

PRE-FS ON INVESTMENT SCHEME FOR JAPANESE PRIVATE SECTOR IN A REDD+ PROJECT IN INDONESIA

PEATLANDS FOREST BIOMASS & CARBON STOCK MEASUREMENT

Wardoyo



MINISTRY OF FORESTRY INDONESIA
in-cooperation with
INTERNATIONAL TROPICAL TIMBER ORGANIZATION



Workshop on Land Cover Land Use Change in South East Asia
Hanoi, 7 – 9 November 2011

OUTLINE:

I. INTRODUCTION

- Forest Land Use Plan of the country**
- Forest land cover**

II. PEAT BIOMASS & CARBON STOCKS

- Why peatlands?**
- Components of peat emissions**

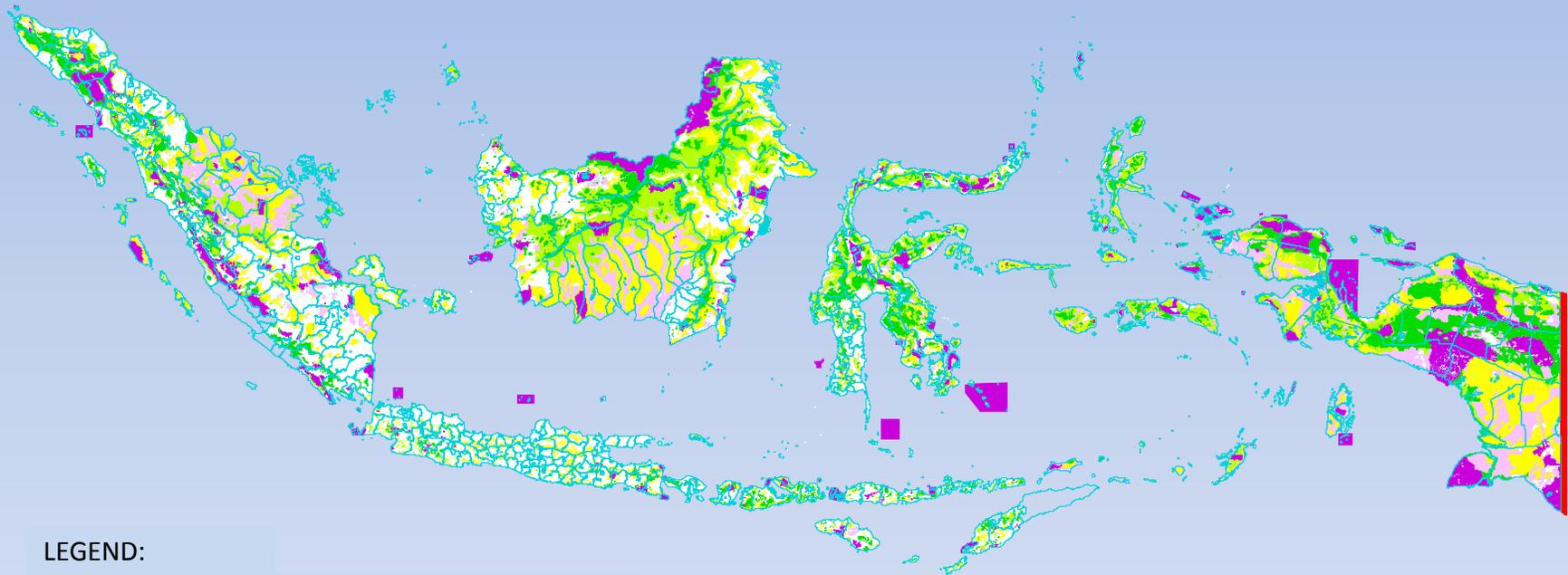
III. PILOT STUDY

- Main Activities**
- Development of methodology:**
 - ... Ground measurement**
 - ... Satellite image interpretation (Landsat, ALOS AVNIR data)**
 - ... Calculation of Biomass & Carbon Stocks**

IV. CONCLUSIONS

I. INTRODUCTION

A MAP OF FOREST LAND USE PLAN (FUNCTIONS)



LEGEND:

- Conservation forest
- Protection forest
- Production forest (Limited)
- Production forest (Regular)
- Production forest (Convertible)
- Non forest lands
- Water bodies (rivers, lakes)

FOREST LAND OF INDONESIA

➤ **Total forest area: 132.4 million ha, consists of 3 functions:**

- **Conservation** 19.7 million ha (14.9%)
- **Protection** 29.9 million ha (22.6%)
- **Production** 82.8 million ha (62.5%)

LAND COVER of INDONESIA

LAND COVER	FOREST LAND		OTHER LAND		TOTAL	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
FOREST	90.135.457	48,0%	8.324.734	4,4%	98.460.191	52,4%
NON FOREST	39.276.188	20,9%	46.490.541	24,8%	85.766.729	45,7%
NO DATA	2.986.084	1,6%	571.647	0,3%	3.557.731	1,9%
Total INDONESIA	132.397.729	70,5%	55.386.922	29,5%	187.784.651	100,0%

➤ **Forest types:**

- **Mountain forest**
- **Low land forest**
- **Swamp forest**
- **Mangrove forest**
- **Peat forest: 16 million ha (total peatlands 22.5 million ha)**



II. PEAT FOREST BIOMASS & CARBON STOCKS

Why more attention to Peatlands recently?

- 1. Peatlands cover 3% area of the world, but peatlands store more than twice forest carbon of the world**
- 2. High demand of peatland forest for other uses (such as, agriculture, oil palm plantation).**
- 3. Carbon emissions of peatlands are 3x bigger than carbon emissions of dry mineral lands.**
- 4. Estimation/measurements of carbon stocks and emissions in peatlands are more complex than those in dry mineral lands, because:**
 - a. peatlands have high diversity in terms of vegetation, land uses, peat thickness and maturity**
 - b. many factors influence GHG emissions of peatlands i.e.: land uses, weather, vegetation growth, water table/level**
 - c. there are various sources of GHG emissions in peatlands**
- 5. Methodology to measure biomass/carbon stock of peatlands has not been well developed**

COMPONENTS of PEAT EMISSIONS:

1. CHANGES OF CARBON STOCK ABOVE GROUND BIOMASS (AGB), & BELOW GROUND BIOMASS (BGB)

AGB Estimation:

-- Allometric equation → Kettering (2000), Brown (2007), Isotomo (2002)

C Stock of AGB:

-- AGB * C-Coefficient

2. CO₂ EMISSION FROM PEAT BIOLOGICAL OXIDATION

-- Peat decomposition

-- Root respiration

3. NON-CO₂ (CH₄, N₂O) EMISSION FROM PEAT BIOLOGICAL OXIDATION

-- relatively small, very limited data available (use IPCC default)

-- need research

4. CO₂ EMISSION FROM PEAT FIRES

-- burned area * emission factor of fuel type

5. NON-CO₂ EMISSION FROM PEAT FIRES

-- relatively small, very limited data available (use IPCC default)

-- need research

III. PILOT STUDY

Pre-FS on Investment Scheme for Japanese Private Sector in a REDD+ Project in Indonesia

