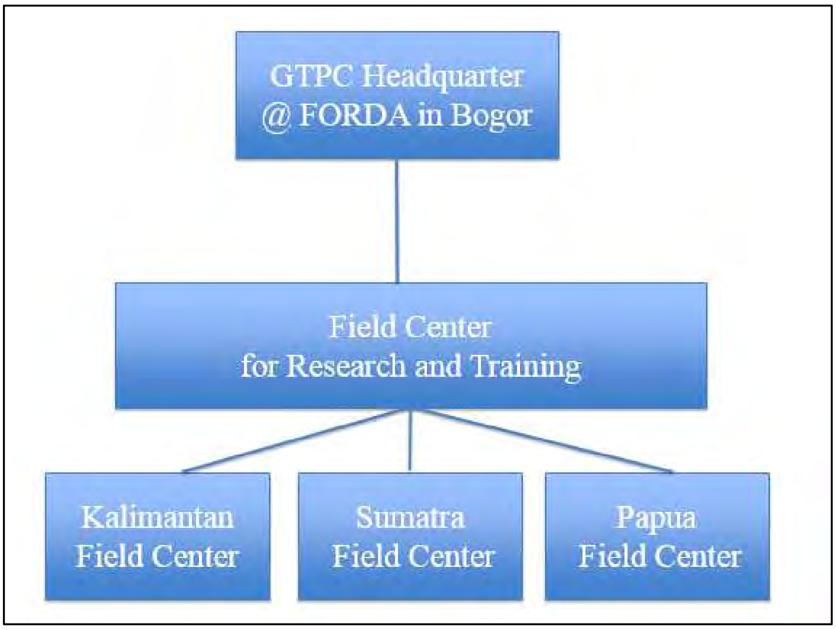
Keynote Speaker : Dr. Mitsuru Osaki (Hokkaido University, Japan)
Title : Global Tropical Peatland Center (#16)

Global Tropical Peatland Center (GTPC)

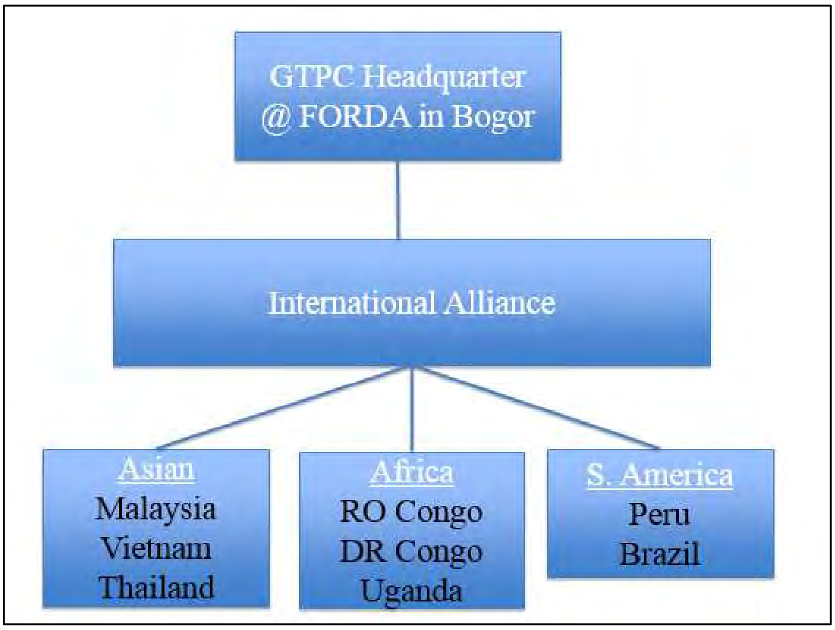
1

2

Annex 03


GTPC Headquarter
@ FORDA in Bogor
Field Center
for Research and Training
Kalimantan
Field Center
Sumatra
Field Center
Papua
Field Center

3


GTPC Headquarter
@ FORDA in Bogor
International Alliance
Asian
Malaysia
Vietnam
Thailand
Africa
RO Congo
DR Congo
Uganda
S. America
Peru
Brazil

4

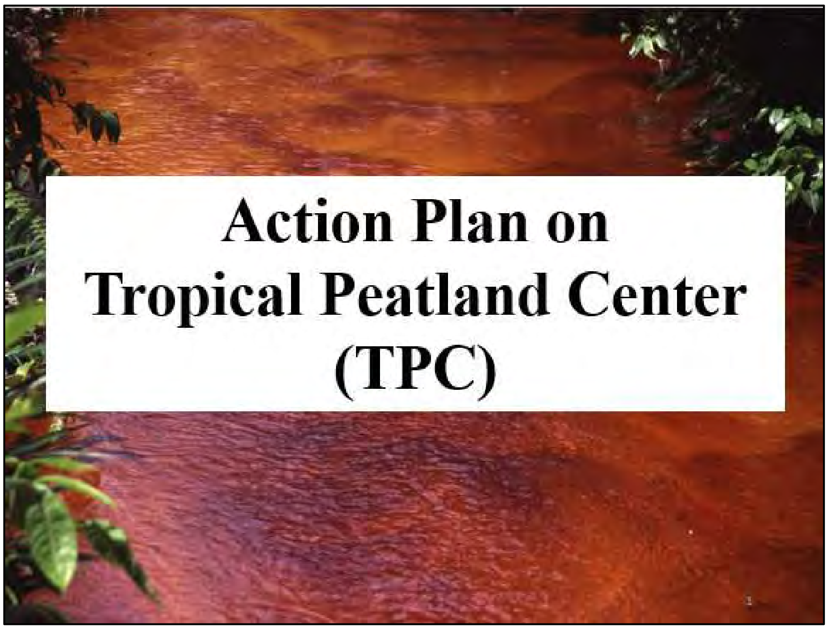
Activity following up "Jakarta Declaration"

- organize an " International Committee for Technical Consultation"
- develop an "Integrated Monitoring System"
- conduct a "Model Project" for responsible management
- Achieve Capacity Building

Annex 03

Appendix X

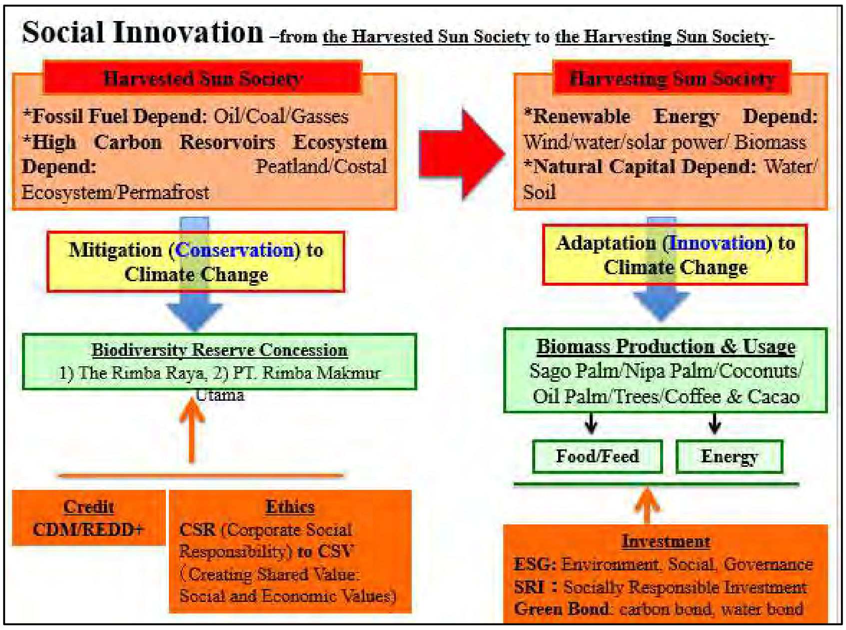
Keynote Speaker : Dr. Mitsuru Osaki (Hokkaido University, Japan)
Title : Action Plan on Tropical Peatland Center (#17)



1

2

Annex 03



3

The Harvesting Sun Strategy on Tropical Peatland Restoration

•Hardware (Technology) Innovation

- AeroHydro Culture: High Bio-Productivity and Conservation [National Security]
- Harvesting Sun: Down-sizing & Wide-scattering Energy: [Biomass Energy]
- Special Dynamic Informatics
- Activation on small and medium-sized enterprises and technology

• Software (Social) Innovation

- Natural Capital Depend Society: Usage of Water and Carbon Function [High SDGs score]
- Gold Carbon Mechanism: Branding of Tropical Peatland [ESG and SRI Investment]
- Activation on local community

4

4

Annex 03

1st Tropical Peatland Roundtable
2nd November 2017
@ Jakarta

"Jakarta Declaration"
on
Responsible Management of
Tropical Peatland

Five pillars of action:

- establish a "Tropical Peatland Center "
- organize an " International Committee for Technical Consultation"
- develop an "Integrated Monitoring System"
- conduct a "Model Project" for responsible management
- achieve capacity building

5

Following up "Jakarta Declaration"

1)Establish a "Tropical Peatland Center "

2)Organize an " International Committee for Technical Consultation"

→ **Institution**
1)2) Tropical Peatland Center (TPC)

3)Develop an "Integrated Monitoring System"

