



Indonesia Satellite Land Monitoring System

Ruandha Agung Sugardiman



Ministry of Forestry
of The Republic of Indonesia

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Outline

- ◆ Land Cover Change
- ◆ Forest Resources Monitoring
- ◆ Continue Monitoring System
- ◆ Quick Count
- ◆ Human Resources Development



Land Cover Change Monitoring

- **Background:**

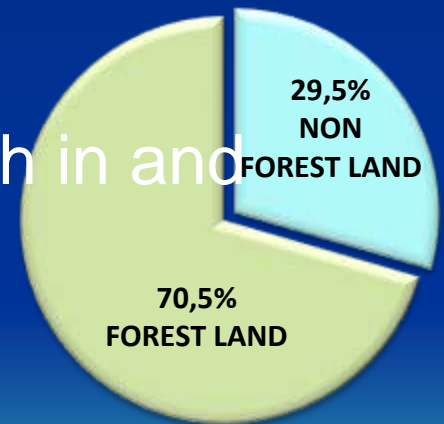
Land cover condition change rapidly, so it is considered necessary to periodically monitor the condition for many purposes.

- **Purpose:**

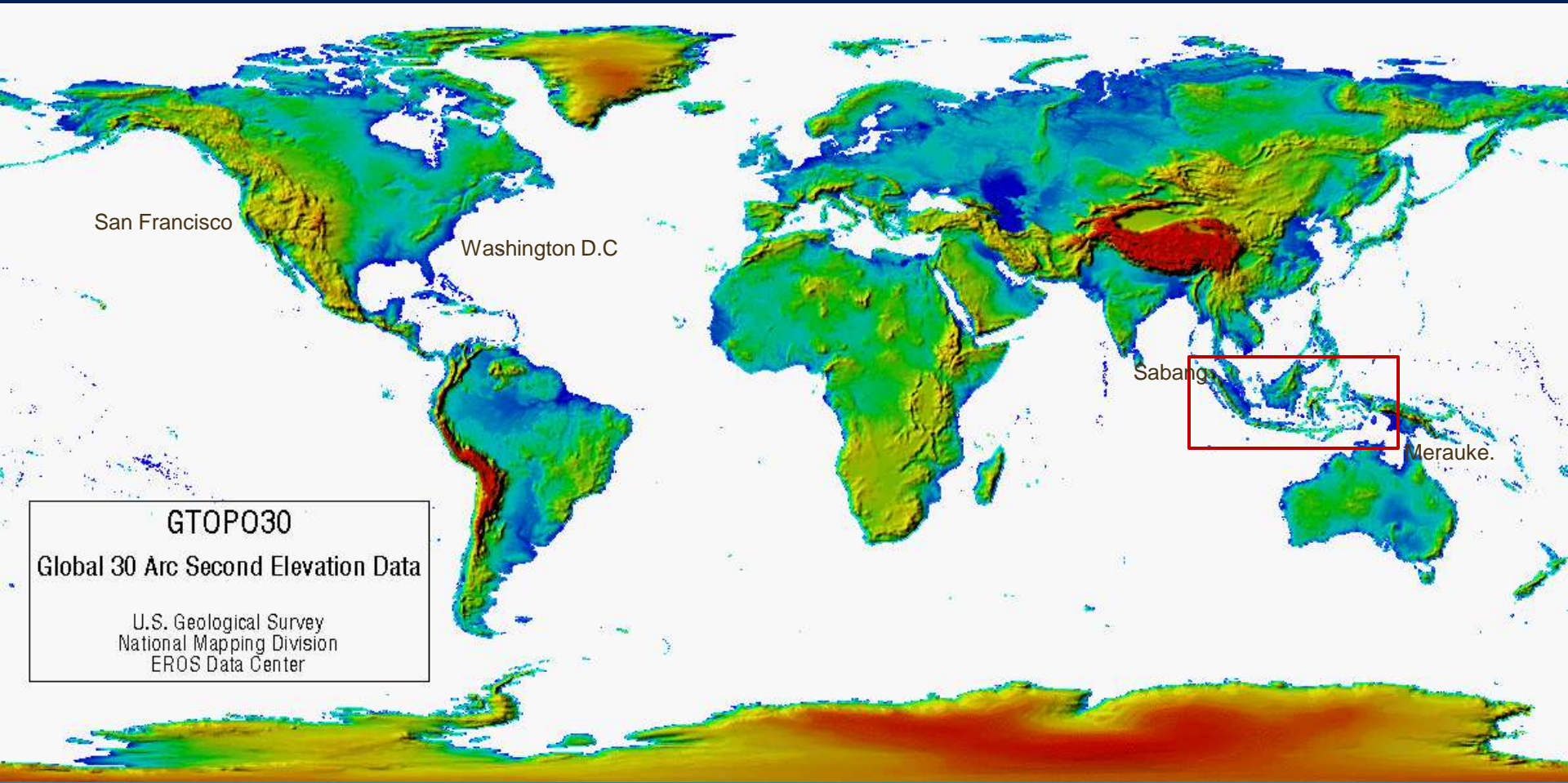
Provide data on forest cover changes both in and outside forest land areas.

- **Scope:**

Analysis on forest cover changes to non forest cover.



How Big is Indonesia?



San Francisco

Washington D.C

Sabang

Merauke.

GTOPO30

Global 30 Arc Second Elevation Data

U.S. Geological Survey
National Mapping Division
EROS Data Center



Challenges

- Most of the forest area are persistently covered by cloud.



FOREST RESOURCES MONITORING

- **MEDIUM SPATIAL RESOLUTION IMAGES**
- **Re-monitor every 3 years**
- **Satellite data:**
 - 1997 Landsat MSS, Landsat 5**
 - 2000 Landsat 7 TM**
 - 2003 Landsat 7 ETM+**
 - 2006-2009 Landsat 7 ETM+, SPOT 4**
- **Outputs:**
 - **Landcover maps – forest, non-forest (1997)**
 - **Landcover maps – 23 classes (2000-2009)**