Cooperation between Ministry of Forestry Indonesia, and International Tropical Timber Organization (ITTO)

Objectives:

- 1. to select forest areas in peatlands as a pilot study to implement REDD+ operationally**
- 2. to develop a Project Design Document (PDD) for a REDD+ project investment**

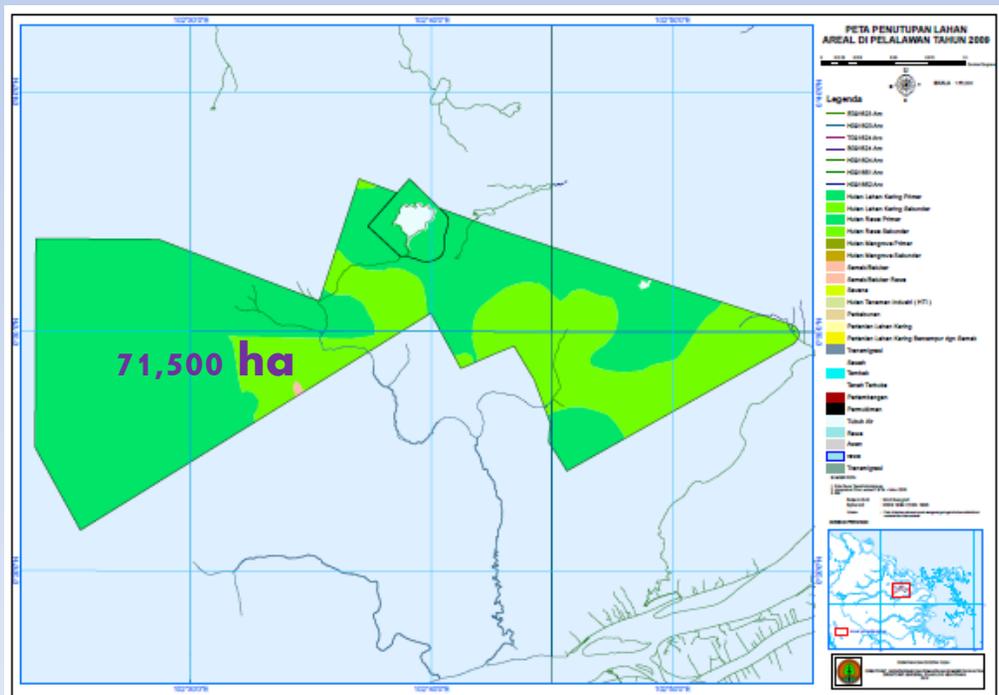
MAIN ACTIVITIES of Pilot Study:

- 1. Site Selection for REDD+ Pilot Areas**
- 2. Analysis of current situation of REDD+/climate change**
- 3. Socialization & coordination with local government**
- 4. Study on REDD+ institutional setting at the FS sites**
- 5. Ground measurement of carbon stocks**
- 6. Consideration of Remote Sensing technology**
 - Collection of satellite images**
 - Interpretation of the images**
 - Analysis of satellite images to measure carbon stock**
- 7. Development guidelines for baseline & monitoring**
- 8. Consideration of MRV Methodology & system**
- 9. REDD+ Project Scheme/Payment Mechanism**

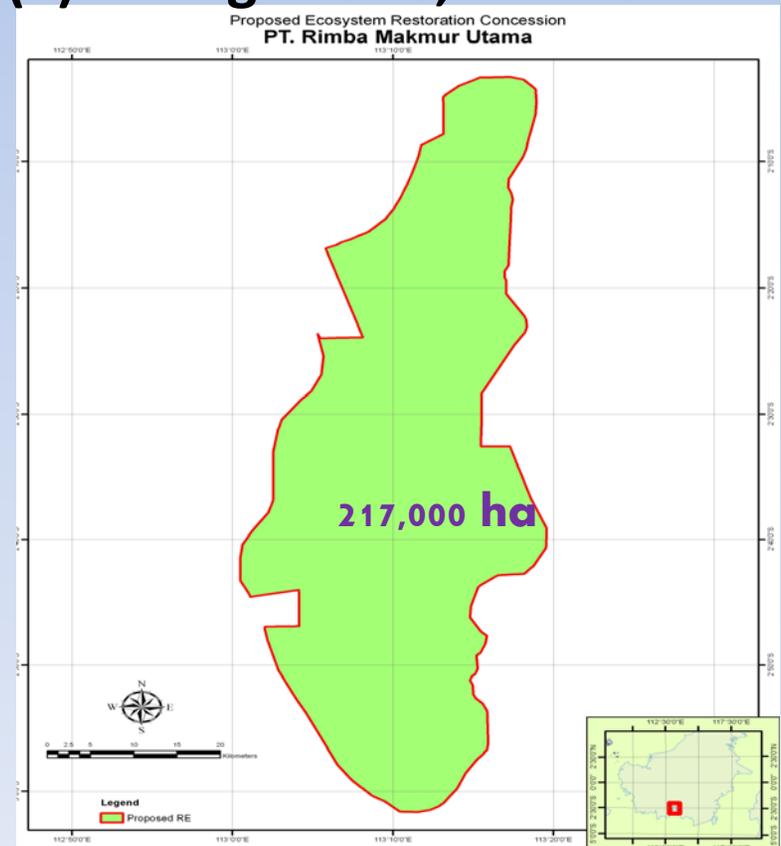
SELECTED PILOT AREAS:

- (i) Peatlands forest of 71,500 ha in Pelalawan, Sumatra
- (ii) Peatlands forest of 217,000 ha in Katingan, Kalimantan

(i) Pelalawan Site, Sumatra



(ii) Katingan Site, Kalimantan



Location of Pilot Areas



This presentation highlights two activities of the project:

A. Ground Measurement (Activity 5)

- Sampling design**
- Plot measurement**
- Calculation of biomass & carbon stocks (ton/ha)**