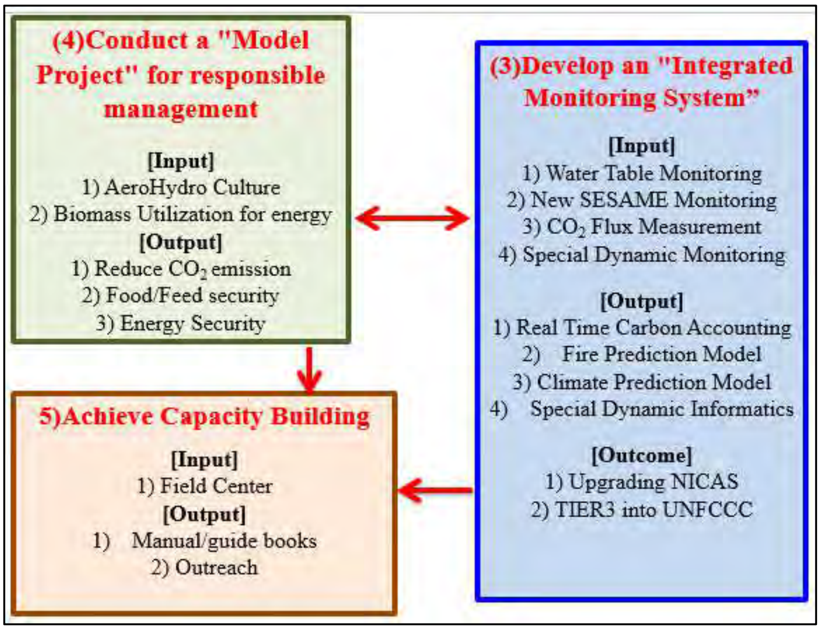
4)Conduct a "Model Project" for responsible management

5)Achieve Capacity Building

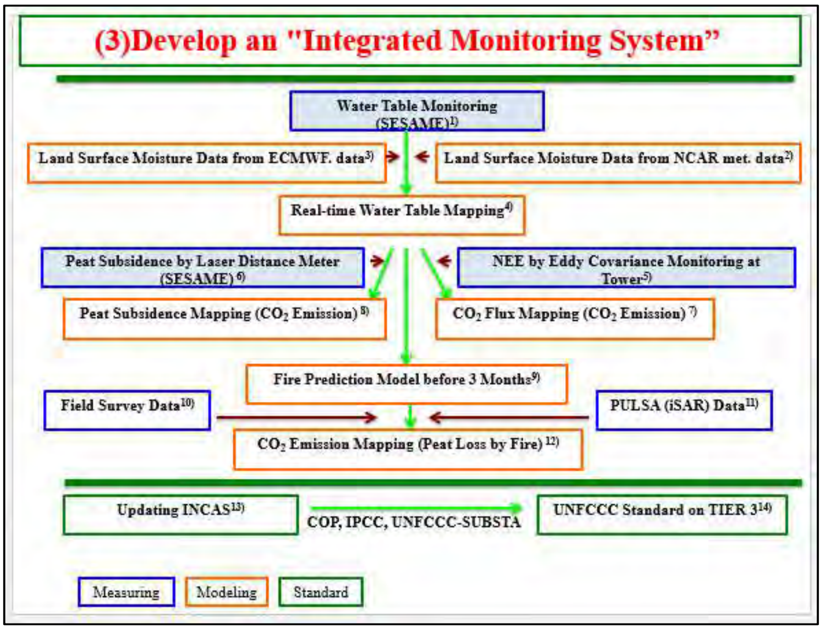
→ **Action Plan**
3) Water/Carbon Mapping & Special Dynamic Informatics
4) Aero Hydro Culture & Biomass Energy
5) Capacity Building & Designate of Field Center

6


ACTION PLAN


(4)Conduct a "Model Project" for responsible management
[Input]
1) AeroHydro Culture
2) Biomass Utilization for energy
[Output]
1) Reduce CO_2 emission
2) Food/Feed security
3) Energy Security
(3)Develop an "Integrated Monitoring System"
[Input]
1) Water Table Monitoring
2) New SESAME Monitoring
3) CO_2 Flux Measurement
4) Special Dynamic Monitoring
[Output]
1) Real Time Carbon Accounting
2) Fire Prediction Model
3) Climate Prediction Model
4) Special Dynamic Informatics
[Outcome]
1) Upgrading NICAS
2) TIER3 into UNFCCC
5)Achieve Capacity Building
[Input]
1) Field Center
[Output]
1) Manual/guide books
2) Outreach

Annex 03



9

Oil Palm grown at high water table
@Mega Timur Village, Sungai Ambawang District, Kubu Raya Regency, Pontianak

1) 8 years palm for 14 ha by Mr. Suparjo (farmer)
2) High productivity: 40 ton/ha/year (very high productivity)
3) Sallow peat (1~2 m depth)
4) High water table (10~20 cm from surface)
4) Final stage of peat
5) Tidal effect
6) Soil surface management by organic matters

10

Annex 03

11

Proposal: AeroHydro Culture Technology

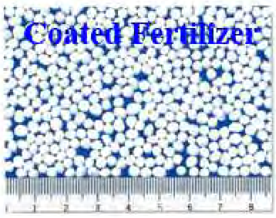
Nutrients/Oxygen Application from Land Surface

1) High Water Table

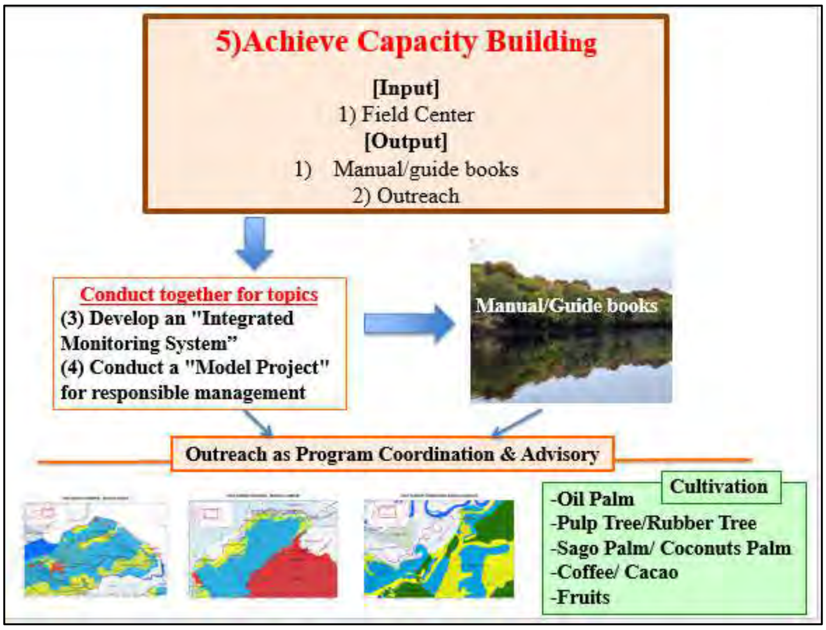
2) Natural Composts by Frond and Cover Crops

3) Slow Release K^+ Nutrients as the Coated Fertilizer

4) Biochar



12

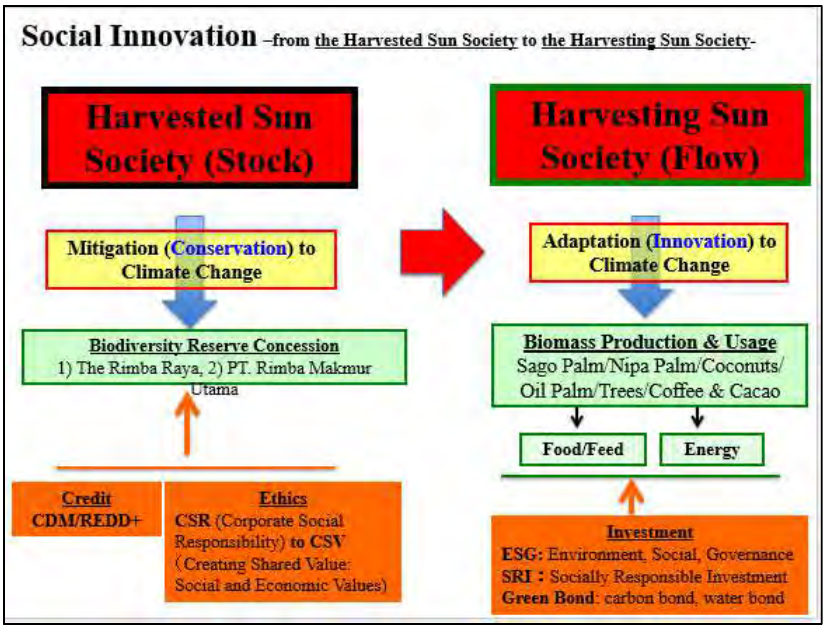

5)Achieve Capacity Building
[Input]
1) Field Center
[Output]
1) Manual/guide books
2) Outreach
Conduct together for topics
(3) Develop an "Integrated Monitoring System"
(4) Conduct a "Model Project" for responsible management
Manual/Guide books
Outreach as Program Coordination & Advisory
Cultivation
-Oil Palm
-Pulp Tree/Rubber Tree
-Sago Palm/ Coconuts Palm
-Coffee/ Cacao
-Fruits