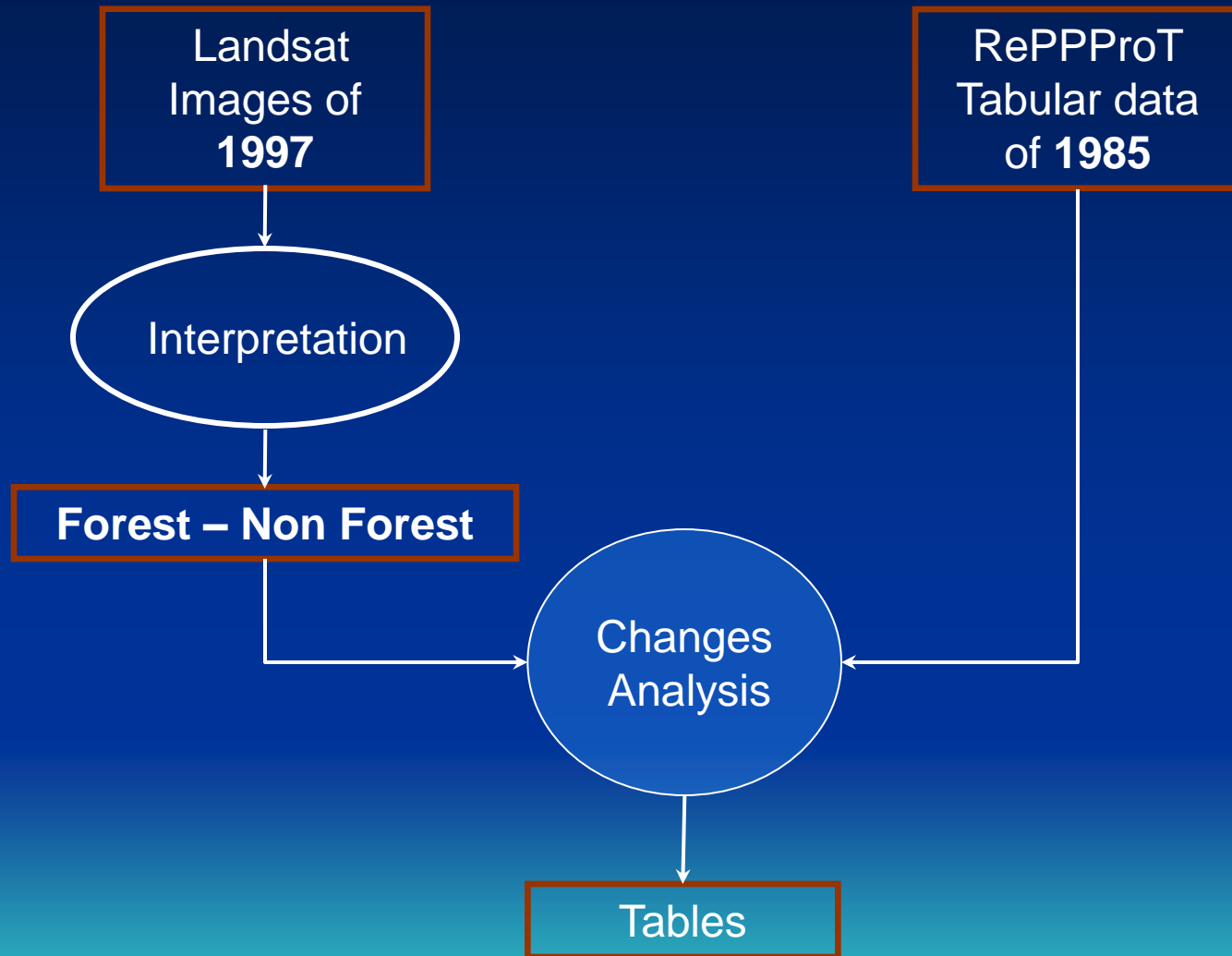


Land Cover Monitoring System in Indonesia

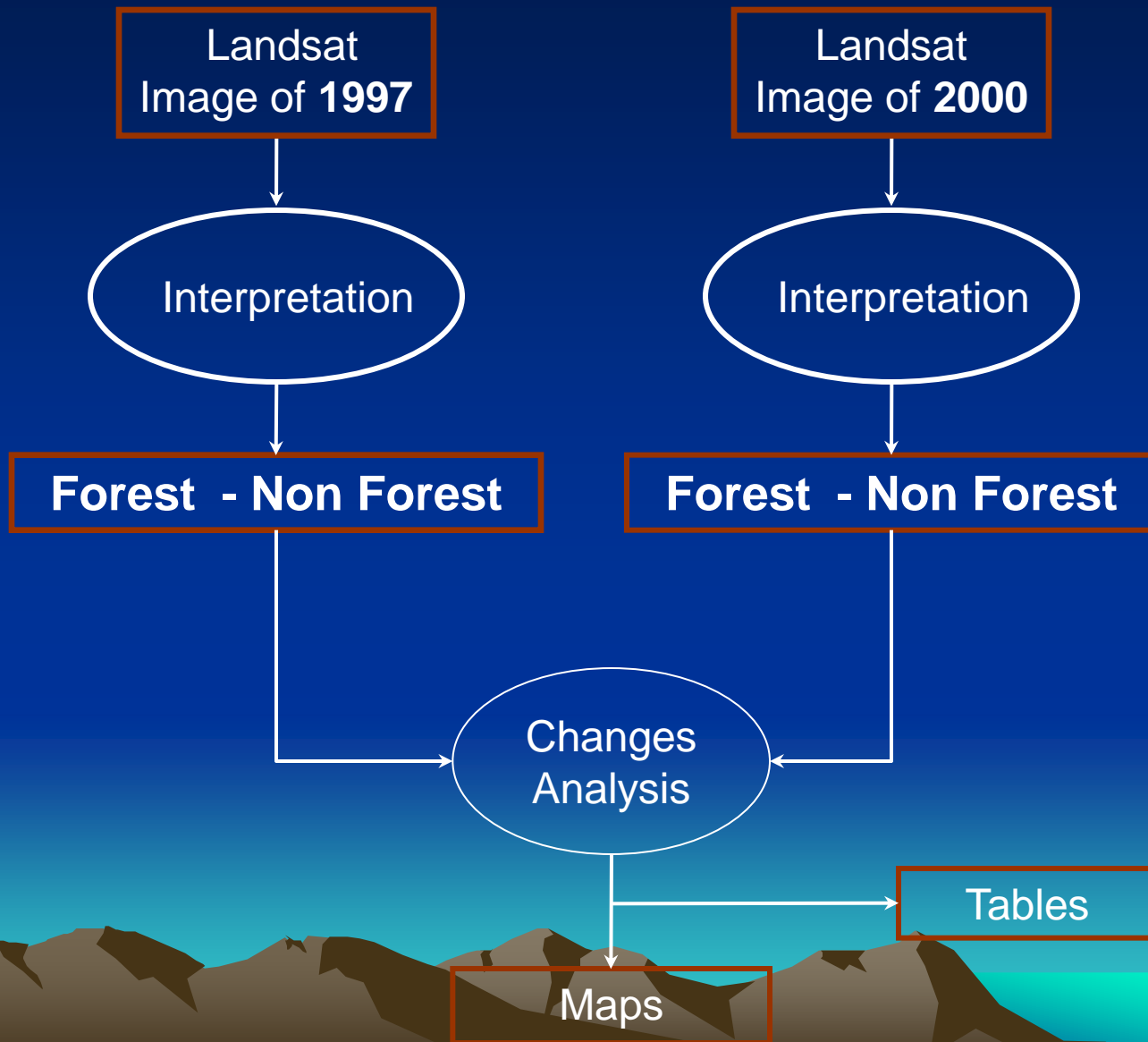
- **Period of 1985 – 1997**
- **Period of 1997 – 2000**
- **Period of 2000 – 2003**
- **Period of 2003 – 2006**
- **Period of 2000 – 2005**
- **Period of 2006 – 2009**



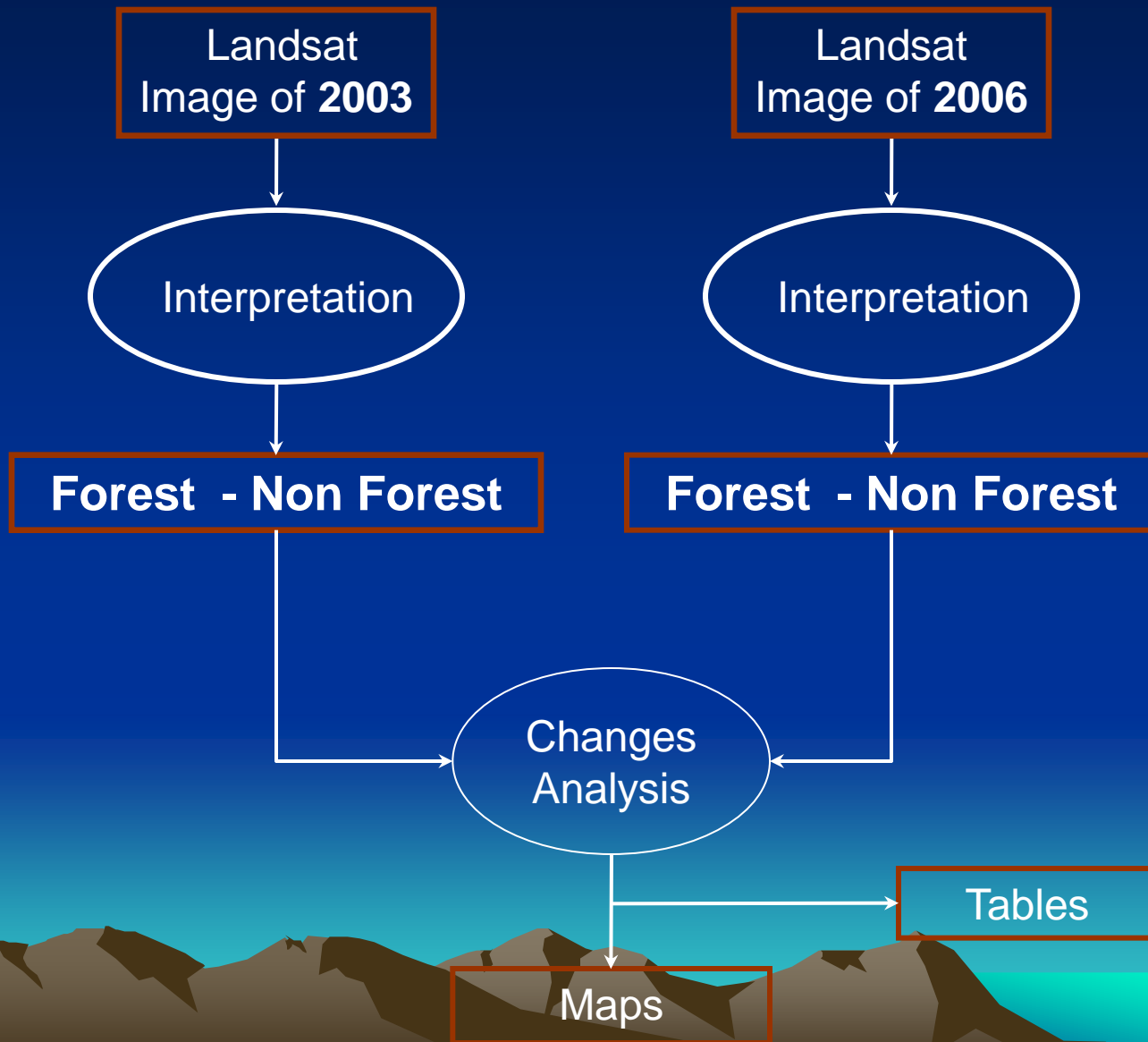
Forest cover changes analysis process (1985-1997)



Forest cover changes Analysis (1997-2000)



Forest cover changes Analysis (2003-2006)



Continue Monitoring System

1. Land cover monitoring for the whole Indonesia by using Landsat images was started in 2000 and repeated every three years
2. Three years interval was chosen in order to get Landsat images with minimal *cloud cover* ($< 20\%$), in fact it was not easy.