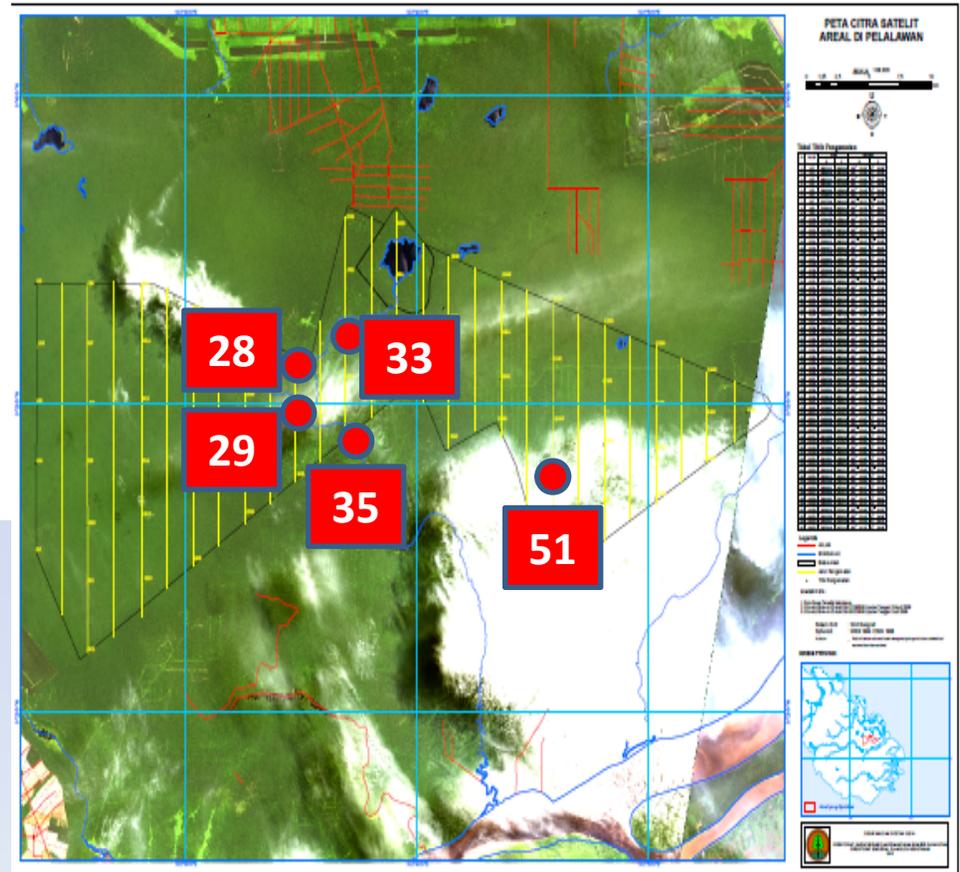
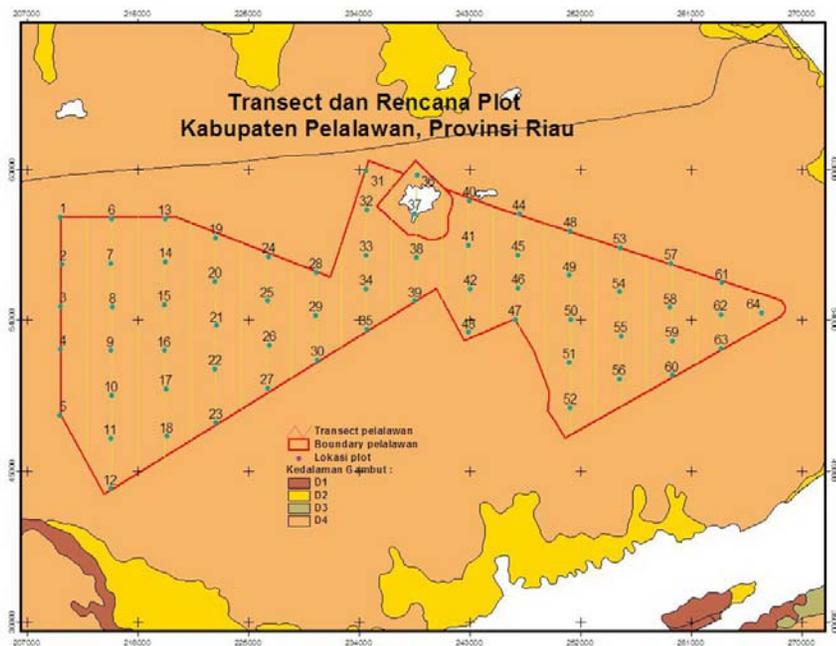
B. Satellite image interpretation (Activity 6)

- Landsat images**
- ALOS – AVNIR images**
- Total biomass & carbon stock calculation (ton)**

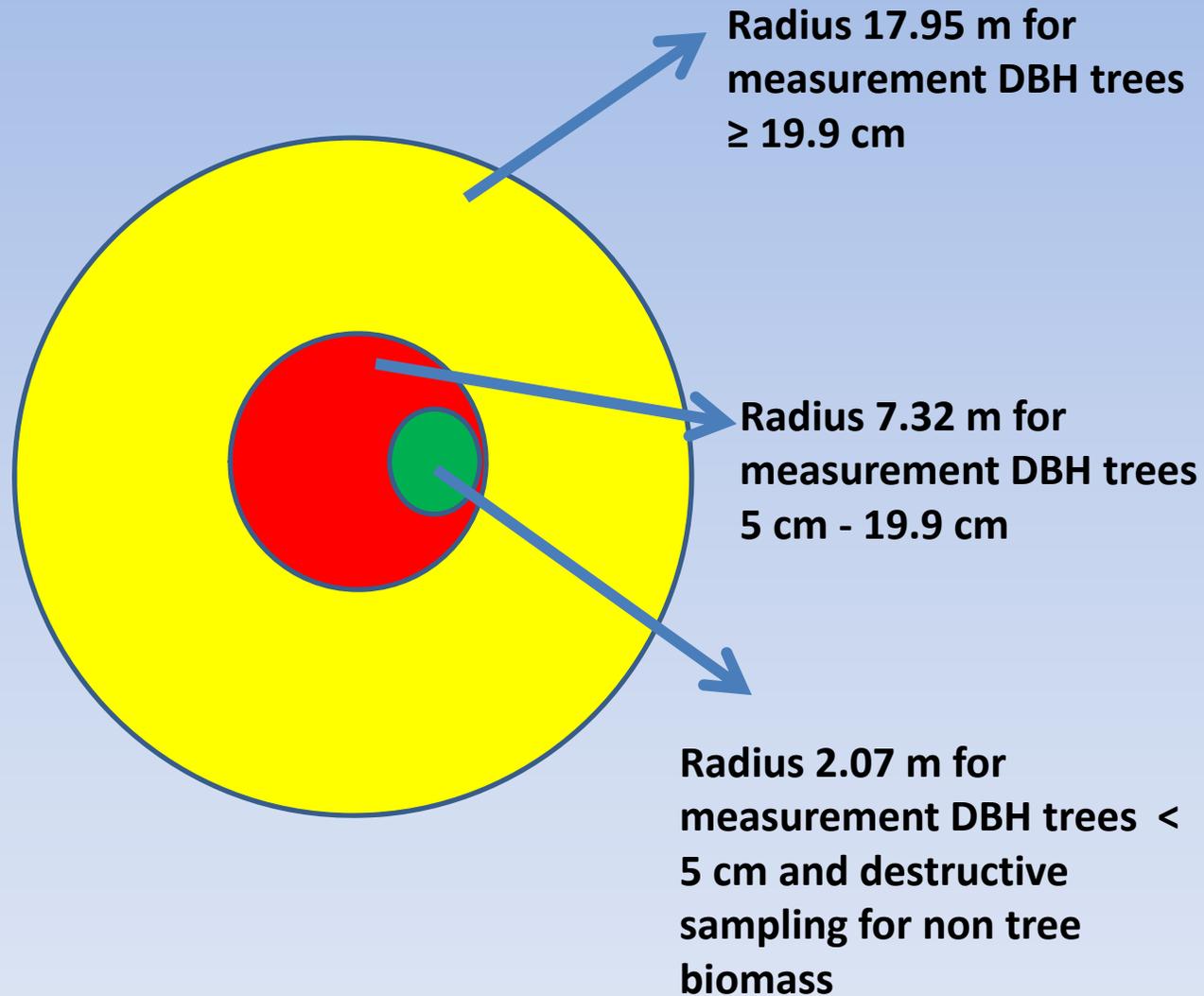
A. GROUND MEASUREMENT

a. Sampling Design

Purposive sampling with random start, sampling intensity 0.0001



Plot Size and Shape (modified from USDA Forest Service, 2000)



b. PLOT MEASUREMENTS

AGB measurement for trees:

Record diameter at breast height (DBH), trees height and tree species.