13


OUTCOME

14

Annex 03



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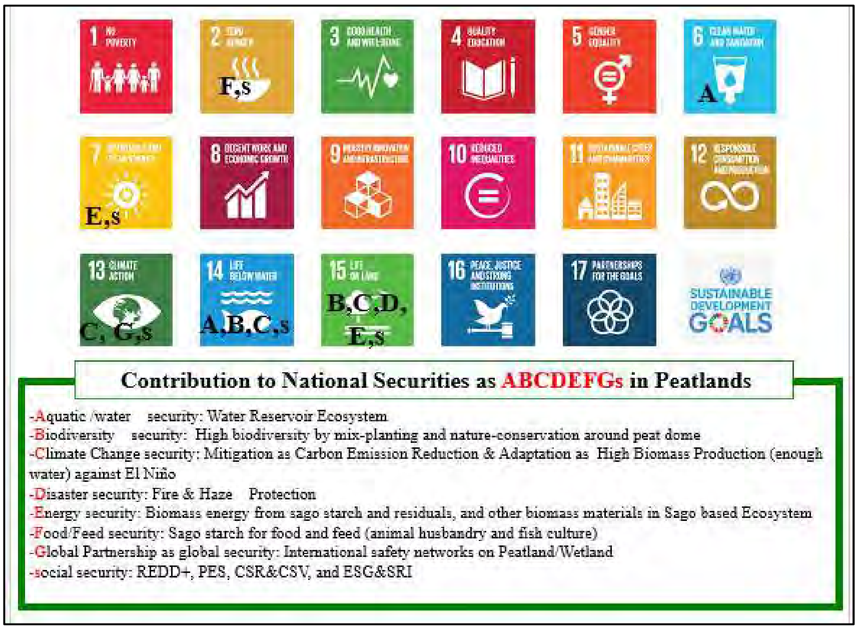
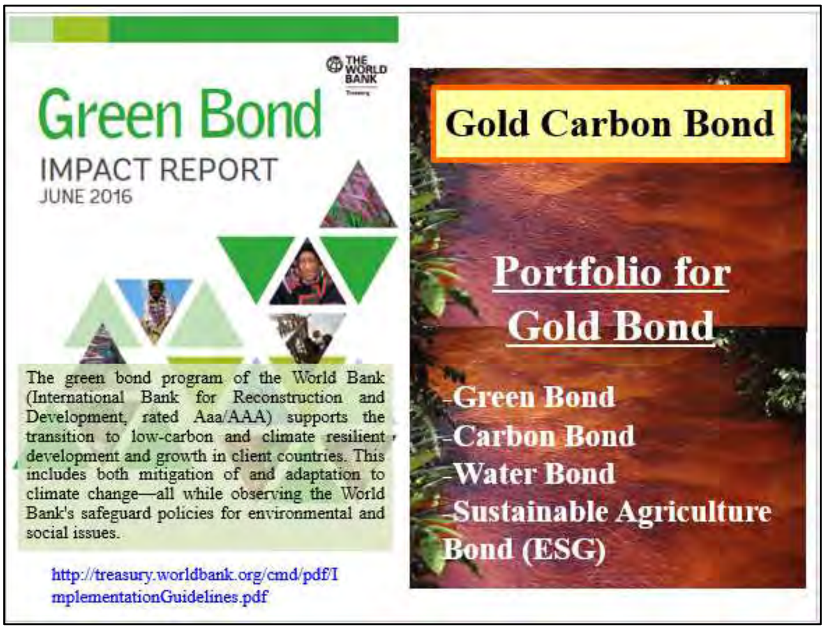


16

Annex 03



Green Bond
IMPACT REPORT
JUNE 2016
THE WORLD BANK
The green bond program of the World Bank (International Bank for Reconstruction and Development, rated Aaa/AAA) supports the transition to low-carbon and climate resilient development and growth in client countries. This includes both mitigation of and adaptation to climate change—all while observing the World Bank's safeguard policies for environmental and social issues.
http://treasury.worldbank.org/cmd/pdf/ImplementationGuidelines.pdf
Gold Carbon Bond
Portfolio for Gold Bond
-Green Bond
-Carbon Bond
-Water Bond
-Sustainable Agriculture Bond (ESG)

Annex 03

Appendix XI

Title : Fieldology" for Mekong Delta Sustainability (#18)

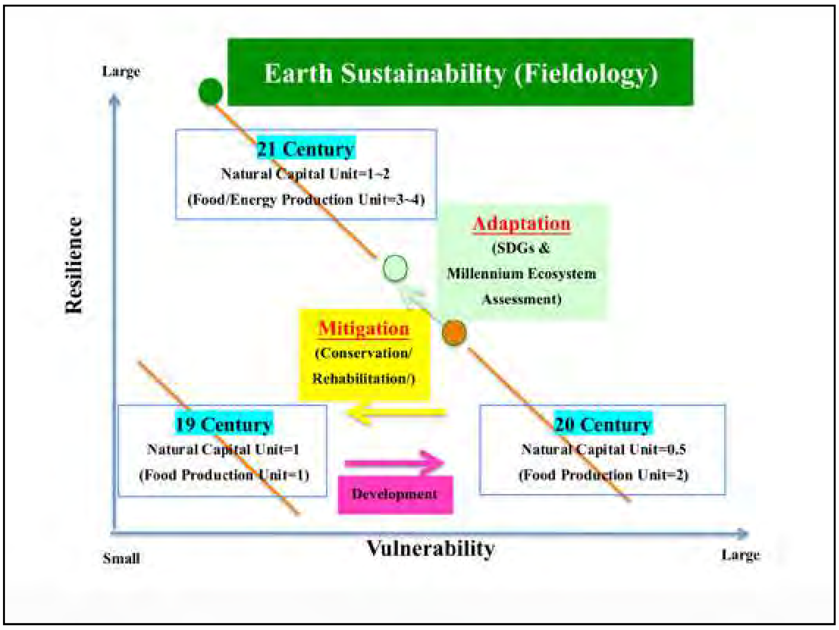
"Fieldology" for Mekong Delta Sustainability

1

I. Concept

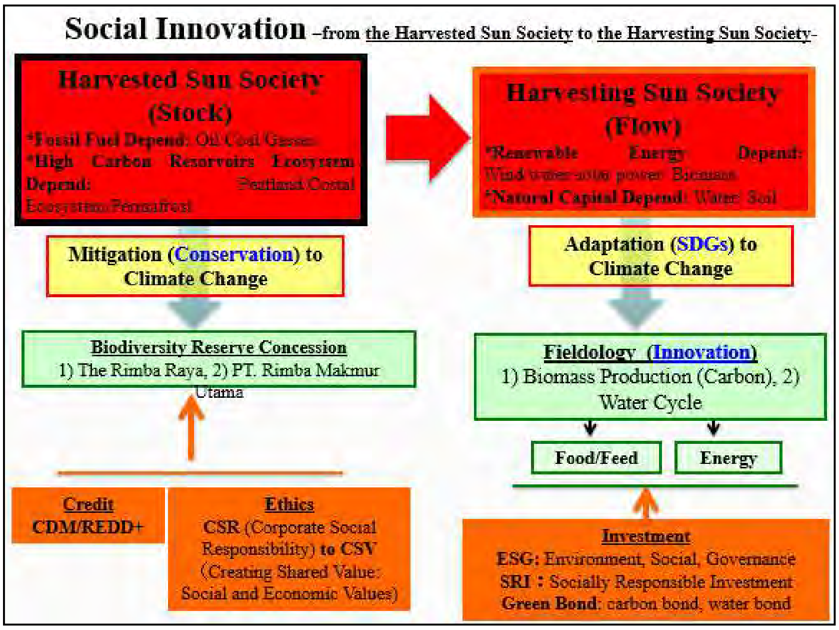
2

Annex 03



Earth Sustainability (Fieldology)
Large
Resilience
21 Century
Natural Capital Unit=1~2
(Food/Energy Production Unit=3~4)
Adaptation
(SDGs &
Millennium Ecosystem
Assessment)
Mitigation
(Conservation/
Rehabilitation/)
19 Century
Natural Capital Unit=1
(Food Production Unit=1)
Development
20 Century
Natural Capital Unit=0.5
(Food Production Unit=2)
Small
Vulnerability
Large

3



Social Innovation –from the Harvested Sun Society to the Harvesting Sun Society-
Harvested Sun Society (Stock)
*Fossil Fuel Depend: Oil Coal Gasses
*High Carbon Reservoirs Ecosystem Depend: Peatland Costal Ecosystem Permafrost
Harvesting Sun Society (Flow)
*Renewable Energy Depend: Wind water solar power Biomass
*Natural Capital Depend: Water Soil
Mitigation (Conservation) to Climate Change
Adaptation (SDGs) to Climate Change
Biodiversity Reserve Concession
1) The Rimba Raya, 2) PT. Rimba Makmur Utama
Fieldology (Innovation)
1) Biomass Production (Carbon), 2) Water Cycle
Food/Feed
Energy
Credit
CDM/REDD+
Ethics
CSR (Corporate Social Responsibility) to CSV (Creating Shared Value: Social and Economic Values)
Investment
ESG: Environment, Social, Governance
SRI : Socially Responsible Investment
Green Bond: carbon bond, water bond

4

Fieldology on Land Function Enhancement

Traditional Function

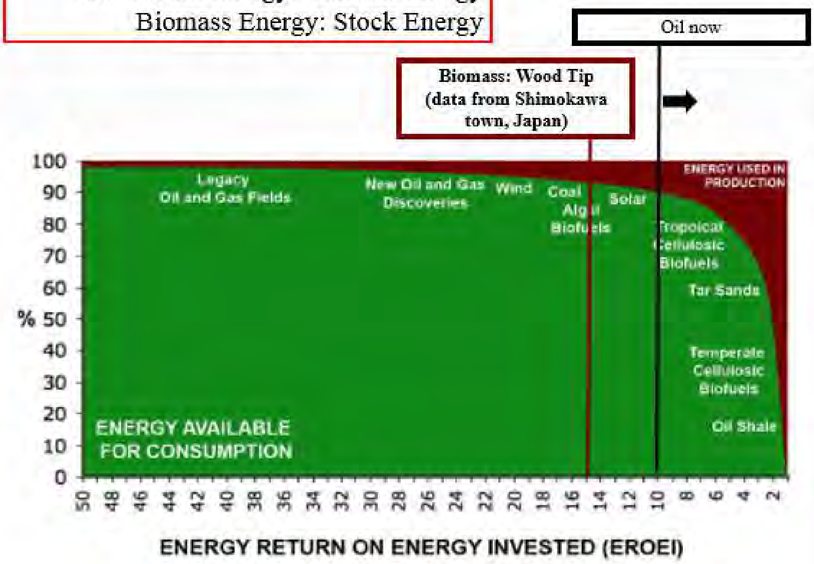
- Food/Feed Production
- Wood Production