Continued

3. Until recently, land cover mapping for the whole Indonesia had been done in **2000, 2003** and **2006**.
4. In **2009** (2008/2009) land cover re-mapping for the whole Indonesia is ongoing.
5. The result will be mapped with scale of **1 : 250.000**

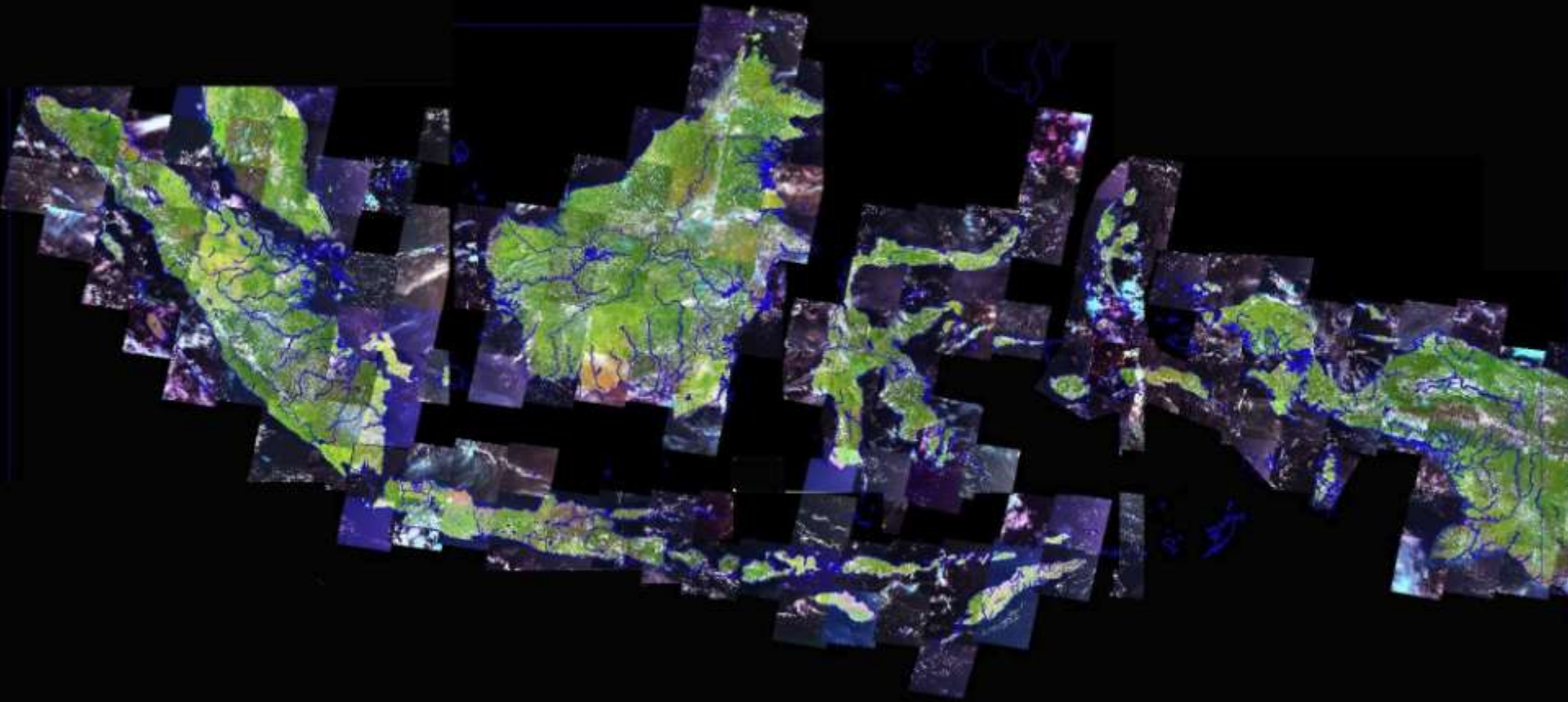


Continued

6. Monitoring activities are executed by Regional Offices/ Forest Land Establishment Unit and supervised by DG of Forest Planning.
7. In order to fill in the interval gap in land cover mapping for the whole Indonesia, yearly monitoring is executed by using **MODIS Data** and **SPOT Vegetation**.



Land Cover Mapping for the whole Indonesia



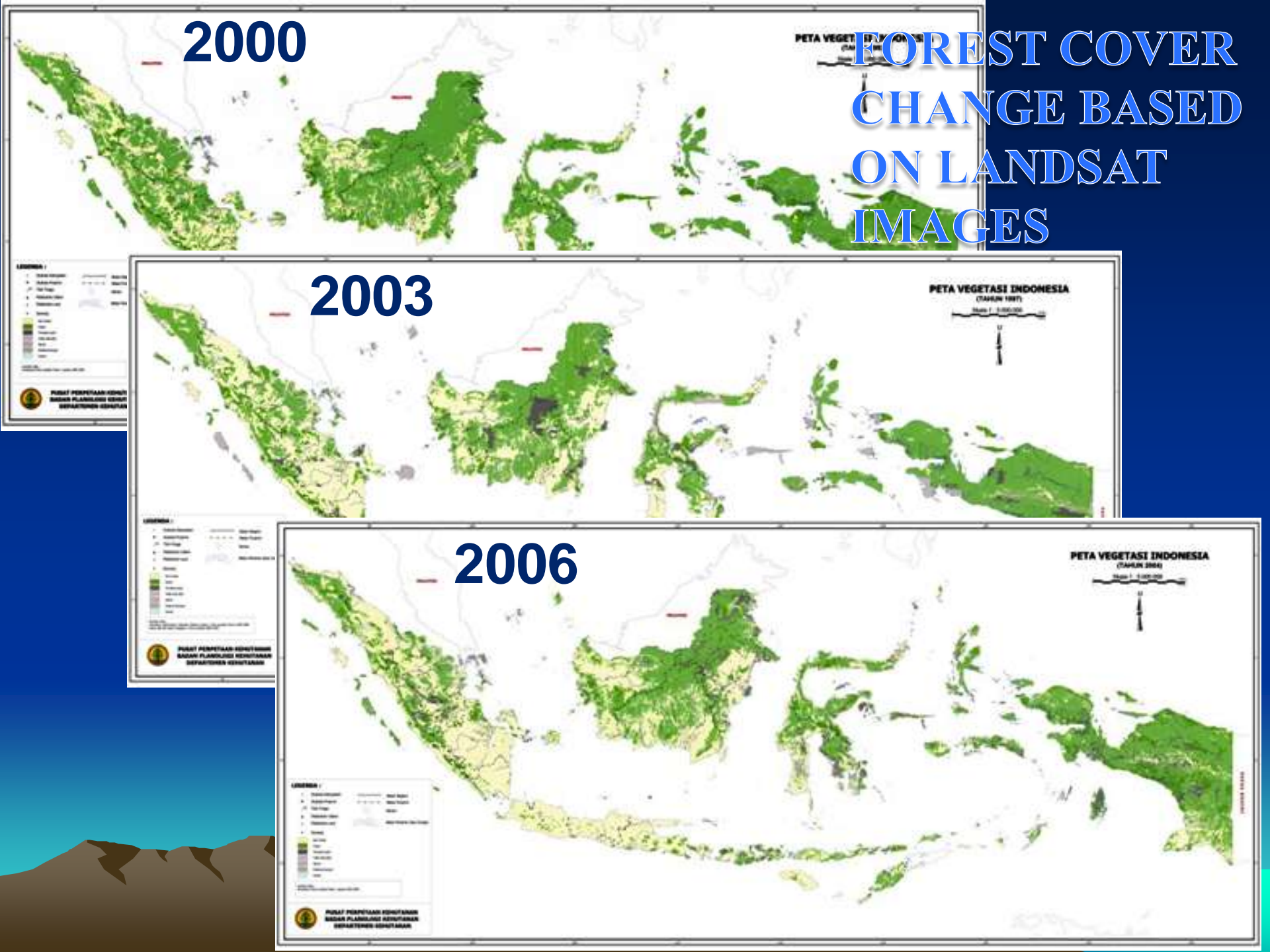
Remark: Landsat 7 ETM+ coverage for the whole Indonesia (217 scene)