Identify land cover: primary forest, secondary forest, burned area, open area

Collect samples of woods for gravity analysis

Collect herbarium

AGB measurement for non-trees:

Destructive sampling: weight understory vegetation (biomass)

BGB measurements:

Peat Depth - Measurement is done by inserting a peat drill or Eijkelkamp. If the drill has reached the mineral soil, then the drill is removed and the depth of peat is recorded.

Peat Sample Collection - for analysis of physical and chemical parameters, especially bulk density and organic carbon. Peat samples were taken every 1 m depth until it reaches a peat depth up to 6 m by using standardized ring sampler.

Water Table Level - to determine indication of drainage and flooding in peatlands. The 2.5-inch diameter PVC pipe with 1.5 m length into the peat soil, and 0.5 m of pipe length above the ground surface (PVC pipe was perforated with holes along 50 cm).

Peat depth measurement , and Peat sample collection



Peat depth measurement



Peat sample collection for
Bulk Density & Carbon Organics

Measurement of Water Table



c. CALCULATION OF BIOMASS & CARBON STOCK (ton/ha):

AGB estimation – allometric equations of Kettering (2001)

-- **Tree biomass dbh > 19.9 cm, and dbh 5 cm – 19.9 cm**

$$\text{Tree biomass (kg/tree)} = 0.11 * \rho D^{2.62}$$

where: ρ = wood gravity (kg/m³),

D = diameter at breast height (cm)

Carbon content = tree biomass x c-coeff.

-- **Tree biomass dbh < 5 cm, and non-tree biomass**

weight biomass of trees dbh < 5 cm, non trees

Total dry weight = sample dry weight x total fresh weight
sample fresh weight

Carbon content = 0.35 x total dry weight

c. CALCULATION OF BIOMASS & CARBON STOCK (ton/ha):

BGB estimation:

a. Peat depth (PD)

$$\text{Peat volume} = \text{PD} \times \text{peat area}$$

b. Bulk density (BD)

Bulk density is defined as the mass of soil (peat) per unit volume. Bulk density should be dried in oven at 105 C for a min 48 hours

$$\text{BD} = \text{dry weight of soil sample (g)} / \text{Volume ring soil sampler (cm}^3\text{)}$$

c. Carbon organic content (C-Org)

→ Peat soil carbon content (ton/ha):

$$= \text{BD (kg/m}^3\text{)} \times \text{PD (m)} \times \text{C-org (\%)} \times 10$$

Peat soil carbon stock (BGB) in Pelalawan Site, Sumatra

No. Plot	Peat Depth (cm)	Bulk Density (gr/cm ³)	Carbon Organic	Carbon Stock (ton/ha)
1	550	0.176	0.57694	5584.779
2	430	0.194	0.56443	4708.475
3	530	0.186	0.52954	5220.205
4	330	0.176	0.56105	3258.578
5	930	0.183	0.53280	9067.723
6	700	0.160	0.48573	5440.213
7	700	0.142	0.48487	4820.480
Average	596	0.174	0.53362	5442.922

Carbon stocks above- and below-ground in Pelalawan Site, Sumatra

Category	Diameter (cm)	Biomass (ton/ha)	Carbon Stock (ton/ha)	CO ₂ Sequestration (ton/ha)
Trees	DBH >19.9	133.98	62.97	230.89
	DBH 5 - 19.9	129.99	61.09	224.00
	DBH < 5	10.68	3.74	13.71
Non Trees	Shrubs	1.34	0.47	1.73
Total above-ground		275.99	128.27	470.33
Total below-ground (Peat soil)	596 cm (average of peat depth)	10269.66	5442.92	19957.37
Total (ton/ha) (above- and below-ground)		10545.65	5571.19	20427.70

Peat soil carbon stock (BGB) in Katingan Site, Kalimantan

No. Plot	Peat Depth (cm)	Bulk Density (gr/cm ³)	Carbon Organic	Carbon Stock (ton/ha)
1	350	0.285	0.51796	5167.884
2	155	0.167	0.48235	1251.554
3	140	0.173	0.51960	1261.745
4	212	0.227	0.54365	2621.102
5	133	0.197	0.54045	1414.020
6	140	0.217	0.59070	1796.283
7	165	0.226	0.61155	2285.213
8	650	0.191	0.52854	6554.989
Average	243	0.211	0.54185	2794.099