New Function

- Carbon Sequestration
- Renewable Energy (especially Biomass)
- Natural Capital Enhancement (Water Cycling, Water Storage, and Water Usage)

5

Solar/Wind Energy: Current Energy
Biomass Energy: Stock Energy



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Targeting Ecosystem on Fieldology

4 scenarios of Ecology and Human Relationship in Millennium Ecosystem Assessment (MA)

Global
for institutions & policies
globally connected

Global Orchestration

TechnoGarden

Reactive
in environmental
policies

Proactive
in
environmental
policies

Order from Strength

Adapting Mosaic

Regional
for institutions & policies
poorly connected

7

Typical Ecosystem in Order from Strength

High Carbon Reservoirs Ecosystems: 1) Peatlands/Wetlands, 2) Costal Ecosystem (Mangrove/Sea grass/Coral), and 3) Permafrost [Rich Water in land surface]

Acid sulfate soil/ Sandy soil/ Saline soil [Poor Water in land surface]

8

Annex 03

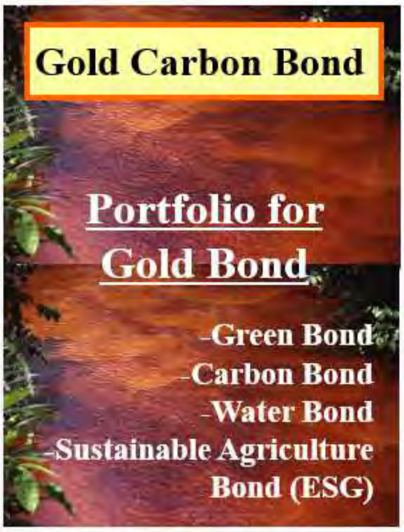
Contribution to National Securities as ABCDEFGs in Peatlands

-Aquatic /water security: Water Reservoir Ecosystem
-Biodiversity security: High biodiversity by mix-planting and nature-conservation around peat dome
-Climate Change security: Mitigation as Carbon Emission Reduction & Adaptation as High Biomass Production (enough water) against El Niño
-Disaster security: Fire & Haze Protection
-Energy security: Biomass energy from sago starch and residuals, and other biomass materials in Sago based Ecosystem
-Food/Feed security: Sago starch for food and feed (animal husbandry and fish culture)
-Global Partnership as global security: International safety networks on Peatland/Wetland
-social security: REDD+, PES, CSR&CSV, and ESG&SRI

9

The green bond program of the World Bank (International Bank for Reconstruction and Development, rated Aaa/AAA) supports the transition to low-carbon and climate resilient development and growth in client countries. This includes both mitigation of and adaptation to climate change—all while observing the World Bank's safeguard policies for environmental and social issues.

http://treasury.worldbank.org/cmd/pdf/ImplementationGuidelines.pdf

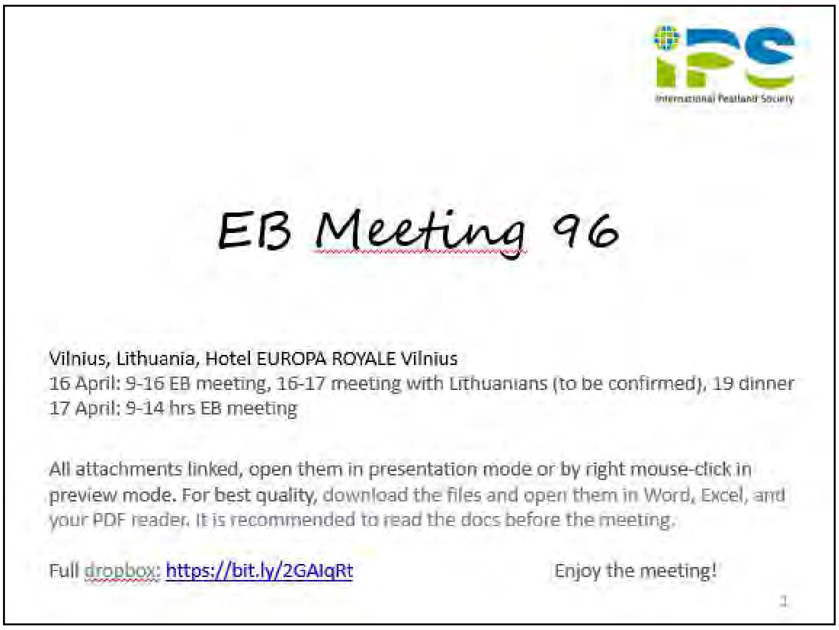


10

Annex 03

Appendix XII

Title : EB Meeting 96 (#19)



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2

Participants

- Gerald Schmilewski — President
- Guus van Berckel — 1st Vice-President
- Samu Valpola — 2nd Vice President

Ordinary Members

- Moritz Böcking
- Donal Clarke
- Erki Niitlaan
- Jack Rieley
- Paul Short

Other attendees

- Susann Warnecke — Communications Manager, IPS

Observers:

- Meng Xianmin
- Supiandi Sabiham
- Mitsuru Osaki
- Lulie Melling

Apologies: Claes Rülcker

If you cannot attend: comments and apologies by 12 April to eb@peatlands.org!

3

Opening

09:15-09:30

- Welcome to participants
  by Gerald Schmilewski
- Ascertaining that a quorum (4+1) is present
- Appointment of a whip and secretary

4

Annex 03

1. Minutes

09:30-10:00

- Homework: Check Action Points EB minutes 93, 94, 95
- Approval of EB minutes 95 (all)

5

2. Rotterdam 2018

10:00-10:30

2.1 Update by Guus on the Jubilee symposium on 11 - 13 September, www.ipsjubileesymposium.nl

2.2 Update by the Summit WG (DC, JR, SV, PS) on Industry Summit on 10 September, www.ips50summit.nl

- List of Speakers, needed actions (GS),
GS sends attachment on 10 April

6

Annex 03

3. Annual Accounts 2017

10:30-11:00

Annual Report (SW), including:

- Report
- Official Financial Statement
- Detailed Income Statement (excel)
- Balance Specifications
- Member Statistics
- Auditor's Draft Statement

- Official Finnish versions (report, financial)

7

4. Secretary General

11:00-11:30

- Report by Recruiting team (DC, SV, GvB)
  - Job Description DC
  - Extract of Espoo Industry meeting minutes 31 Jan 2018
- Actions, schedule, finance, impact on 2018 budget?
- Decision on:
  - Location
  - Funding (fulltime?) 47K sure so far
  - How to go forward?

8

5. Finances 2018

11:30-12:00

- Income statement Q1/2018 (SW)
- Balance 31 March 2018
- Unpaid invoices

(available after 10 April, will be apps 14-16)

9

6. Budget and Fees 2018/19

13:00-13:30

- Industry fees, frozen until 2020 with inflation increase (minutes Espoo 31.1.)
- National Committee & Industry Fees 2018-2019
- Budgets 2018 and interim 2019

-> For submission to Annual Assembly

10

Annex 03

7. EB Elections 2018

- Note status of nominations, deadline extended to 30 May:
- Nominations so far:
  - Giedrius Kavaliauskas
  - Lulie Melling
  - Jack Rieley
  - Claes Rülcker
  - Iman Santoso
  - Frank Tamminga
- Additional actions?

13:30-13:45

11

8. Allan Robertson Grants

- Decision on winners (proposal by SV, JR)
- Amounting to 8 x 500 €
- Contributions 4K from:
  UK 2K, Estonia 1K, IPS 1K (to be invoiced)
- Applications

13:45-14:00

12

9. IPS online store

International Peatland Society

14:00-14:15

- Permission to use Holvi services, including a simple webstore for IPS publications and services
- Sign permission

https://about.holvi.com/products/online-store/

13

10. IPS Website

International Peatland Society

14:15-14:30

- IPS Project team? (SV)
- Budgeted so far 12K for 2018, 20K in 2019
- Selection of communication and technical partners
- Schedule?

14

11. Member applications

International Peatland Society

14:30-14:45

- Approval of new members:
  - Justin Wyatt
  - Alex Cobb

15

15

12. Proceedings in print

International Peatland Society

15:00-15:15

- Approval of Curran agreement (SW) to print and sell IPS proceedings and abstracts

16

16

13. ISHS-IPS Milano

15:15-15:30

- Acknowledgement of event cooperation agreement (signed)
  - Milano 2019 contract
  - Overall contract ISHS-IPS (2012)

17

14. Mires and Peat

15:30-15:45

- Note Editor's Report 2017

18

15. Host of IPC 2024

International Peatland Society

09:00-10:30

- Presentation of bidding National Committees: China, Ireland, Netherlands (15 minutes presentation + 5 min questions)
- Recommendation of the EB to the Annual Assembly, to be given latest before AA 2019

19

16. International Peatland Congress Tallinn 2020

International Peatland Society

10:30-11:00

- Update on developments (EN)
- Impact of Midsummer holiday 19 June (Swe, Fin)
- Impact of EB seat on Congress
- Involvement of the SAB
  - Chairman - Erki Niitlaan
  - Scientific Chairman - Jaanus Paal
  - Excursion Coordinator - NGO Estonian Wetland Society
  - Head of Secretariat - Olga Kaju
  - Head of Communication - Margit Pulk
  - Local Organising Commitee - NGO Peatland Congress 2020

20

Annex 03

17. Peat for Food and Quality of Life Projects

International Peatland Society

11:30-12:00

17.1 Peat demand forecast China

Report GvB, IPS paid € 6,200 in 2017

17.2 Peat demand forecast word wide

"Growing Media Vision 2020-2050: Reflections on the world's need for growing media for food and quality of life until 2050"

Report GvB & GS. Approved, not invoiced yet, 8K

17.3 "Identification of potential global horticultural peat resources to meet future demand"

GvB & GS to report. Proposal to be accepted. Funding 6K Rotterdam + 6K IPS

21

18. SRPM Update

International Peatland Society

13:00-13:15

- Proposal and timeline (JR)

22

22

Annex 03

19. UK Peatland Strategy

International Peatland Society

13:15-13:30

- Note and discuss UK Strategy (JR)

23

20. Next EB meeting

International Peatland Society

13:30-13:45

- Phone meeting week 23, starting 4 June?
- Geeste 29 - 31 August
- Rotterdam, Tue 11 September?