2000

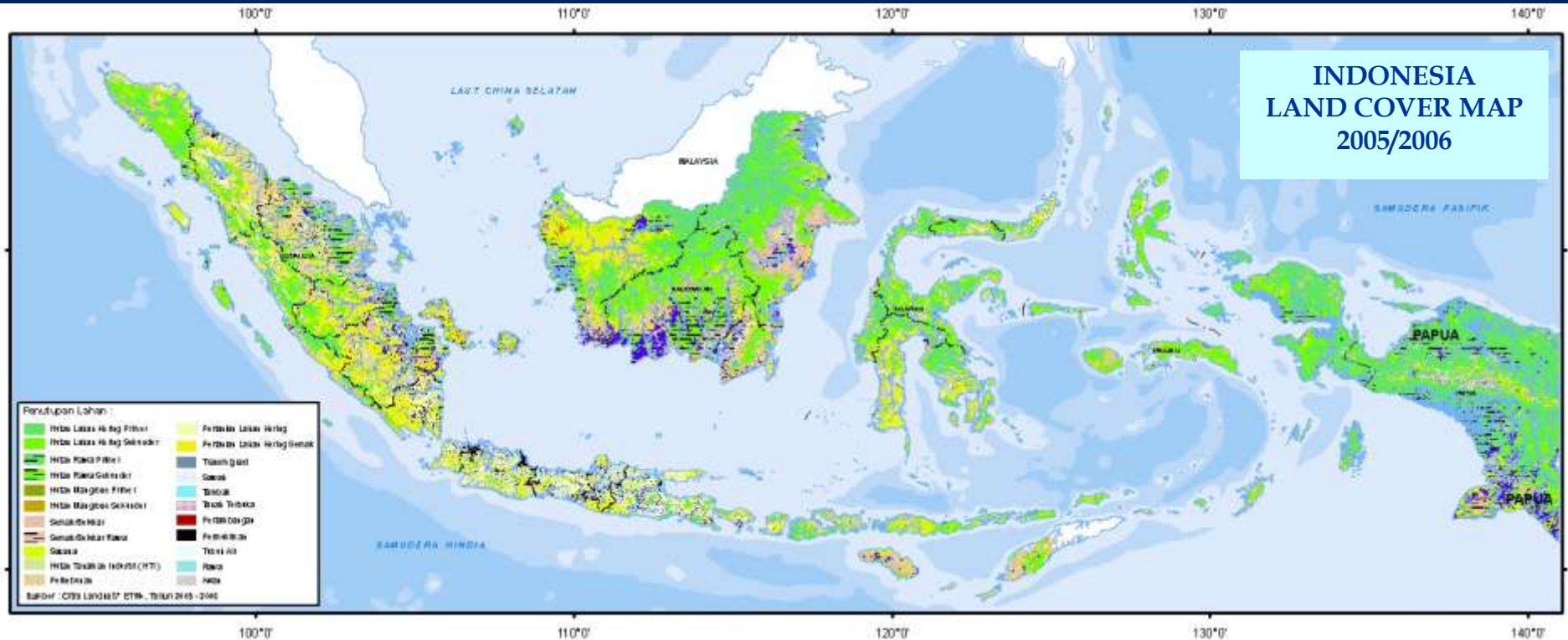
**FOREST COVER
CHANGE BASED
ON LANDSAT
IMAGES**

2003

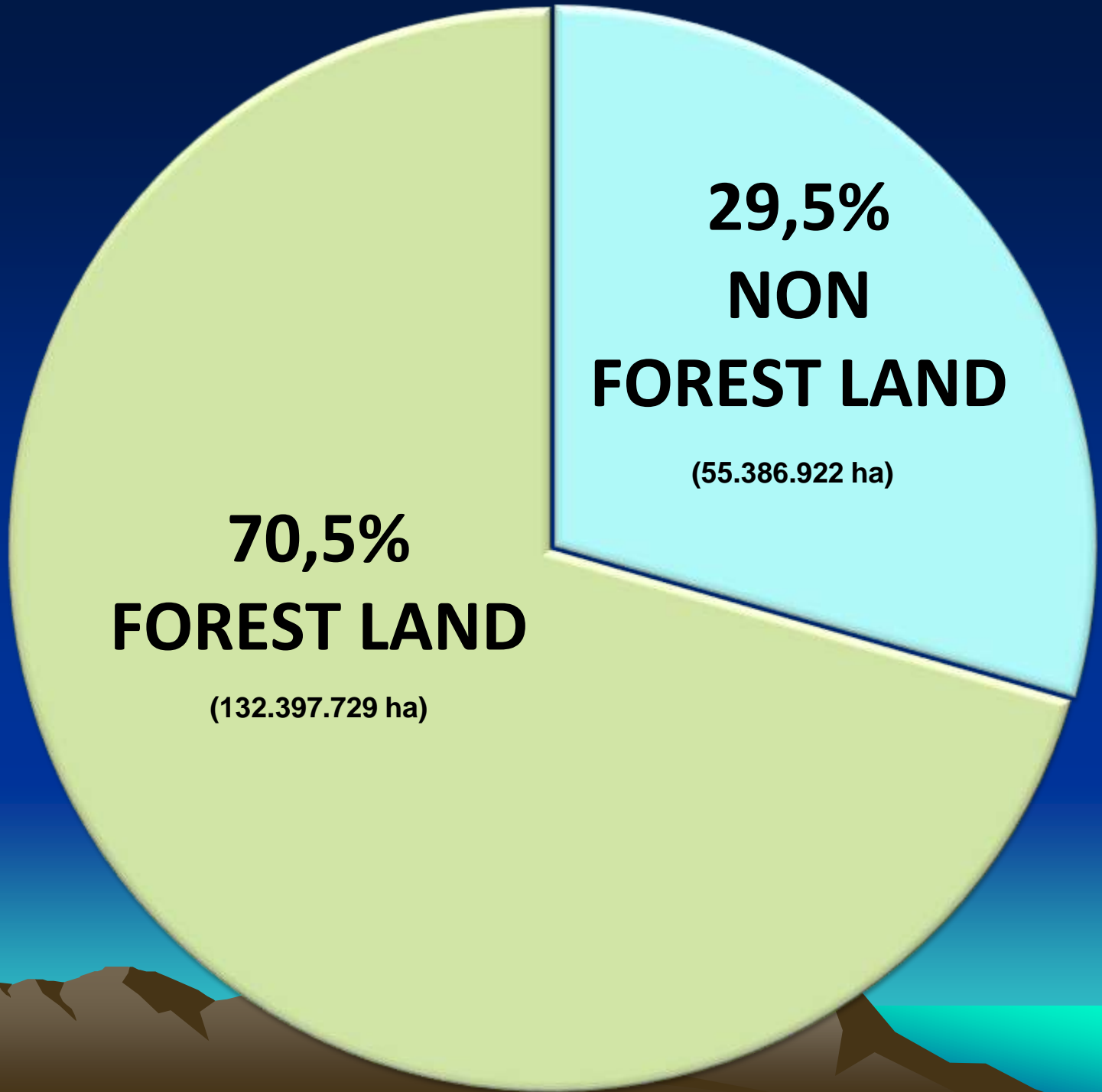
2006



Land Cover Mapping Recalculation using image of Landsat 7 ETM+ (2005/2006)



Remark: Landsat images of 2005/2006 were orthorectified, using SRTM and ground checked.



70,5%
FOREST LAND
(132.397.729 ha)

29,5%
NON
FOREST LAND
(55.386.922 ha)

LAND COVER CALCULATION

| LAND COVER | FOREST AREA | | NON-FOREST AREA | | TOTAL | |
|---------------------|--|-----|-----------------|-----|-----------|------|
| | Area (ha) | % | Area (ha) | % | Area (ha) | % |
| FORESTED | 92,328 (Primer=43,801, LOA=48,526) | 49% | 8,412 | 4% | 100,740 | 54% |
| NON FORESTED | 40,071 | 21% | 46,976 | 25% | 87,047 | 46% |
| TOTAL | 132,399 | 71% | 55,388 | 29% | 187,787 | 100% |

Sources: Landsat 7 ETM+ 2005/2006





FOREST RESOURCES MONITORING

- **LOW SPATIAL RESOLUTION IMAGES (MODIS, SPOT VEGETATION)**
- **Re-monitor every year**
- **Fill gaps of Landsat 3 yearly monitoring**
- **Cover class: forest, non forest**
- **Map scale 1:500.000**