Carbon stock aboveground and belowground in Katingan Site, Kalimantan

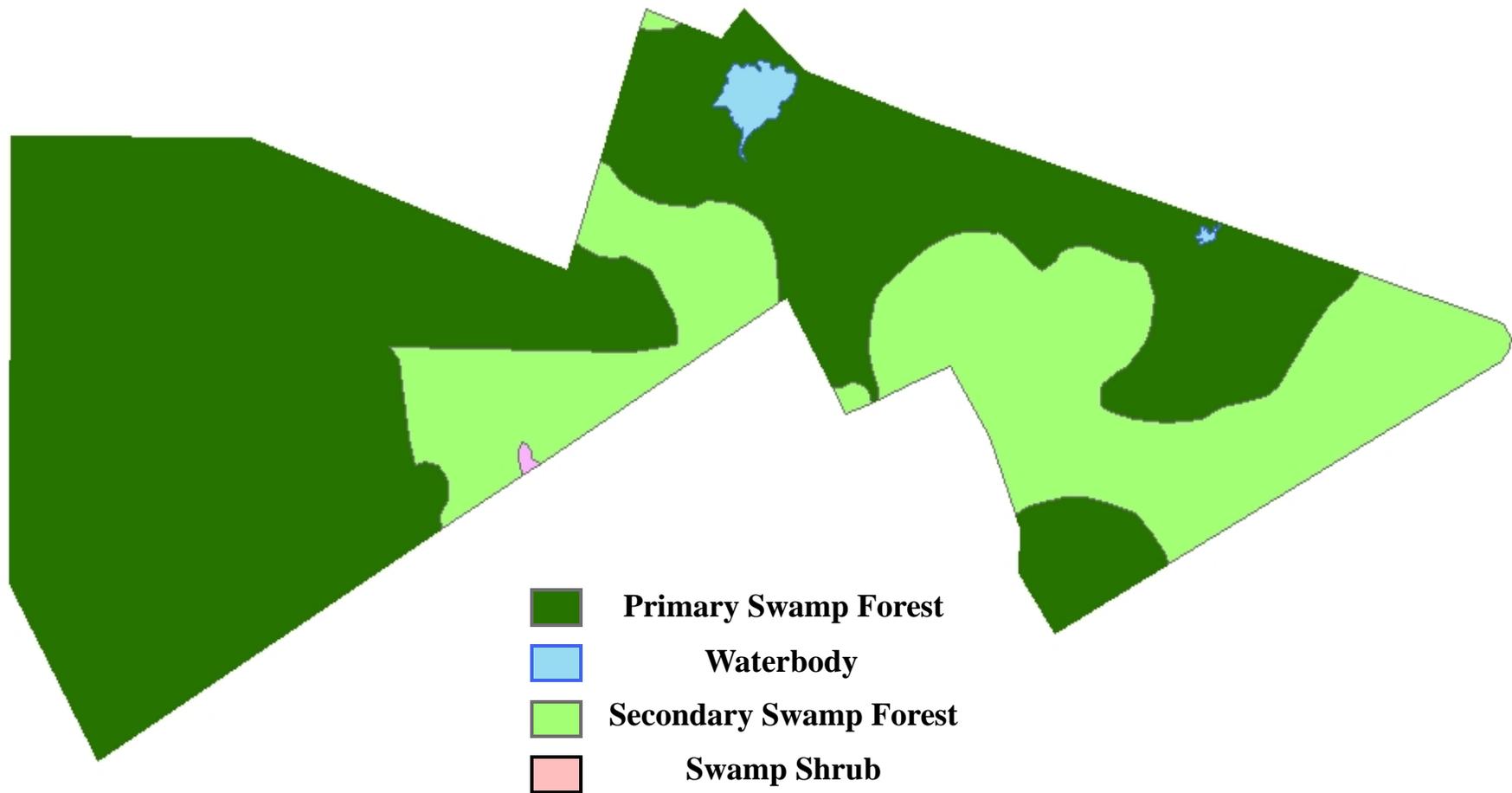
Category	Diameter (cm)	Biomass (ton/ha)	Carbon Stock (ton/ha)	CO ₂ Sequestration (ton/ha)
Trees	DBH >19.9	112.80	53.02	194.41
	DBH 5 - 19.9	56.58	26.59	97.50
	DBH < 5	18.20	6.37	23.35
Non Trees	Shrubs	4.90	1.71	6.29
Total above-ground		192.48	87.69	321.55
Total below-ground (Peat soil)	243 cm (average of peat depth)	5156.59	2794.10	10245.03
Total (ton/ha) (above- and below-ground)		5349.07	2881.79	10566.58

B. SATELLITE IMAGE INTERPRETATION

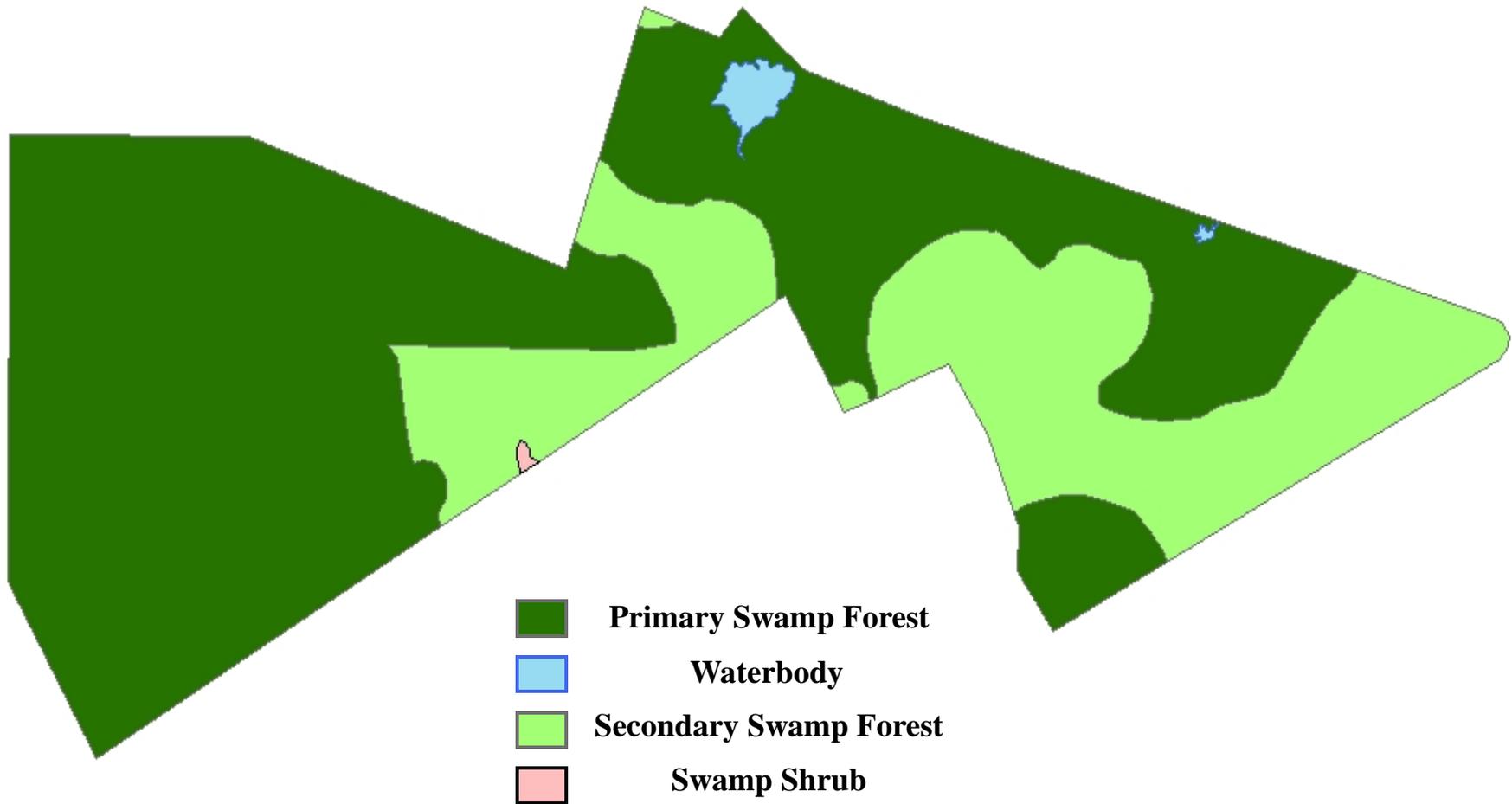
(i). Landsat images

- **Land Cover maps : 2000, 2003, 2006 and 2009**
- **For Pelalawan site, 4 classes : Primary Swamp Forest, Secondary Swamp Forest, Shrub Swamp and Water Body**
- **For Katingan site, 7 classes : Secondary swamp Forest, shrub swamp, shrub, cropland, bareland, waterbody, swamp**

Landcover of Pelalawan Sites (Landsat 2006)



Landcover of Pelalawan Sites (Landsat 2009)