24

21. Closing

13:45-14:00

- Any other business
- Minutes to be written by 23 April, agreed by 30 April, signed in Rotterdam

25

Annex 03

Title : Short Agenda for 2nd Tropical Peatland Roundtable (#20)

Short Agenda

2nd Tropical Peatland Roundtable

Purpose

1st Tropical Peatland Roundtable was held on 2nd November 2017 @ Jakarta, and released "Jakarta Declaration" on Responsible Management of Tropical Peatland. "Jakarta Declaration" recommend to promote five pillars of action:

- establish a "Tropical Peatland Center “
- organize an “International Committee for Technical Consultation”
- develop an “Integrated Monitoring System”
- conduct a "Model Project" for responsible management
- achieve capacity building.

2nd Tropical Peatland Roundtable should follow up "Jakarta Declaration" and further coordinate International alliance.

Topics

1) Following-up Jakarta Declaration
2) Following-up The Brazzaville Declaration on Guarding the planet’s carbon treasure - three countries sign the Brazzaville Declaration held on 21-22 March 2018 in Brazzaville

Date

Early November 2018

Place

Bogor for meeting
Riau for field trip

Organizer

IPS, JPS, Indonesia Peatland Society, Malaysia Peatland Society (?), BRG (Peatland Restoration Agency, Indonesia), FORDA and Ministry of Environment and Forest (MoEF)

Financial Support (tentative)

BRG and MoEF from UNEP, UNDP, Norwegian
JICA
Australia
FAO (provide human resource)
World Bank
others (CIFOR, ICRAF)

Annex 03

Reference 1

1st Tropical Peatland Roundtable

2nd November 2017

"Jakarta Declaration" on
Responsible Management of Tropical Peatland

Truly effective Tropical Peatland Restoration in Indonesia will require substantial development of an integrated peatland management system based on scientific and technical knowledge and information. Achieving this requires the establishment of an International Committee for Technical Consultation to facilitate Tropical Peatland Restoration Action.

For this purpose, the IPS (International Peatland Society), BRG (Peatland Restoration Agency, Indonesia) and JPS (Japan Peatland Society) organized the 1st "Tropical Peatland Roundtable" on the 1st and 2nd November 2017 in Jakarta, supported by JICA (Japan International Cooperation Agency), Norwegian Embassy, UNDP (United Nations Development Programme), and BRG.

After two days of thorough discussion, a principal strategy of Responsible Management of Tropical Peatland was agreed. This includes five pillars of action:

- establish a "Tropical Peatland Center"
- organize an "International Committee for Technical Consultation"
- develop an "Integrated Monitoring System"
- conduct a "Model Project" for responsible management
- achieve capacity building

We release this "Jakarta Declaration" as a milestone for promoting action on "Responsible Management of Tropical Peatland", also as a basis for bridging Indonesian stakeholders and the international community.

Gerald Schmilewski	Nazir Foead	Mitsuru Osaki
The President of the International Peatland Society (IPS)	The Head of Peatland Restoration Agency (BRG)	The President of Japan Peatland Society (JPS)

Annex 03

Reference 2
https://www.unenvironment.org/resources/publication/managing-peatlands-cope-climate-change-indonesias-experience)

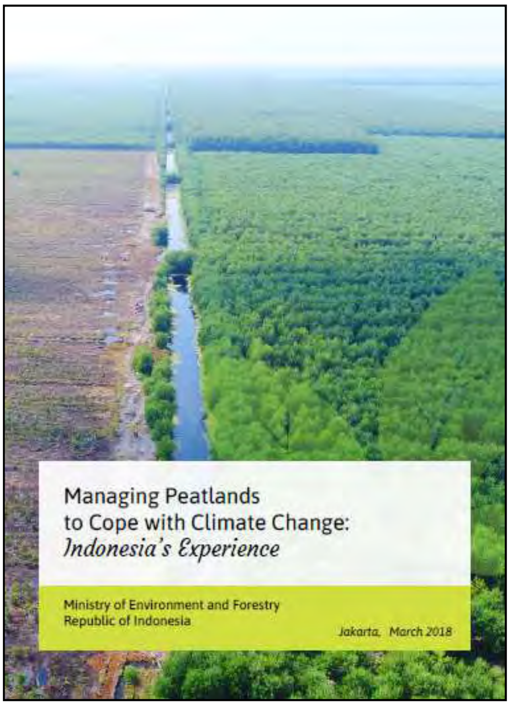
Managing Peatlands to Cope with Climate Change: Indonesia's Experience
Ministry of Environment and Forestry Republic of Indonesia *Jakarta, March 2018*

Another initiative to support peat management in Indonesia and other tropical countries is the development of Tropical Peatland Research Centre (TPRC) to serve as a networking platform. The development of TPC in Indonesia is very strategic as Indonesia has extensive experiences in managing and conserving tropical peatland and has plenty of research and development agencies working on peatland that can be the backbones of the centre. The proposed scopes of the TPC are:

1. Database Development
2. Networking and Research collaboration
3. Paludiculture, Agroforestry, & Restoration techniques
4. Utilization zone of Peat Hydrological Unity (PHU) for social forestry
5. Tenure allocation in the utilization function of PHU
6. Strengthening method of GHG emission estimation on peatland
7. Conservation and sustainable peatland management
8. Bio-technology for mitigating peatland fire

Annex 03

Title : Managing Peatlands to Cope with Climate Change: Indonesia's Experience (#21)



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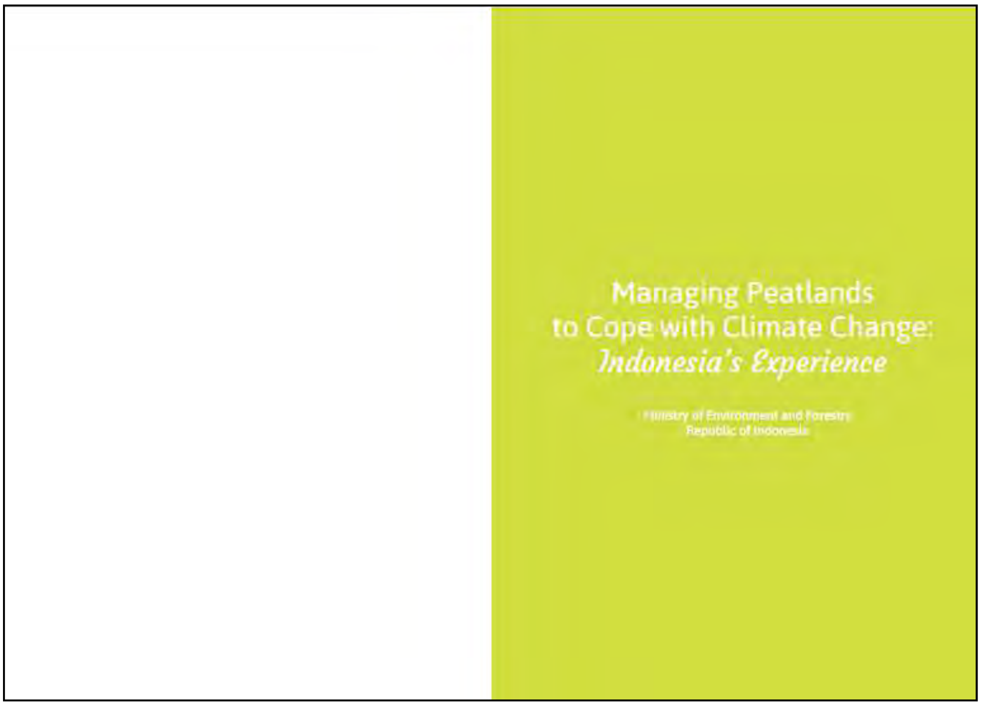

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Annex 03

Foreword

For more than 40 years, in particular during El-Nino, a massive peat and forest fire is unavoidable and causing severe haze and along with the huge environmental economic and social costs. Hence, the current regime has set ultimate goals, which great changes: **No more peat and forest fires in Indonesia**. Indonesia has prioritized environmental strategy to restore degraded peatland while conserving the good ones with focus for alternative livelihood for communities reside within and surrounding peat areas. In addition, learning from the severe 2015 forest fires, the government has also undertaken firm legal actions by bringing responsible individuals and corporations before the law with both administrative and criminal accusation.

The results of the new approach in managing the drivers of fires are very significant. Indonesia has proven dramatic reduction of fire spots by 93.6% from 2015 to 2017. This achievement significantly led to reduction of emissions from forests and lands, including from peatlands. We can proudly claim emission from peat fires in 2017, which was 12,5 million tons CO2e, is equal to only 1.56% of emissions from peat fires in 2015. We keep maintaining our vigilance at all levels of government, from national to sub-national at province and district untill village councils. We should also nurture the excellent support from all stakeholders, including the Civil Society and especially the private sector. This great achievement need to be continuously maintained and improved in the future.