Start 2006, cooperation with SDSU, WB, WRI,
and Wageningen University

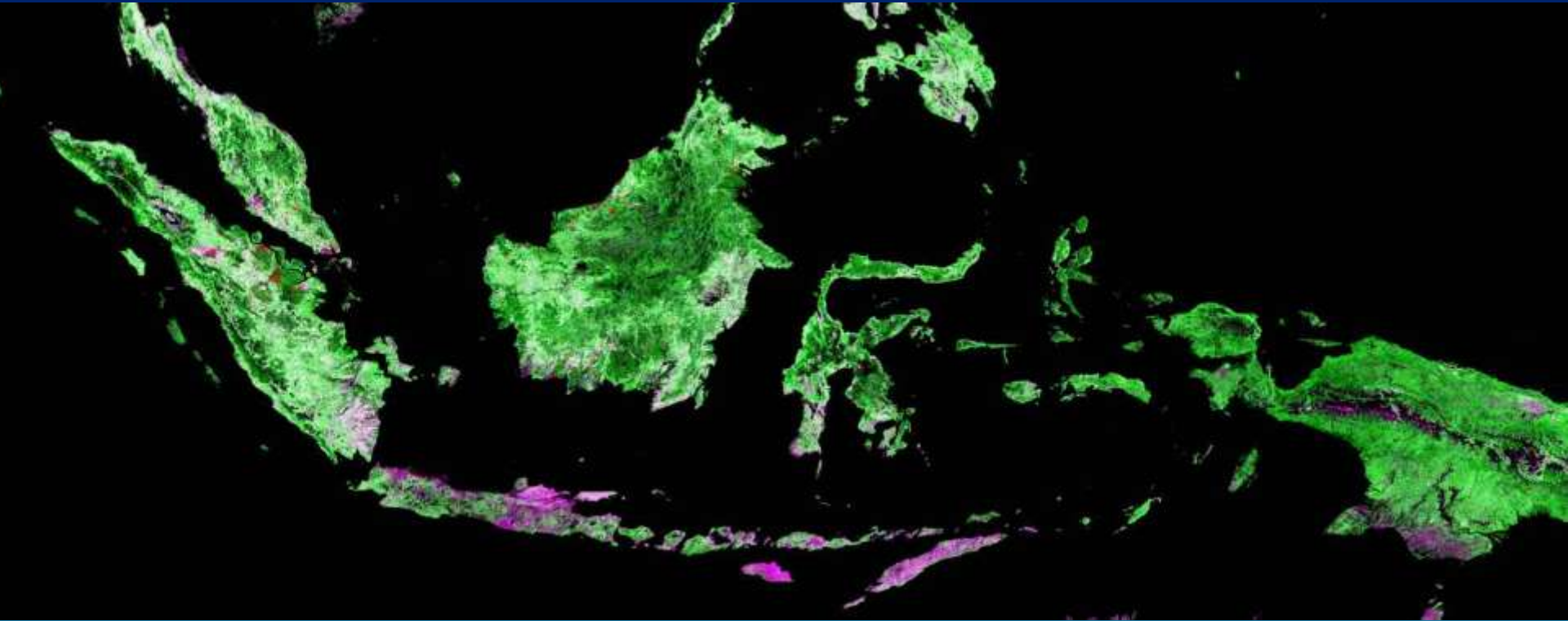


Land Cover Mapping by using MODIS

1. This mapping activity is executed under cooperation between MOFRI and **South Dakota State University (SDSU)**.
2. Mapping is based on MODIS data with spatial resolution of 500 meter and captured in 2000-2005.
3. Land Cover Mapping by using MODIS data shows that deforestation rate is **728.600,00 ha/year**.



CHANGES OF FOREST COVERS BASED ON MODIS 2000 - 2005



Deforestation rate by using MODIS Data of 2000-2005

| Year | Deforestation (1.000 ha/year) | | | | | | | |
|-----------|-------------------------------|------------|----------|--------|-------|------|--------|-----------|
| | Sumatera | Kalimantan | Sulawesi | Maluku | Papua | Jawa | Nustra | Indonesia |
| 2000-2001 | 158,0 | 38,8 | 8,2 | 0,6 | 4,8 | 1,5 | 8,2 | 220,1 |
| 2001-2002 | 460,4 | 156,1 | 19,9 | 9,1 | 5,4 | 5,6 | 11,9 | 668,4 |
| 2002-2003 | 474,4 | 181,6 | 12,3 | 10,7 | 11,5 | 1,1 | 2,0 | 693,6 |
| 2003-2004 | 646,6 | 195,0 | 23,2 | 0,8 | 9,1 | 0,6 | 3,8 | 879,1 |
| 2004-2005 | 855,7 | 268,6 | 15,8 | 0,5 | 36,1 | 1,0 | 4,0 | 1.181,7 |
| 2000-2005 | 2.595,2 | 840,1 | 79,4 | 21,8 | 66,8 | 9,8 | 29,9 | 3.643,0 |

Average of Deforestation Rate period 2000-2005 is
 $3.643.000,0/5 = \underline{728.600,00 \text{ ha/year}}$

Source: Hansen, et al, 2006



Land Cover Mapping by using SPOT Vegetation

1. The activity was executed under the cooperation between MOFRI and **Wageningen University-The Netherlands**.
2. Land Cover Mapping based on SPOT Vegetation data with spatial resolution of 1.000 meter.
3. Monitoring was executed by using data of 1999-2005.



Continued : Land cover mapping by using SPOT VEGETATION

4. Land cover mapping by using SPOT Vegetation shows that deforestation rate is **1.089.560,00 ha/year**.
5. There is difference in deforestation rate generated by MODIS and SPOT Vegetation images. This is due to differences in *criteria on forest, sensor specification and applied calculation methods*.



CHANGES OF FOREST COVERS BASED ON SPOT VEGETATION 2000 - 2005



Deforestation rate by using SPOT VEGETATION image of 2000-2005

| Year | Deforestation (1.000 ha/year) | | | | | | | |
|-----------|-------------------------------|------------|----------|--------|-------|-------|----------------|-----------|
| | Sumatera | Kalimantan | Sulawesi | Maluku | Papua | Jawa | Bali and Nusra | Indonesia |
| 2000-2001 | 259,5 | 212,0 | 154,0 | 20,0 | 147,2 | 118,3 | 107,2 | 1.018,2 |
| 2001-2002 | 202,6 | 129,7 | 150,4 | 41,4 | 160,5 | 142,1 | 99,6 | 926,3 |
| 2002-2003 | 339,0 | 480,4 | 385,8 | 132,4 | 140,8 | 343,4 | 84,3 | 1.906,1 |
| 2003-2004 | 208,7 | 173,3 | 41,5 | 10,6 | 100,8 | 71,7 | 28,1 | 634,7 |
| 2004-2005 | 335,7 | 234,7 | 134,6 | 10,5 | 169,1 | 37,3 | 40,6 | 962,5 |
| 2000-2005 | 1.345,5 | 1.230,1 | 866,3 | 214,9 | 718,4 | 712,8 | 359,8 | 5.447,8 |

Average of Deforestation Rate period 2000-2005 is
 $5.447.800,0/5 = \underline{1.089.560,00}$ ha/year

Source: SPOT-VEGETATION, Ministry of Forestry RI-Wageningen
 University, The Netherlands



Quick Count

(*TIMBER VOLUME ESTIMATION*)

- The use of aerial photograph 1 : 20.000
- Volume estimation: $V = f C D H$
 - C: *crown density* (kerapatan tajuk)**
 - D: *crown diameter* (diameter tajuk)**
 - H: *height* (tinggi)**
- Available **SPOT 5**: bundle - multispectral 10 m and superimposed 2.5 m Black & White → natural color 2.5 meter (*real pixel value*)
- **Landsat and SPOT 5** are not provide information on H (*height*), only on C (*crown density*) and D (*crown diameter*)

MULTISTAGE CONCEPT

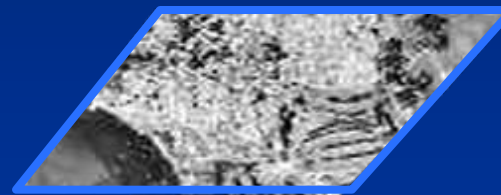
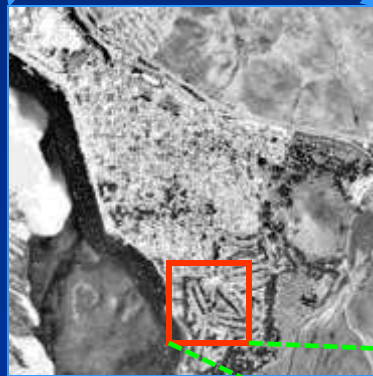
Medium
Resolution
Images

Landsat 7



High
Resolution
Images

SPOT 5



STRATIFICATION

Forest Type

- Mangrove
- Swamp
- Dry land

Succession

- Primer
- Secondary

Density (Landsat)

- Dense
- Medium
- Sparse

Crown cover [C] Crown diameter [D]

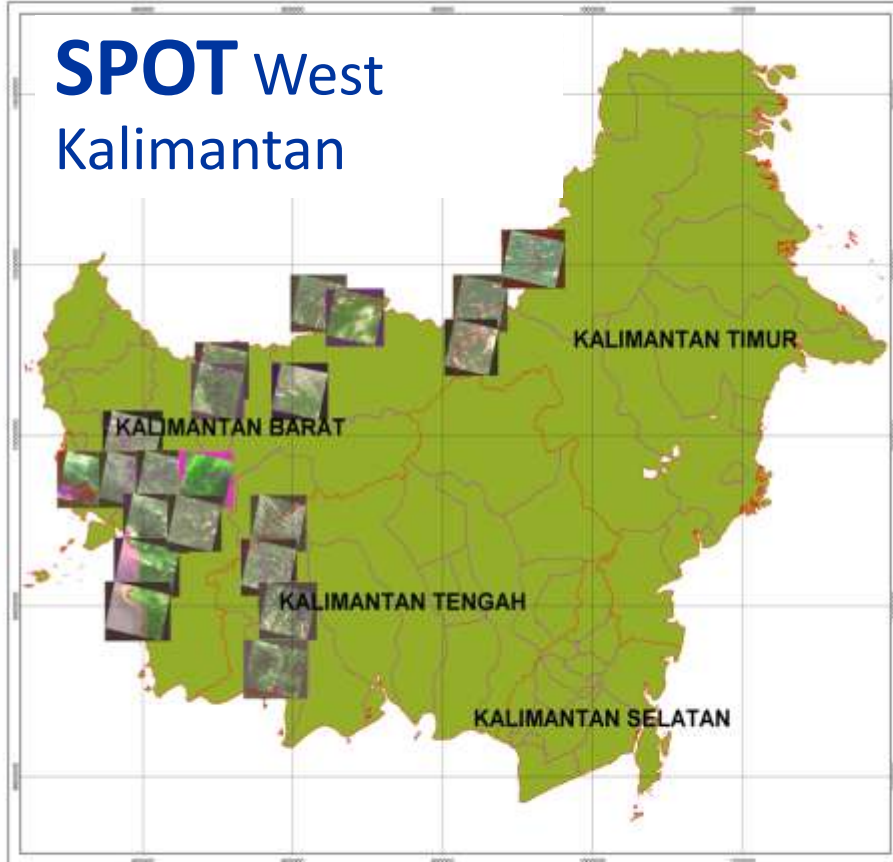
- C1: 10-30 %
- C2: 31-50 %
- C3: 51-70 %
- C4: > 70 %