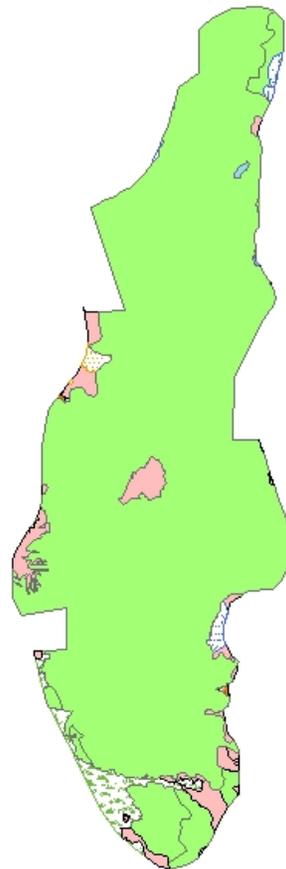
Land Cover Change Year 2006-2009 in Pelalawan Site (Landsat Images)

Land Cover Year 2006	Land Cover Year 2009 (Ha)				
	Primary Swamp Forest	Water Body	Secondary Swamp Forest	Swamp Shrubs	Total
Primary Swamp Forest	50,403.79				50,403.79
Water Body		557.31			557.31
Secondary Swamp Forest			20,479.51		20,479.51
Swamp Shrubs				52.52	52.52
Total	50,403.79	557.31	20,479.51	52.52	71,493.12

Deforestation of Area of Pelalawan Site and Pelalawan Regency		
Year	PELALAWAN AREA	PELALAWAN REGENCY
2000-2003	0	68,722.48
2003-2006	52.52	108,509.04
2006-2009	0	105,879.92
Total Deforestation		283,111.43
Deforestation per-Year		31,456.83

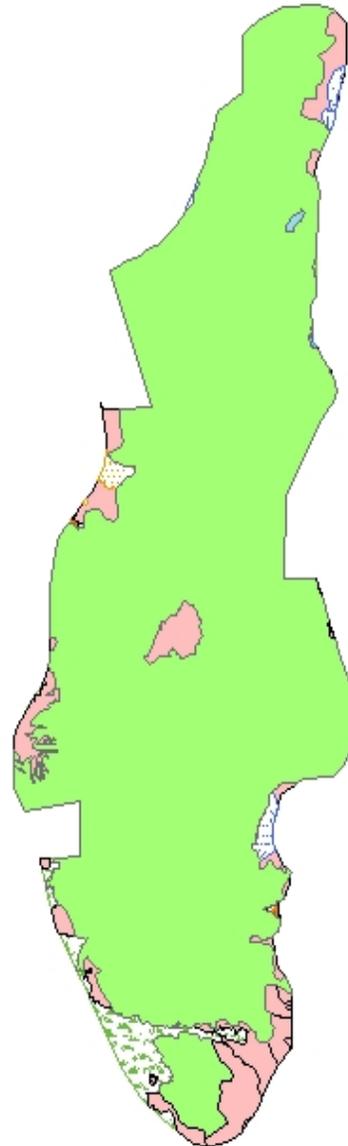
Landcover of Katingan Sites (Landsat 2006)

-  **Shrubs**
-  **Cropland**
-  **Bareland**
-  **Waterbody**
-  **Secondary Swamp Forest**
-  **Shrub Swamp**
-  **Swamp**



Landcover of Katingan Sites (Landsat 2009)

-  Shrubs
-  Cropland
-  Bareland
-  Waterbody
-  Secondary Swamp Forest
-  Shrub Swamp
-  Swamp



Land Cover Change Year 2006-2009 in Katingan Site (Landsat Images)

Land Cover Year 2006	Land Cover Year 2009 (Ha)					Grand Total (Ha)
	Bare land	Water Body	Secondary Swamp Forest	Swamp Shrubs	Swamp	
BareLand	872.40					872.40
Water Body		217.18				217.18
Secondary Swamp Forest			193,712.90	6,091.89		199,804.79
Swamp Shrubs				15,034.00		15,034.00
Swamp					1,528.99	1,528.99
Grand Total (Ha)	872.40	217.18	193,712.90	21,125.89	1,528.99	217,457.36

Deforestation of Area of Katingan Site and Regency of Kotawaringin Timur and Katingan		
YEAR	KATINGAN SITE	REGENCY (KTWRGN TIMUR AND KATINGAN)
2000-2003	1,640.44	17,710.73
2003-2006	155.92	47,544.50
2006-2009	6,053.51	108,296.30
Total Deforestation	7,849.87	173,551.53
Deforestation per-Year	872.21	19,283.50