Several other measures were also taken to improve peatland management, from issuing policy and regulations; developing institutional arrangements; conducting research and development; as well as providing incentives for conservation and sustainable management of peatlands. We also build international cooperation to foster global environmental benefits. Indonesia's active participation in the Global Peatland Initiative (GPI) should significantly contribute to the development for excellent platform for policymakers, scientists and private sector. We are keen to make Indonesia as an international centre of excellence and to share our experiences and lessons learned to global stakeholders.

Jakarta, March 2018

Dr. Siti Nurbaya
Minister of Environment and Forestry
Republic of Indonesia

Figure 1. Pristine Peatland of Indonesia, Giam Siak Biosphere Reserve, Riau Province (2017)

Introduction

Managing Peatlands, to Cope with Climate Change:
Indonesia's Experiences[1]

Indonesia has over 15 million ha of peatlands, which is over 12% of its forest land spreading across islands of Sumatra, Kalimantan, Sulawesi and Papua. This is the largest tropical peat land in the world, followed by Democratic Republic of Congo, with the peatland area reaches 9 million ha, and the Republic of Congo with the area reaches about 5.5 million ha (Miles et al., 2017).

Peatland can be defined as soil formed from the accumulation of organic matters such as the remnants of plant tissue that lasted for a long time (Kelompok Kerja Pengelolaan Lahan Gambut Nasional, 2006). According to Government Regulation (GR) No. 71 of 2014 that has been amended by GR No. 57 of 2016 on the Protection and Management of Peat Ecosystem, peatland is defined as a naturally occurring organic material of plant residues that decomposes imperfectly and accumulates in swamps. Furthermore, the regulation also defines peat ecosystem as the order of peatland components that forms an integrated system affecting one another and forming a balance, stability, and productivity.

As the home for the largest peatland areas, the local lives in harmony with peat. They have developed an environment sustainably method. As for example, the Dayaks and Banjareses, living in Kalimantan island continue preserving rotating farming system which maintain balance between utilization process to natural cycle (Suwardi et al., 2005). They divide the land use into zones comprising settlement, bushes, harvested paddy field (*junungan*), dry paddy field (*pahumaan*), plantations, sacred zones, and protected zones (*kayuan*). Sacred zones are customary protected zones that should not be cleared for agricultural land. They also have what so called "*Handil*" a small canal only for access to their small agriculture areas without damaging peat hydrological system. Peat areas uses for subsistence only and conducted sustainably.

1. Policy Paper of the Indonesian Delegation at Global Peatlands Initiative: 3rd Meeting of Partners, Brazzaville 21 – 23 March 2018

Annex 03

In 1960's, as part of national transmigration program, many people from Java, the most densely populated areas, were moved to Kalimantan and Sumatra islands. Coupled with timber boom in 1970s, Sumatra and Kalimantan were also opened for logging followed by the development of industrial plantation forest and estate crop, especially oil palm, since 1990s. These two main drivers (transmigration and industrialisation of forest and peat areas) significantly cause peat degradation. It was estimated almost half of Indonesia's peatland have been degraded and mostly located in Sumatra and Kalimantan (Wahyunto et al. 2014 in Masganti, Wahyunto, Dariah, Nurhayati, & Yusuf, 2014; Setyawati et al., 2014). For more than 40 years, in particular during El-Nino, a massive peat and forest fire is unavoidable and causing severe haze and health problem in addition to other economic and social costs.


Figure 2. Industrial Plantation Forest in Peatlands, Riau Province

Considering the significance of Indonesia's peatlands for the environment as well as for the livelihoods of the communities surrounding the area, Indonesia has prioritized its environmental strategy to restoring degraded peatland, conserving the remaining good peatland and providing alternative livelihood for communities living inside and surrounding peatland. Several measures were taken including issuing policy and regulations reflecting the commitment for better peatland management, developing institutional arrangements to deal with problems in peatland management, conducting research and development to better manage Indonesia's peatland, and providing incentives for conservation and sustainable management of peatland.

In addition, Indonesia is also strengthening its international cooperation to deal with peatland and fire management since it is not only important for domestic benefits, but also influential to global environmental benefits. One of Indonesian participation in international fora is the Global Peatland Initiative that provides an excellent platform for scientists, policymakers and private sector to share experiences and lesson learnt between the major tropical peat countries within the world and international centres of excellence.

Indonesia's Peatland Governance

Governing a vast peatland across several islands in Indonesia is a huge task. In the past, Indonesia experienced unsustainable peatland management leading to the degradation of peatland and peat fires. Thinking over the negative impacts resulted from peat degradation and fires, the government of Indonesia has prioritized the protection and sustainable management of peatlands, including the restoration of heavily degraded peatlands.

Presidential Instruction No. 8 of 2015 on the Suspension of New


Figure 3. The Development of Policies and Regulations for Peatland and Fire Management

Licenses and the Improvement of Primary Forest and Peatland Governance or commonly referred to as Inpres Moratorium is a monumental decision reflecting the commitment of Indonesian government to reform its peatland and forest management. It has targeted the postponement of formal licenses for companies. The coverage of peatlands and primary forests affected by this policy has been mapped and update every six months. This political will has been supported or followed up by other regulations, including:

1. Government Regulation No. 57 of 2016 on the Amendment of the Government Regulation No. 71 of 2014 on the Protection and Management of Peat Ecosystem;
2. Environment and Forestry Ministerial Regulation No. 15 of 2017 on the Procedures for Measuring Water Table in the Peat Ecosystem Management Area;

3. Environment and Forestry Ministerial Regulation No. 16 of 2017 on the Technical Guide for Recovering the Function of Peat Ecosystem; and
4. Environment and Forestry Ministerial Decree No. 77/2015 on the Mechanisms to Deal with Burnt Area within Production Forest Concessions;
5. Environment and Forestry Ministerial Regulation No. 17 of 2017 on the Amendment of the Environment and Forestry Ministerial Regulation No. 12 of 2015 on the Development of Industrial Plantation Forest.
6. Environment and Forestry Ministerial Decree No. 129 of 2017 on the Development of Peat Hydrological Unity Map
7. Environment and Forestry Ministerial Decree No. 130 of 2017 on the Development of Peat Ecosystem Function Map.

Government Regulation No. 57 of 2016 is intended to intensify the efforts for protecting and sustainably managing peatland, responding to the big peat fire in 2015. Environment and Forestry Ministerial Regulation No. 15 of 2017 guides the measurement of water table at the peat ecosystem management sites, while Environment and Forestry Ministerial Regulation No. 16 of 2017 is providing guidance to improve efforts for protecting vulnerable peat ecosystems. In addition, Environment and Forestry Ministerial Decrees No. 129 and 130 of 2017 classify peat hydrological unit as protection and cultivation areas.


Figure 4. President Jokowi's visit for field directives to the Minister of Environment and Forestry, Chief of Army, and Chief of Police at a burnt peatland forest, Central Kalimantan September, 2015

Environment and Forestry Ministerial Decree No. 77/2015 guides the restoration of peat ecosystem in production forest. This regulation is an effort to have a better management of timber within Indonesia's peatlands. Furthermore, Environment and Forestry Ministerial Regulation No. 17 of 2017 provides directions for concession holders in restructuring and reforming their working areas. These regulations may be lesson learned for other countries such as Democratic Republic of Congo that now has about 20% of its peatlands under forest concessions, and approximately 53% of these are in the process (Miles et al., 2017).

The results of Indonesia's political will and commitment to implement sustainable management of peatland are dramatic. The extent of fire in 2017 decreased by 61.8% compared to fires in 2016 and by 93.6% compared to the extent of fire in 2015. Table 1 shows the reduction of the area burnt and number of hotspot during 2015 – 2017.

Table 1. The Extent of Burnt Area and Number of Hotspots from 2015 to 2017

Year	Number of Hotspot	Burnt Area (Ha)		
		Peat	Mineral	Total
2015	70,971	891,275	1,720,136	2,611,411
2016	2,844	97,787	340,576	438,363
2017	2,440	13,555	151,929	165,484

Figure 5. Number of Hotspots from 2015 to 2017

The success to reduce the number of hotspots and the area burnt during the last three years has led to the reduction of emissions from forests and lands, including from peatlands. Emissions from peat fires in 2017 was about 12,5 million tons CO2e or only 1.56% of emissions from peat fires in 2015 that reached 803 million tons CO2e. This is a big achievement that need to be maintained and institutionalized at all level of governments, from central to provincial and district until village governments.

Figure 6. Police lines by MoEF investigation, 2015

Policies and regulations developed for governing Indonesian peatland have also been supported by law enforcement implemented by the Ministry of Environment and Forestry and other law enforcement bodies. After big land and forest fires in 2015, about 500 cases have already been brought to justice and some of them have received sanctions, including a historic USD 1.2 billion fine to a private corporation proven to have committed crimes against the environment. This law enforcement does not only prevent others to do similar crimes, but also improves public trust in environmental law enforcement in Indonesia.

Figure 7. Peatland areas burnt from 2015 to 2017

International Cooperation for Managing Peatland

As indicated in the previous section, Indonesia does not only work by itself to mitigate problems in relation to peat management and peat fires. We also communicate and collaborate with other countries and international agencies to stop peat degradation and prevent peat fires. In the Southeast Asia Region, as the ASEAN member, Indonesia has ratified the ASEAN Agreement on Transboundary Hazard Pollution (AATHP) through Law No. 26 of 2014 on AATHP Endorsement, dated 14 October 2014. AATHP aims to prevent and control cross-border smoke pollution as a result of land and/or forest fires particularly in peatlands that must be implemented through intensive national, regional and international efforts based on commitment, a spirit of partnership, and a tradition of solidarity to achieve peace, progress and prosperity among ASEAN countries.