- D1: < 10 m
- D2: 10-20 m
- D3: > 20 m

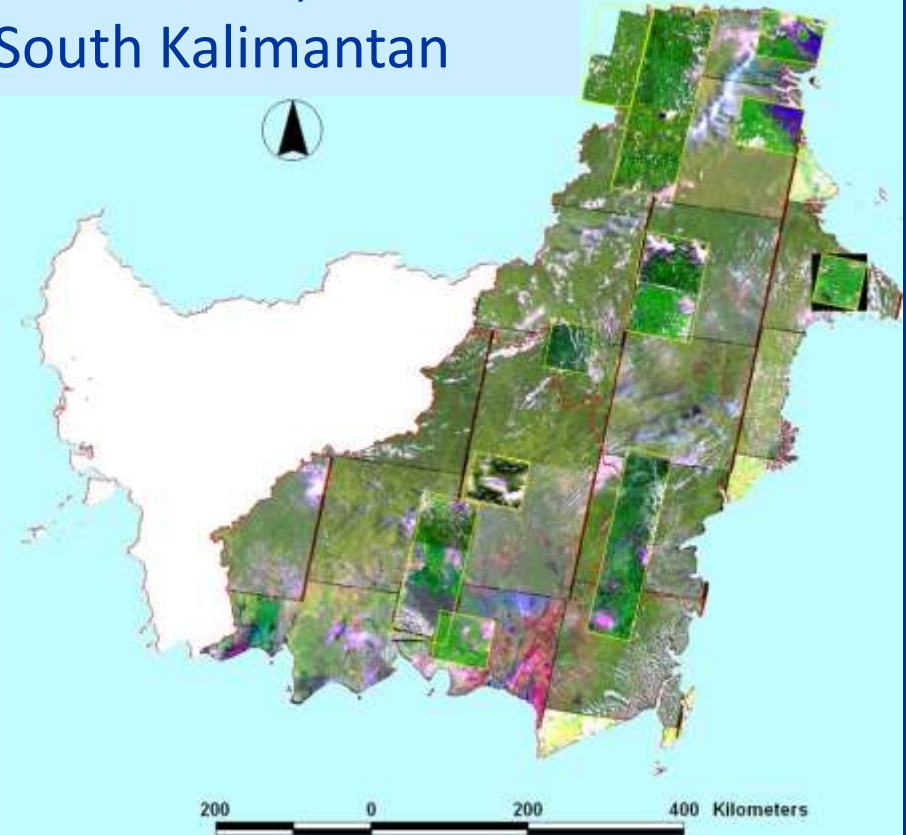


SPOT (High Resolution 2.5 m)