(ii). ALOS - AVNIR images

Sensor type: Optical sensor

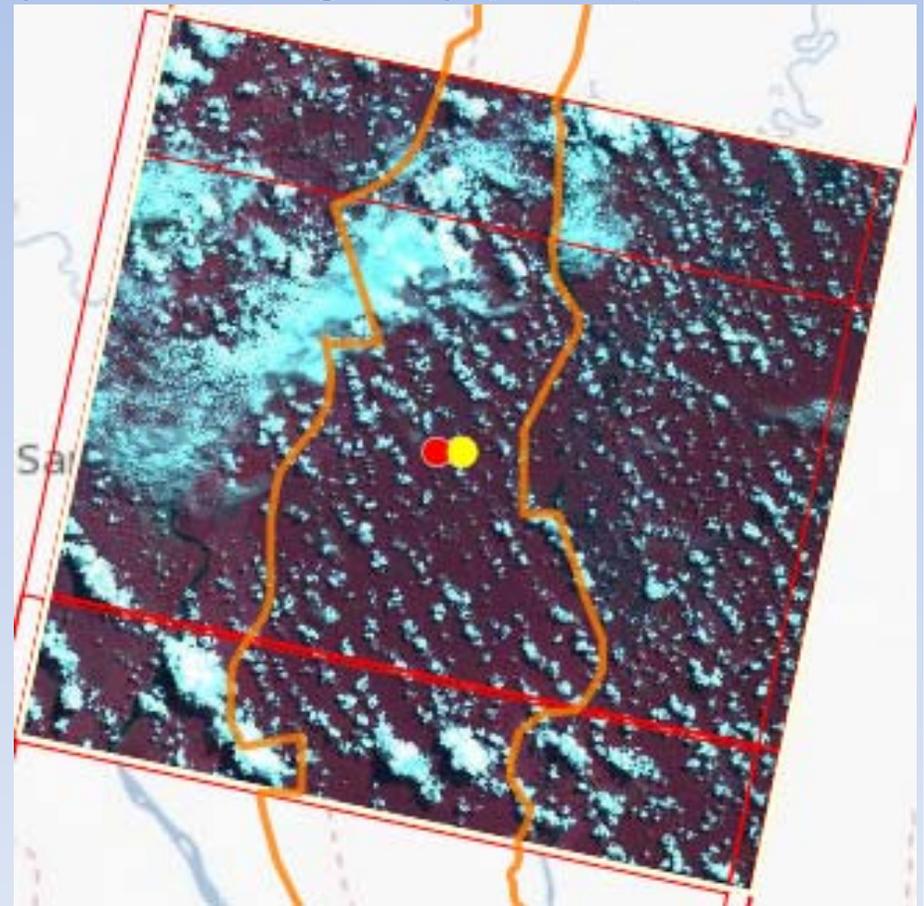
Spatial resolution : 10 m

Data acquisition: 2009/2010

**Data Source: Japan Aerospace
Exploration Agency (JAXA)**



(i) Pelalawan Site, Sumatra



(ii) Katingan Site, Kalimantan

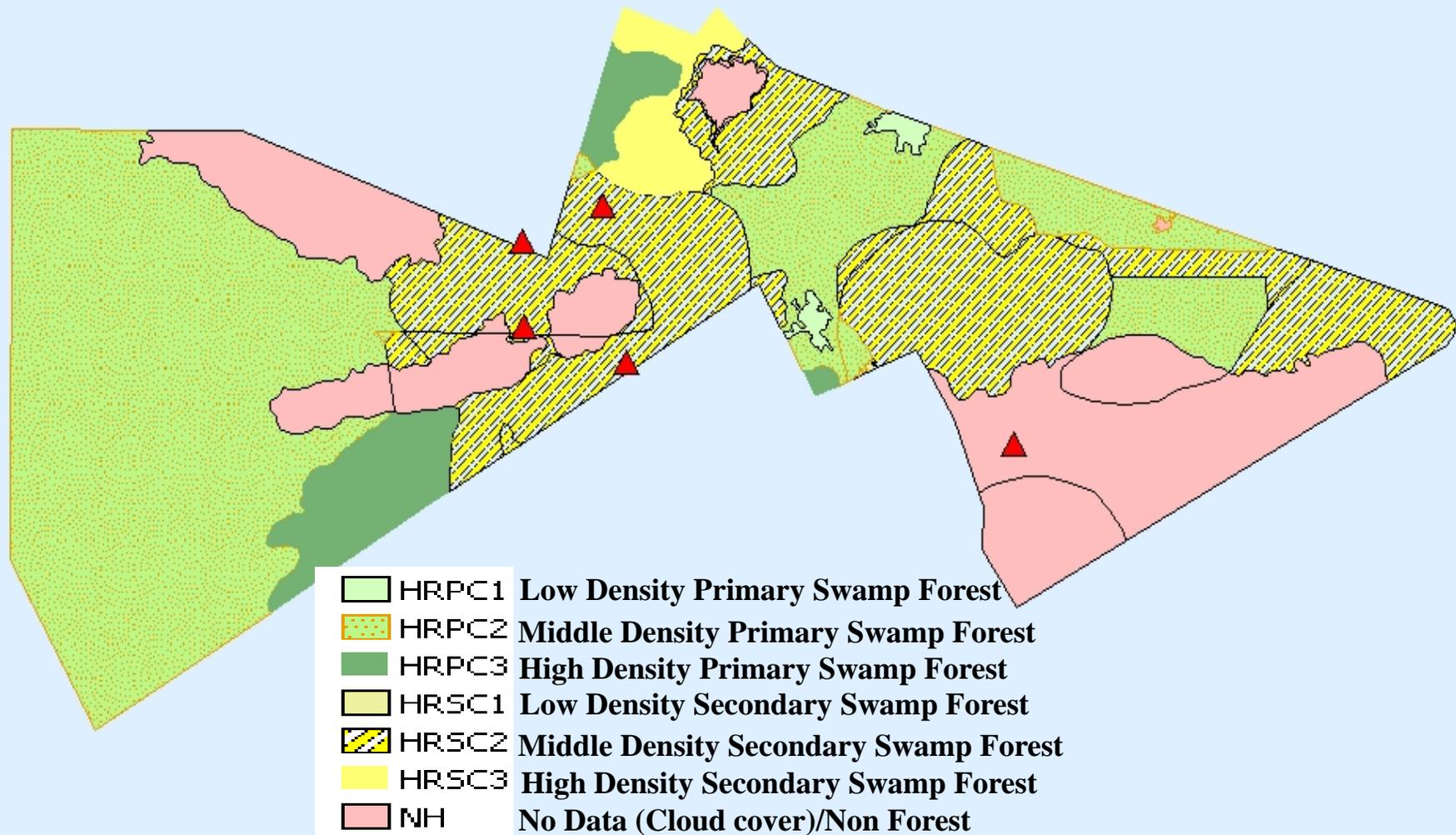
(ii). ALOS - AVNIR images

Forest cover Classes:

- a. High Density Primary Swamp Forest**
- b. Medium Density Primary Swamp Forest**
- c. Low Density Primary Swamp Forest**
- d. High Density Secondary Swamp Forest**
- e. Medium Density Secondary Swamp Forest**
- f. Low Density Secondary Swamp Forest**
- g. Non forest (consist of cloud cover, waterbody, swamp shrubs, swamp and bareland)**

Land Cover of Pelalawan Site (ALOS – AVNIR 2009/10)

ALOS AVNIR images: April 2010 and August 2009



Land Cover and Crown Density of Pelalawan Site (ALOS - AVNIR 2009/10)

No.	Land Cover	Crown Density (Ha)				Total (Ha)
		Non-Forest	Forest			
			Low Density	Middle Density	High Density	
1	Primary Swamp Forest		384.5	35,913.8	3,713.7	40,012.1
2	Secondary Swamp Forest		19.6	29,060.8	1,843.3	30,923.7
3	Water Body	557.3				557.3
Total		557.3	404.1	64,974.6	5,557.1	71,493.1

Land Cover Katingan Site (ALOS – AVNIR 2009/10)

ALOS AVNIR imagery of September 2010 and April 2009

-  Non Forest/No density
-  Low Density Swamp Forest
-  Middle Density Swamp Forest
-  High Density Swamp Forest



Land Cover and Crown Density of Katingan Site (ALOS – AVNIR 2009/10)

No.	Land Cover	Crown Density (Ha)				Total (Ha)
		Non-Forest	Forest			
			Low Density	Middle Density	High Density	
1	Primary Swamp Forest				43,306.9	43,306.9
2	Secondary Swamp Forest		32,549.4	94,502.7	16,663.9	143,715.9
3	Swamp Shrubs	25,292.2	2,820.9		0.0	27,669.4
4	Bare Land	800.0				800.0
5	Water Body	55.6				55.6
6	Swamp	1,465.9				1,465.9
Total		27,613.7	35,370.3	94,502.7	59,970.8	217,457.4

Land Cover of Pelalawan Site (Landsat vs ALOS-AVNIR)

(Ha)

Land Cover		LANDSAT				Total
		Primary Swamp Forest	Secondary Swamp Forest	Swamp Shrubs	Water Body	
ALOS-AVNIR	Primary Swamp Forest	38049.32	1962.77			40012.09
	Secondary Swamp Forest	12354.47	18516.74	52.51667		30923.72
	Water Body				557.3065	557.3065
Total		50403.79	20479.51	52.51667	557.3065	71493.12

Land Cover of Katingan Site (Landsat vs ALOS-AVNIR)