The ASEAN Task Force on Peatlands (ATFP) was established to assist monitoring and supporting the implementation of the ASEAN Peatland Management Strategy (APMS 2016-2020). Its main role is to achieve the objectives of the APMS through overseeing the design and implementation of the ASEAN Program on Sustainable Management of Peatland Ecosystems (APSMPE 2014-2020) and other relevant program/projects and facilitating cooperation with relevant partners, and reporting the progress of APMS implementation to COM to AATHP.

An ASEAN cooperation project is the "Measurable Action for Haze-Free Southeast Asia" (MAHFSA) funded by the International Fund for Agricultural Development (IFAD) and involves Cambodia, Indonesia, Malaysia, Lao PDR, Philippines, Thailand and Viet Nam. The MAHFSA initiative will help strengthen existing ASEAN coordinating mechanisms to engage all stakeholders, strengthen capacity, harmonize relevant programs and projects, and facilitate donor agencies to promote fog-free agriculture, sustainable management of peat swamp forests and implementation of ASEAN Haze Roadmap.

At the international level, Indonesia is one of the three founding countries of the Global Peatlands Initiative, together Peru and the Republic of Congo, as well as 11 international organizations lead by the UN Environment. Among the members, Indonesia is the first ever country undertaking large scale peatland restorations. The establishment of GPI aims to protect peat from degradation based on long-term field research. The GPI undertakes a thorough assessment of the world's peat status and stored carbon where peat can help in achieving climate change mitigation as mandated by Paris Agreement. In addition, the GPI assists countries by strengthening knowledge and finding options for reducing peat degradation and improving sustainable peat management.

Figure 8. L-R: Tim Christophersen, UN Environment; Minister Arlette Soudan-Nonault (Republic of the Congo); Minister Siti Nurbaya (Indonesia); and Minister Amy Ambatobe Nyongolo (DRC)

Best Practices of Peatland Management

Indonesia's peatlands have been utilized since the end of 19th Century. Prior to 1920, Dayak rural communities in South Kalimantan have begun to manage shallow peatlands in the area behind the river bank (back swamp) which they call the *lawau* and manage it for rain-fed rice fields (Suwardi et al., 2005). The river area is a fertile area because it is influenced by sediment runoff from rivers. Basically Dayak people are very environmentally friendly. In managing the land, they have a rotating farming system that always maintains a balance with the utilization process following a natural cycle (Suwardi et al., 2005). They divide the lands into zones comprising settlement, bushes, harvested paddy field (*jurungan*), dry paddy field (*pahumaan*), plantations, sacred zones, and protected zones (*kayuan*). Sacred zones are customary protected zones that should not be cleared for agricultural land. When the agricultural land has become infertile, they will move to look for similar land in other places. After being left for 1-7 years the former fields will become bush and after 7-12 years the bush will become a forest. They will reopen the former field after 30 years, when it has become a forest again. This is done continuously and sustainably.

In 1950's, Banjar people started to access peatland for farming (Suwardi et al., 2005). First, they build "*handil*", a main drainage canal. Handil is made upraised with a large river, and is usually an extension of the existing river branch that is excavated and extended to an annex land up to 4-10 km long. The depth of the canal may reach 1 meter, with 2 meter width. *Handil* serves as: (1) drainage canal; (2) irrigation; and (3) communication channel. Secondly, they build "*parit*", the secondary canal upraised to the handil and located every 30 meter along the *handil*. The depth and width of the parit are 1 m and 50 cm respectively. Using this traditional *parit* and handil, an excessive drain can be prevented and soil subsidence can be slowed. These are the example of how traditional knowledge and wisdom can manage peatland sustainably and prevent peat degradation that may lead to fires.

Annex 03

Figure 9. Traditional Utilisation of Peatland for Farming

Indonesia is also developing modern and advanced techniques in managing peatland and preventing fires. Forestry and Environmental R&D and Innovation Agency (FOERDIA) has provided scientific-based techniques and policies in managing peatlands and preventing fires. In the last 8 years, FOERDIA has been able to provide information related to: (1) Typology and distribution of peatland in Indonesia; (2) Technology to rehabilitate degraded peatland; (3) Phenology of tree species that can adapt to peatland; (4) Alternatives for participatory peatland management; and (5) the impact of deforestation in peatland on GHG emissions.

Another institution, Agency for Assessment and Application of Technology (*Badan Pengkajian dan Penerapan Teknologi*/BPPT) also provides technology for monitoring water table level in peatlands. They provide two technologies for monitoring the main parameter for determining the soundness of peatland.

First technology is provided in collaboration with Japanese scientists to monitor water table using Sensory Data Transmission Service, called SESAME. The second technology is called MORPALAGA (*Monitoring Real Time Tinggi Permukaan Air Lahan Gambut*/Realtime monitoring for peatland water table level).

The Role of Private Sectors in Supporting the New Policies in Managing Peatland

Figure 10. Canal Blocking Perimeter of a private company in Riau Province

The role of private sectors in balancing economic and ecological aspects of peatland management is important. As they manage the peatland based on regulations and technical guides provided by the government, their compliances to the regulations will ensure the sustainability of Indonesian peatlands. Some of the peatland has been utilised for commercial purposes by 100 concessionaires, including 99 concessions for industrial plantation forest and 1 concession for logging natural production forest concession. In 1990s the number of concessionaires were only 12, in 2000s the number increased significantly to become 73. Since 2010, the number of concessionaires have increased by 17 to become 100 concessionaires in total.

Figure 11. Canal Blocking Perimeter of a private company in Riau Province

Of the 99 concessionaires developing industrial plantation forests in peatlands, 55 concessionaires have fully adjusted their working plans to comply with the new regulation on peat ecosystem function, 20 concessionaires are being assessed, and 12 concessionaires need to revise their new plans. This is a significant measure in ensuring the ability of peatland to provide economic benefits and social welfares through an environmentally friendly way.

Peatland Management and Nationally Determined Contribution (NDC)

Figure 12. Forest Fire in South Sumatra, November 2015

Peatland is a storage of huge amount of carbon. It is estimated that peat can contain about 6 tonnes per hectare of 1 cm depth. Overall, Indonesian peatlands stores about 46 Giga tons, or about 8-14% of the carbon stored in the world peatlands. It is this carbon content that has become source of problems due to its emission when burnt, and at the same time also become a potential solution if well managed. In the context of climate change mitigation and adaptation. In our First National Determined Contribution submitted to the UNFCCC, 17% or over half of the 29% of the emission reduction target, comes from land based sector, which are mainly forest and peatlands.

The Indonesian NDC has targeted to restore 2 million ha of degraded peatland by 2030 with about 90% success rate. The strategy to restore 2 million ha of degraded peatland can be implemented by restoring 150,000 ha of peatland every year from 2018 until 2030. This strategy may reduce emissions for about 1 GtCO2e within 13 years from now (Muttaqin, Suryandari, Alviya, & Wicaksono, 2017). This is a significant contribution to the achievement of Indonesian NDC. To be able to achieve this target, collaborative actions among parties such as Ministry of Environment and Forestry, Peat Restoration Agency, Research Centres, Universities, Local Governments, Communities and NGOs are a must.

The restoration of degraded peatland has been conducted through:

1. Application of peat restoration techniques that include water management on site level (operational scale);
2. Construction, operation and maintenance works, including the arrangement of canal blocking installation (rewetting infrastructure);
3. Application of cultivation according to local wisdom; and/or
4. Research and development, taking into account and adhering to the development of science and lessons learnt from international perspectives.

As the NDC requests for 90% success rate, peatland restoration needs to comply with indicators of success. According to Environment and Forestry Ministerial Regulation No. 16 of 2017 on the Technical Guides for Recovering Peat Ecosystem, the recovery of peat ecosystem function is declared successful when:

1. There is no exposure to pyrite and/or quartz sediments under the peat layer at the point of compliance;
2. Water table level in peatlands are less than 0.4 (zero point four) meters below the surface of peat at the point of compliance;

Figure 13. Fire-fighting by Manggala Agni, MoEF, 2015

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3. The condition is better than the standard criteria for degraded peat ecosystem as specified in the Environmental Permit;
4. The condition is better than the "degraded standard" of spatial analysis resulted from field survey activities or data analysis and information scale 1: 250,000 (one in two hundred fifty thousand) or the results of monitoring of the point of compliance; and/or
5. The number of plants growing at least in a healthy condition are 500 (five hundred) stems/hectares in the third year.

The importance of peat restoration is also related to the prevention of peat fire that may lead to a huge amount of carbon released to the atmosphere. To deal with the fire problem, a Grand Design of Forest, Estate and Land Fire (*Karhutbunla*) Prevention in 2017-2019 has been developed by the Coordinating Ministry for Economic Affairs, National Development Planning Agency and Ministry of Environment and Forestry to improve coordination, synergy and harmonisation between central and regional governments and increase the participation of other sectors. The scenario of the reduction of *karhutbunla* in the grand design uses two approaches comprising: (1) Ensuring that the 2.4 million hectares of peat land area under Peatland Restoration Agency are not burnt; and (2) Ensuring that 731 villages identified by MoEF as fire-prone villages are not burnt.