SPOT West Kalimantan



SPOT East, Centre & South Kalimantan

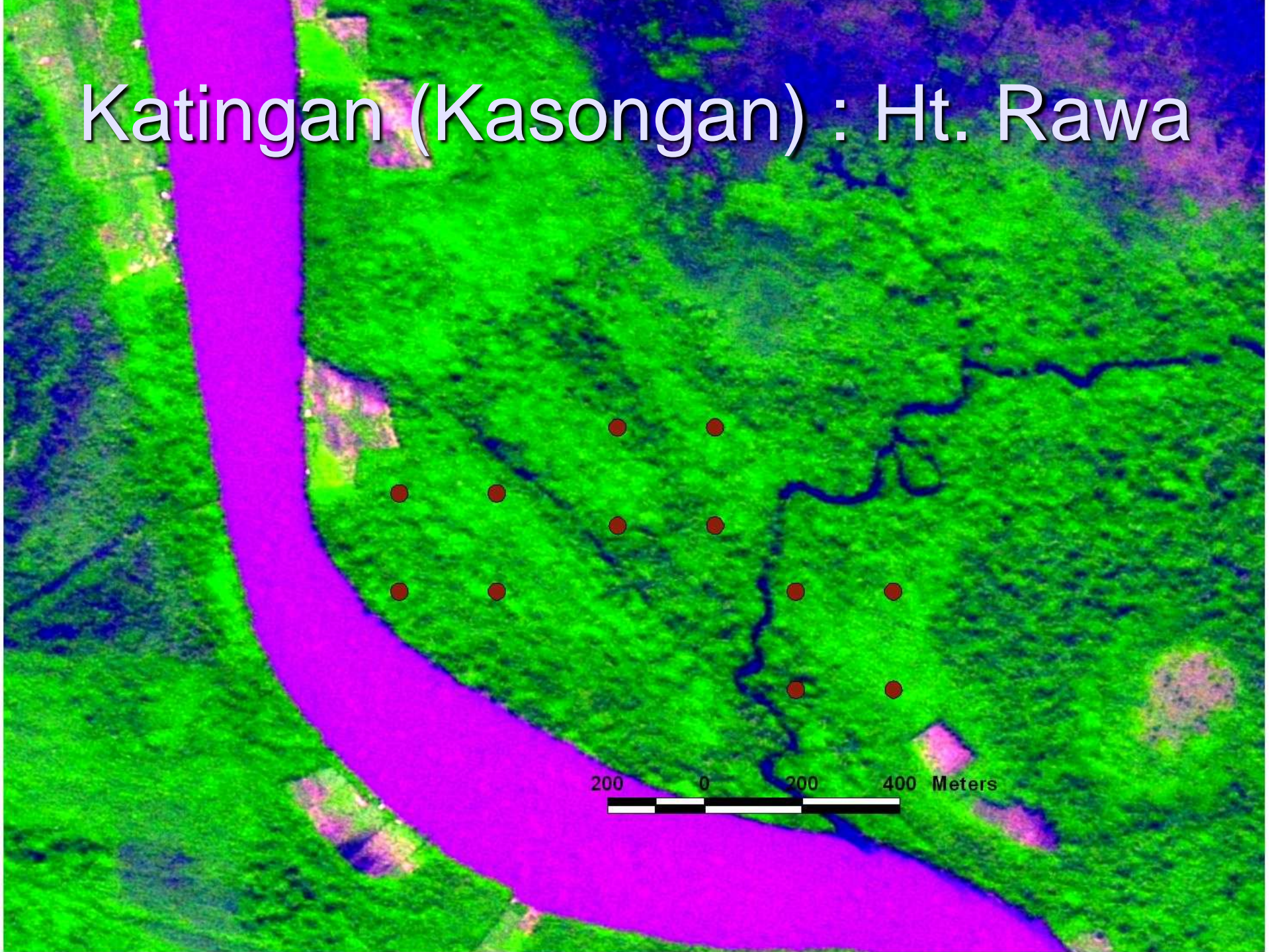




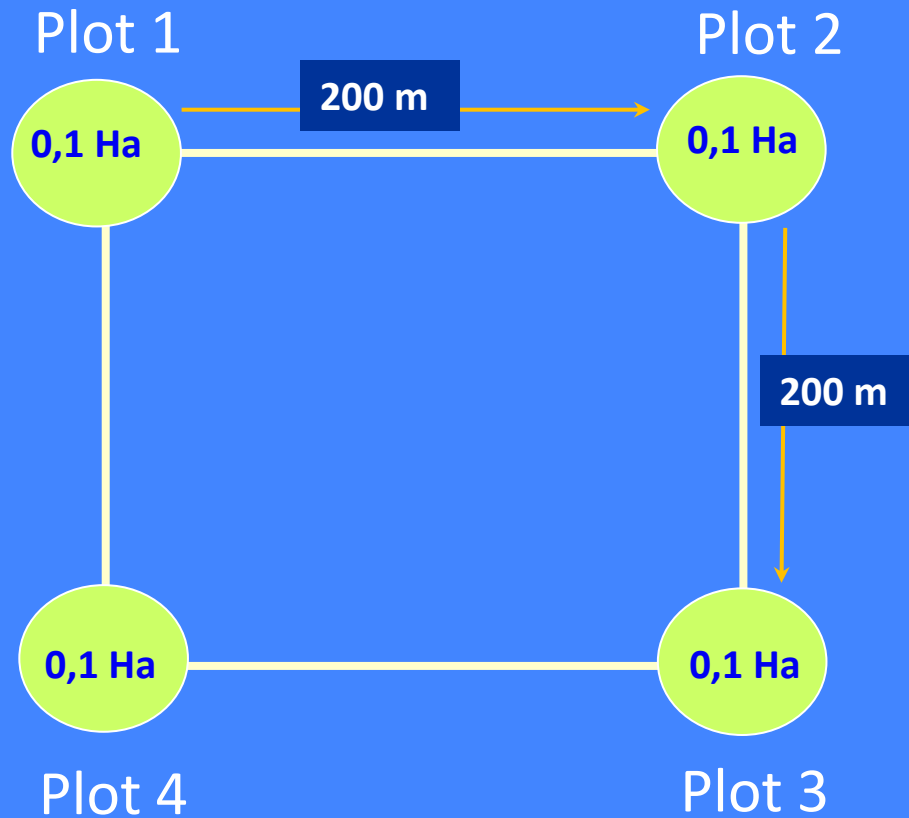
C1D3

C2D1

Katingan (Kasongan) : Ht. Rawa

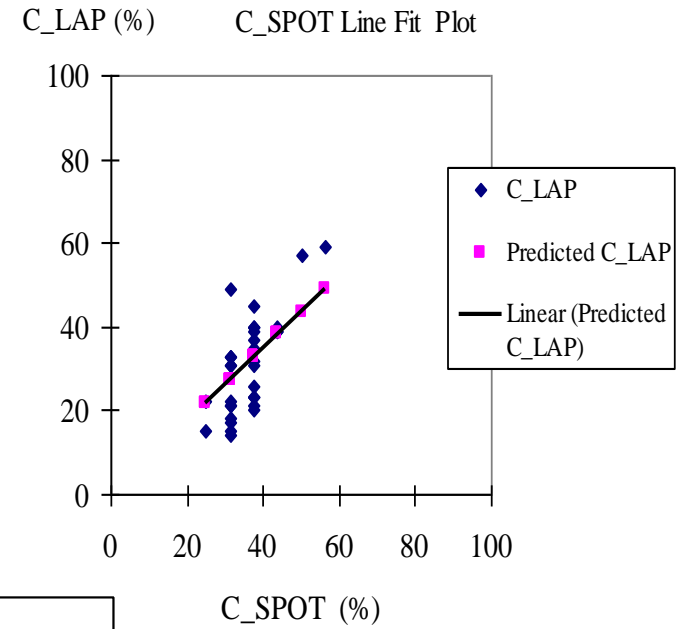
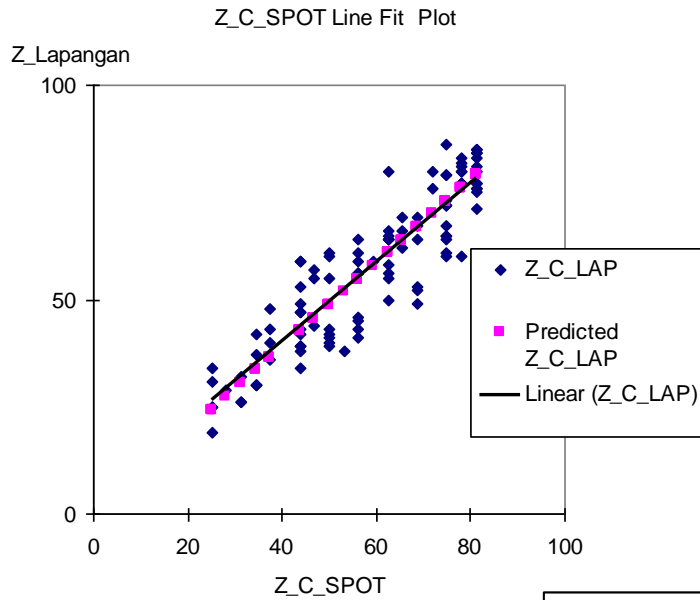


CLUSTER and PLOT in the Field

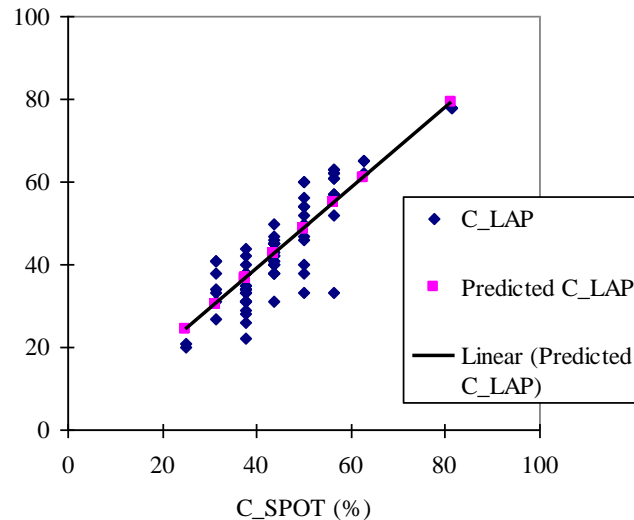


PURPOSIVE SAMPLE

Consistency C_{lap} vs. SPOT



C_SPOT Line Fit Plot



Ht. Mangrove

- $C_{lap} = 0,97$ CTS
- $R^2 = 82\%$

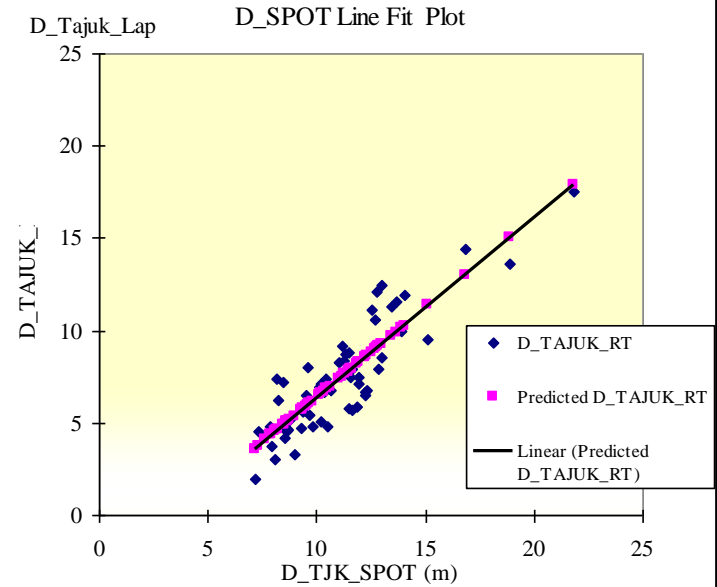
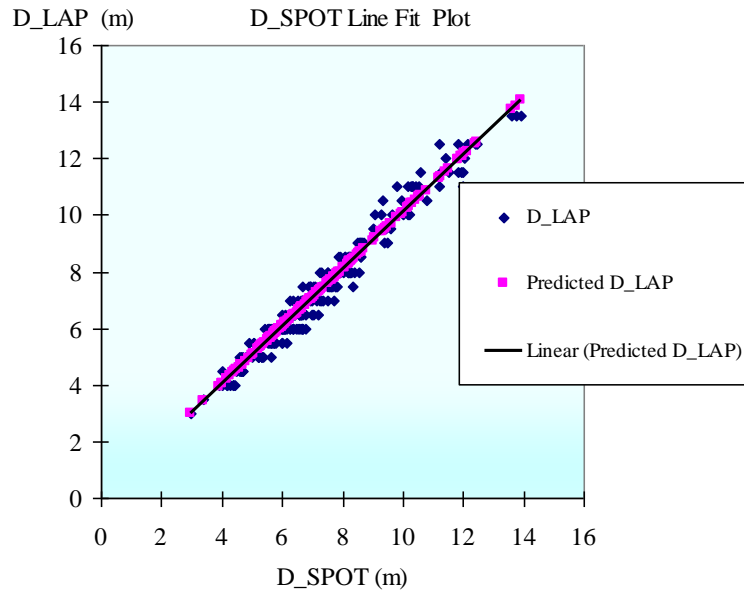
Ht. Rawa

- $C_{lap} = 0,87$ CTS
- $R^2 = 93,19\%$

Ht. Lahan Kering

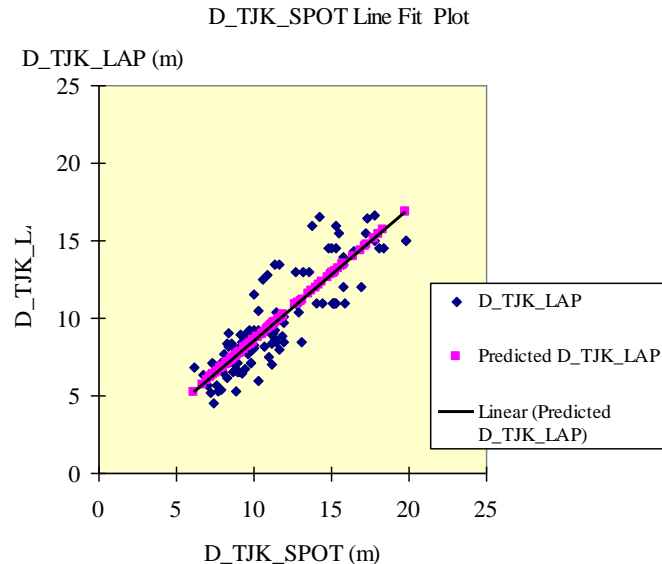
- $C_{lap} = 0,9231$ CTS
- $R^2 = 96,17\%$

Correlation D_{lap} vs. DTS (image)