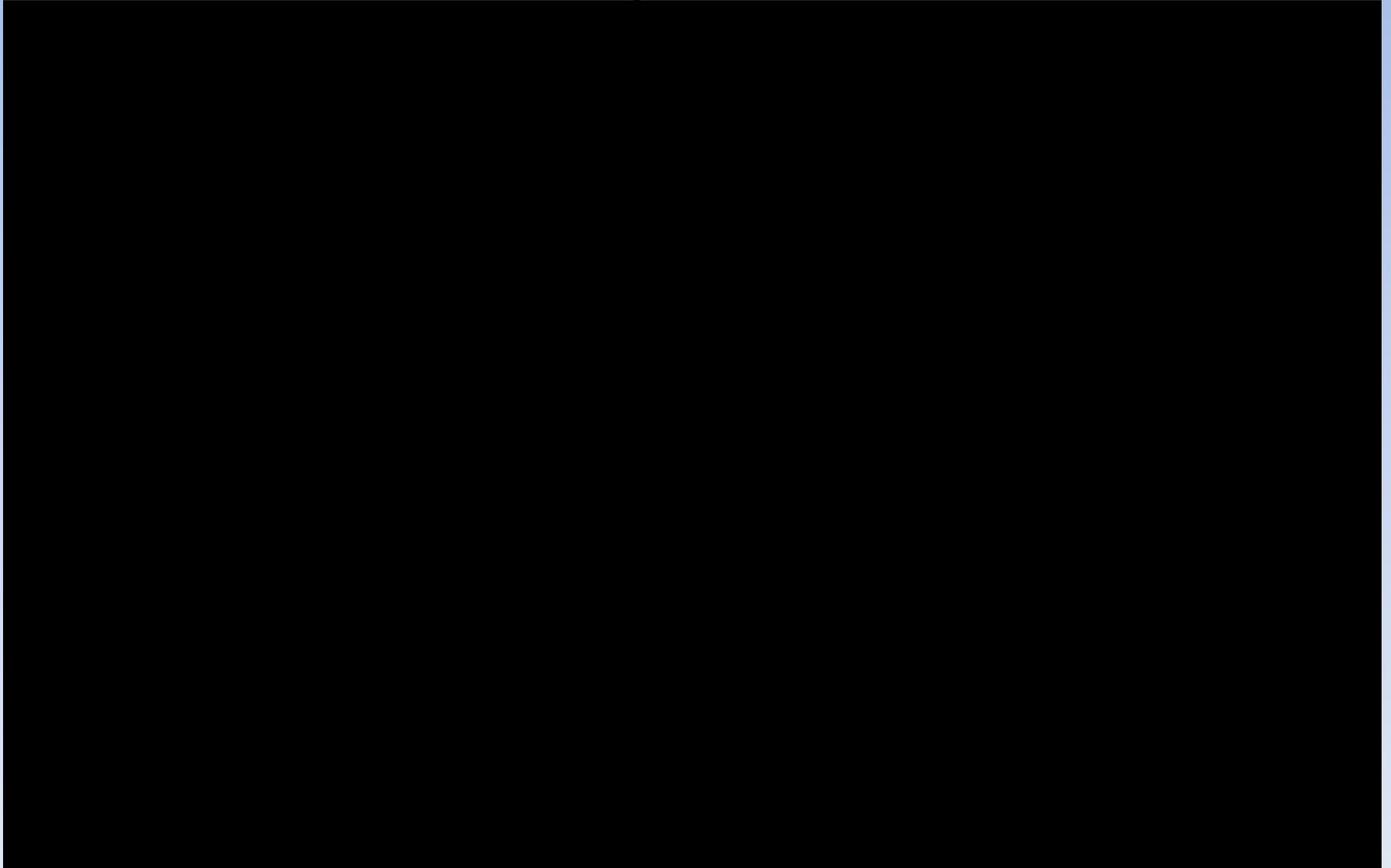
(Ha)

Land Cover		LANDSAT					Total
		Secondary Swamp Forest	Swamp Shrubs	Bare Land	Swamp	Water Body	
ALOS - AVNIR	Primary Swamp Forest	43,306.9					43,306.9
	Secondary Swamp Forest	142,853.5	822.4			40.0	143,715.9
	Swamp Shrubs	7,544.7	20,303.5	80.2	63.1	121.6	28,113.1
	Bare Land	7.9		792.1			800.0
	Swamp				1,465.9		1,465.9
	Water Body					55.6	55.6
	Total	193,712.9	21,125.9	872.4	1,529.0	217.2	217,457.4

Total Carbon Stock in Pelalawan Site, Sumatra

Land Cover Class	Emission Factor		Area (Ha)	Total Carbon (ton)
	Carbon	Biomass		
	(ton/ha)	(ton/ha)		
Secondary Swamp Forest (Medium Density)	112.67	225.35	29,060.25	3,274,408.29
Secondary Swamp Forest (Low Density)	62.04	124.08	19.60	1,216.01
Primary Swamp Forest (Medium Density)	162.6	325.20	35,913.80	5,839,583.88
Secondary Swamp Forest (High Density)				
Primary Swamp Forest (High & Low Density)	162.6	325.20	5,941.50	966,087.90
Waterbody	0	0	557.30	0
Total			71,493.00	10,081,296.08

Total Carbon Stock in Katingan Site, Kalimantan



IV. CONCLUSIONS

- 1. Peat forests have significant roles in mitigation and adaptation of GHG emissions. However, a methodology to measure biomass, carbon stock and emission in this area is not well understood and developed.**
- 2. Development of a methodology in this Pre-FS was encouraging. Initial data/information of above and below ground biomass have been collected, and based on the data, a Project Design Document (PDD) for a REDD+ Project Investment has been developed.**
- 3. Interpretation of ALOS-AVNIR image of 2009/2010 showed that Pelalawan Site has better forest cover (99% forest cover) than that of Katingan Site (86% forest cover). Similarly, interpretation of Landsat images 2000 – 2010 indicated that deforestation rate in Pelalawan site was lower (5.8 ha/year) than that in Katingan site (872 ha/year).**
- 4. Carbon stock (ton/ha) was higher in Pelalawan site (5,571.71 ton/ha) than that in Katingan site (2,881.79 ton/ha). In addition, average peat depth was 5.96 m (3.30 m – 9.30 m) in Pelalawan site and 2.43 m (1.33 m – 6.50 m) in Katingan site.**
- 5. Based on satellite data interpretation and ground measurement, Total carbon stock of Pelalawan site was 10,081,296 ton, and in Katingan site 13,448,551 ton.**

Next activity:

- 1. More plots will be established to get more accurate results.**
- 2. Higher spatial resolution of satellite images would be used to get more detailed delineation of forest cover classes.**
- 3. Radar images (such as, ALOS PALSAR image) would be explored to support data collection in cloud covered areas. The use of radar images to measure water table/level and peat depth may be explored and researched as well.**
- 4. Data on other emission components of peatlands (CH₄, N₂O etc.) are very limited, and need to be collected and researched.**



Thank You