Peatland Management and Sustainable Development Goals (SDGs)

The ultimate goal of the sustainable development goals is to end poverty, protect the planet and ensure prosperity for all. Hence, managing peatlands should also comply with the goals. However, managing peatlands to provide livelihoods for local communities as well as to conduct intensive agriculture and forestry may contradict with the protection of the environment. The options are whether peatlands should be drained or to be sustainably managed

If peatlands should not be drained, then the question is what are the alternatives for economic activities? Paludiculture and agroforestry could be the answer. Paludiculture is the agricultural or silvicultural system of wet and rewetted peatlands (Wichtmann & Joosten, 2007). Hence, the agriculture or forestry is conducted in wet peatlands under conditions in which the peat is conserved or even newly formed. Indonesians have experiences in paludiculture by utilizing or cultivating jelutung (*Dyera sp.*), a latex producing tree. Other species that are also utilised in a wet peat situation include Belangiran (*Shorea balangeran*), Ramin (*Gonystylus bancanus*), *Alstonia pneumatophora*, *Combretocarpus rotundatus* and *Macaranga pruinosa*.

People also utilise Gemor (*Alseodaphne coriacea*), well-known as peat swamp tree of which the bark is harvested and is used as a mosquito repellent and sold on local markets. There are many more species

Figure 10. Agroforestry in peatland at Lakitan FMU, South Sumatra

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of which the timber and non-timber products can be utilised using paludiculture in Indonesia. Even a wet peatland is also sources of food such as Sago (Metroxylon spp.) and nipah (Nypa fruticans). Table 2 shows examples of species that have been used for paludiculture in Indonesia. Table 2. Suitable Species for Paludiculture in Indonesia.

Table 2. Suitable Species for Paludiculture in Indonesia

No.	Benefit / Use	Species
1.	Food (fruits, carbohydrate, protein, spice)	Sago (*Metroxylon sago*), Kerantungan (*Durio oxyelaxus*), Pepaken (*Durio kutejensis*) Mangga Kesturi (*Mangifera casturi*), Kweni (Margifera ofodara), Nipah (*Nypa fruticans*), Durian (*Nephelium* spp.), asam kandis (*Garcinia xanthoxymus*)
2.	Fiber	Geronggang (*Cratoxylum arborenscens* Terentang (*Campnosperma auriculatum*), gelam (*Melaleuca cajuput*)
3.	Bio-energy	Gelam (*Melaleuca cajuput*), sago, nipah
4.	Latex	Jelutung (*Dyera polyphylla*), nyatoh (*Palaquium leiocarpum*), sundi (*Payena* spp. *Madhuca* spp.)
5.	Medicine	Akar kuning (*Coscinium fenestratum*), pulai (*Alstonia pneumatophora*)
6.	Others (Non-timber)	Gemor (*Alseodaphne* sp.; *Notaphoebe* sp.), purun (*Elaeocharis dulcis*), rattan (*Calamus tracycoleus*), gaharu
7.	Conservation-value	Ramin (*Gonystylus bancanus*), *Shorea* spp.

Source: Tata and Susmianto (2016)

Secondary crops (*palawija*) and horticultural plants, that have a short root system, such as corn, cassava, and pineapple are also able to grow well in shallow peatlands with closed water channels, therefore, in some locations agroforestry can be applied in peat forests (Tata & Susmianto, 2016). Furthermore, if paludiculture is also conceptualised as a broader technique to utilise peatland for productive uses, silvofishery, silvopasture and peatland-based ecotourism can also be classified as paludiculture, as long as the role and function of the peat ecosystem is not disturbed (Tata & Susmianto, 2016).

When peatland is drained for forestry and agriculture, an option that can be taken is Land Clearing without Burning (*Penyiapan Lahan Tanpa Bakar/PLTB*). PLTB is a practice that needs to be done to prevent the use of fire in clearing plant remnants in the area to be planted. Litter or crop residues can be processed into several types of products such as:

1. Compost; plant remnants can be utilized for composting raw materials so that during the growing season farmers can use compost as a natural fertilizer that is environmentally friendly because it can reduce the use or even do not have to use chemical fertilizers.
2. Wood vinegar; making wood vinegar is a PLTB strategy that is relatively new and is still being disseminated to communities. Wood vinegar is useful as a fertilizer as well as compost. Wood vinegar helps restore soil fertility; therefore farmers can produce it and use it for plating purposes.
3. Charcoal briquettes; the use of waste wood or twigs for the production of charcoal briquettes can also be done so that agricultural waste in the form of wood and twigs are not burned away. Charcoal briquettes can be used as more environmentally friendly fuel for cooking. It is also cheaper. However, there are still obstacles in community-based charcoal briquettes production since the equipment for producing the briquettes is expensive.

Figure 15. Measuring Water Level

Peatland Restoration Agency:
A smart way to obtain a quick win

The Jokowi Administration have seen that improving forest and land governance may take times. Thus, it needs an acceleration and simultaneous actions to have results in a relatively short period. In terms of fire prevention strategy, the Government of Indonesia then established Peatland Restoration Agency (*Badan Restorasi Gambut/BRG*) in January 2016, after the big fire incident of 2015. The Agency is tasked to rehabilitate 2 million hectares by 2019, and the current program is to carry out 2.49 million hectares restoration, which include 1.1 million ha to be performed by the Government and partners, while 1.39 million hectares by relevant private companies. This agency focuses on rehabilitating and restoring heavily degraded peatlands in fire-prone areas. Thus, this agency supports the grand strategy for peatland management developed by Directorate of Peatland Degradation Control, Directorate General for Pollutant and Environmental Degradation Control, Ministry of Environment and Forestry

By the end of 2016, peat restoration priorities of 2,492,527 hectares have been mapped. Another achievement is social intervention through community support in 104 villages in four priority districts of 806,312 hectares. Social intervention is crucial in order for a community consultation process and consensus agreements where canals and a drill canal will be built. Thirty six concession holders have been assigned, spreading in South Sumatra, Central Kalimantan, West Kalimantan, Riau and Jambi Provinces for peat restoration on 650,389 hectares or 26% of the area of peat restoration. In the restoration, concession holders also obtained technical guidance including water level and humidity monitoring techniques.

Figure 16. Canal Blockage for Rewetting Peatland

By the end of 2017, activities in 75 villages had been initiated in six provinces, with a total area of 1,180,446 hectares. These villages are called peat-caring villages, with thousands of its population are considered as guards in the maintenance of peat ecosystems. Revitalization has been undertaken for the livelihoods of 101 community groups (kelompok mayarakat/pokmas) through assisting community to clear lands without burning, developing local commodities, providing training of freshwater fish cultivation, livestock breeding and bee honey production. The area of restored land reaches 1.2 million hectares. This figure does not include 93 thousand hectares of peatlands restored by partners, and is spread over six provinces.

Other accomplishments are the preparation of the National and Provincial Peat Ecosystem Restoration Plan (*Rencana Restorasi Ekosistem Gambut/RREG*) and Peat Ecosystem Mapping Inventory. The RREG objective is to restore degraded peat ecosystem area caused by forest fires and 2 million hectares of land, with the focus being the Peat Hydrological Units (*Kesatuan Hidrologis Gambut/KHG*).

Peat ecosystem data is very important, as it can be used to identify and intervene degraded peatland based on the causes of degradation. Using Light Detection and Ranging (LIDAR) technology, very detailed ecosystem data can be obtained including topographic data, land cover, hydrological conditions, and carbon content estimates.

Observation points of peat water level have been established, that is eight in South Sumatra, seven each in Riau, Jambi, and Central Kalimantan, and one in West Kalimantan. The water level data can be accessed in real time modes. Monitoring the peatland water level is important to identify potential fires and forests. Drained peatlands is a trigger for forest fires that have been a relatively persistent problem for Indonesia. The restoration measures are relatively comprehensive. Not just wetting, trying to restore the peat ecosystem, making the community a vanguard for sustainable peatland management, but also early prevention of fire disasters.

Another initiative to support peat management in Indonesia and other tropical countries is the development of Tropical Peatland Research Centre (TPRC) to serve as a networking platform. The development of TPC in Indonesia is very strategic as Indonesia has extensive experiences in managing and conserving tropical peatland and has plenty of research and development agencies working on peatland that can be the backbones of the centre. The proposed scopes of the TPC are:

1. Database Development
2. Networking and Research collaboration
3. Paludiculture, Agroforestry, & Restoration techniques
4. Utilization zone of Peat Hydrological Unity (PHU) for social forestry
5. Tenure allocation in the utilisation function of PHU
6. Strengthening method of GHG emission estimation on peatland
7. Conservation and sustainable peatland management
8. Bio-technology for mitigating peatland fire

Lessons learned

Indonesia has gained extensive knowledge on peatland management through experiences, research and development, and institutional arrangements. In the past, Indonesian people have traditionally utilised peatland for their livelihoods, but some unsustainable management of peatland have also been experienced by Indonesia during timber boom and agricultural expansion era. These experiences have led Indonesia to focus on the conservation and sustainable management of its peatland.

A comprehensive actions have been taken by Indonesian government including formulating policy and regulations, establishing a special agency for peat restoration, and coordinating actions with all levels of government and stakeholders. Policies, regulations, law enforcement and institutional arrangements in improving management of Indonesian peatland have dramatically reduced the degradation of peatland and peat fire events. This also reflects a better governance of Indonesian peatlands that can ensure protection of good peatland areas from degradation and stop degraded peatland from further damage.

Indonesia also collaborates with international partners to implement its target and ambition in achieving sustainable peatland management. Indonesia is aware that addressing peatlands properly will prevent fire and carbon emissions that will avoid damaging disaster and contribute to global action in mitigating climate change.

Indonesia intends to share these experiences with other countries with peatlands in the tropical world through south-south and triangular collaboration. Indonesia deems it important to share and to assist other tropical countries as parts of its contribution to wider efforts towards achieving sustainable development for the betterment of the planet. The GPI and the UN Environment support the establishment of international research centre on tropical peatlands in Indonesia.

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