Hutan Mangrove

$$D_{lap} = 1,009 D_{SPOT}$$
$$R^2 = 99,72 \%$$



Hutan Rawan

$$D_{lap} = -3,327 + 0,969 D_{SPOT}$$
$$R^2 = 77,58 \%$$

Hutan Lahan Kering

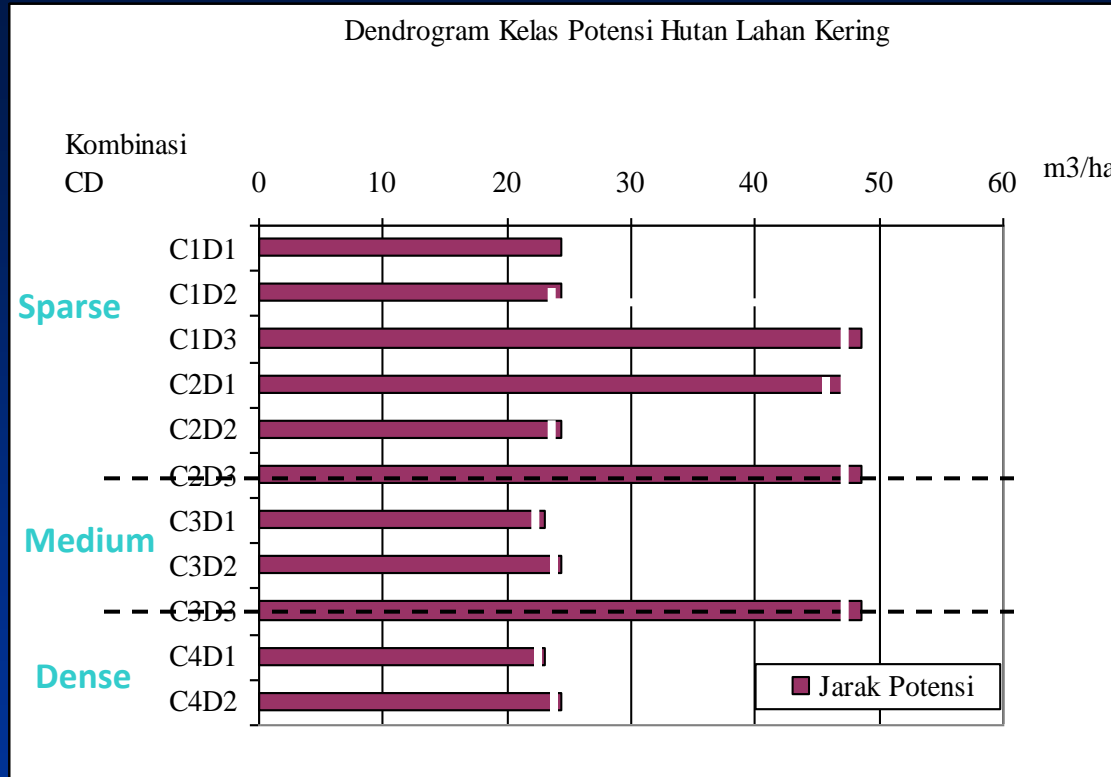
$$D_{lap} = 0,85055 D_{SPOT}$$
$$R^2 = 97,66 \%$$

Satellite (image) Stand Volume Table: (Lowland Forest)

$$V_{bc} = 2.345984 + 0.479639 \text{ CTS} + 0.012151 \text{ DTS}^2$$

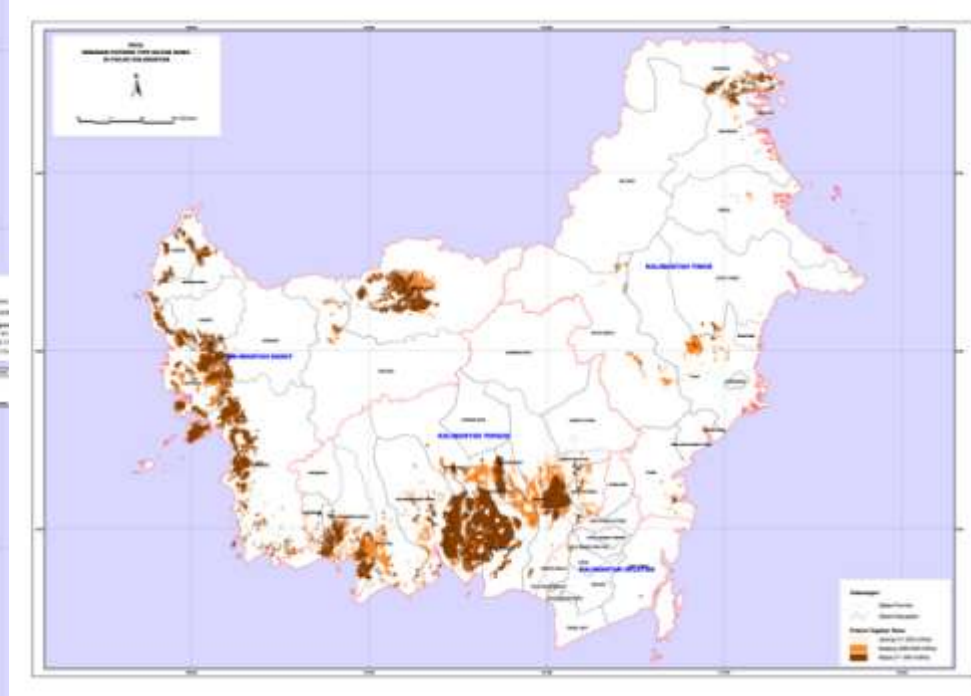
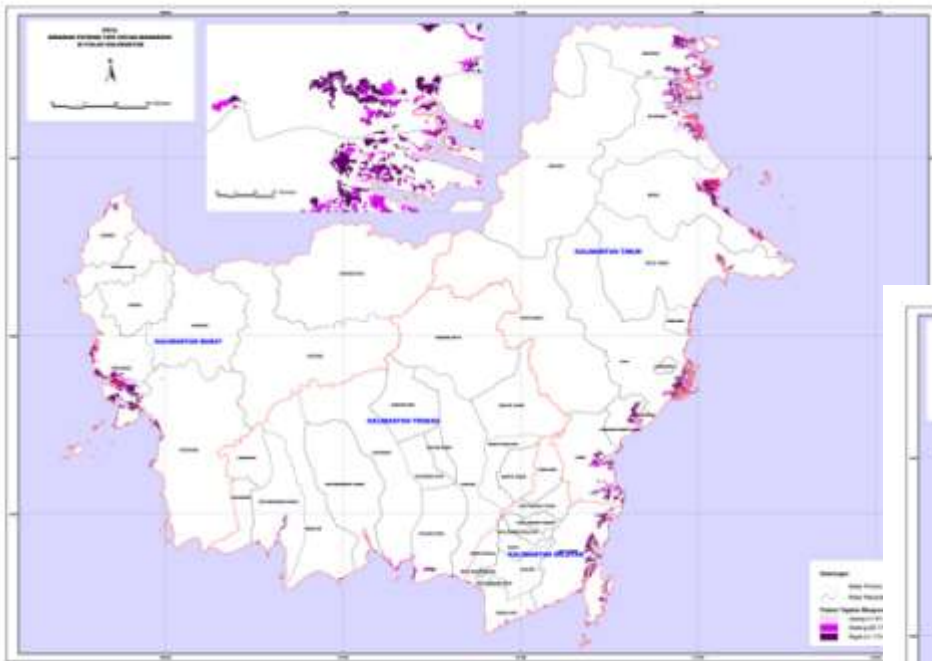
| | Kls D | D1 | | D2 | | D3 |
|----------------|-------|--------|--------|--------|--------|--------|
| Kelas C | | 5 | 10 | 15 | 20 | 25 |
| | 10 | 74.46 | 83.57 | 98.76 | 120.03 | 147.37 |
| | 15 | 98.44 | 107.56 | 122.75 | 144.01 | 171.35 |
| C1 | 20 | 122.43 | 131.54 | 146.73 | 167.99 | 195.33 |
| | 25 | 146.41 | 155.52 | 170.71 | 191.97 | 219.31 |
| | 30 | 170.39 | 179.50 | 194.69 | 215.96 | 243.30 |
| | 35 | 194.37 | 203.48 | 218.67 | 239.94 | 267.28 |
| C2 | 40 | 218.35 | 227.47 | 242.66 | 263.92 | 291.26 |
| | 45 | 242.34 | 251.45 | 266.64 | 287.90 | 315.24 |
| | 50 | 266.32 | 275.43 | 290.62 | 311.88 | 339.22 |
| | 55 | 290.30 | 299.41 | 314.60 | 335.87 | 363.21 |
| C3 | 60 | 314.28 | 323.39 | 338.58 | 359.85 | 387.19 |
| | 65 | 338.26 | 347.38 | 362.56 | 383.83 | 411.17 |

Low land Forest



| Class in Landsat | Lowland Forest Potency (m ³ /ha) | CD Class in SPOT |
|------------------|---|------------------------------|
| Sparse | ≤ 267 | C1D1, C1D2, C1D3, C2D1, C2D2 |
| Medium | 268 ~ 363 | C2D3, C3D1, C3D2 |
| Dense | ≥ 364 | C3D3, C4D1, C4D2 |

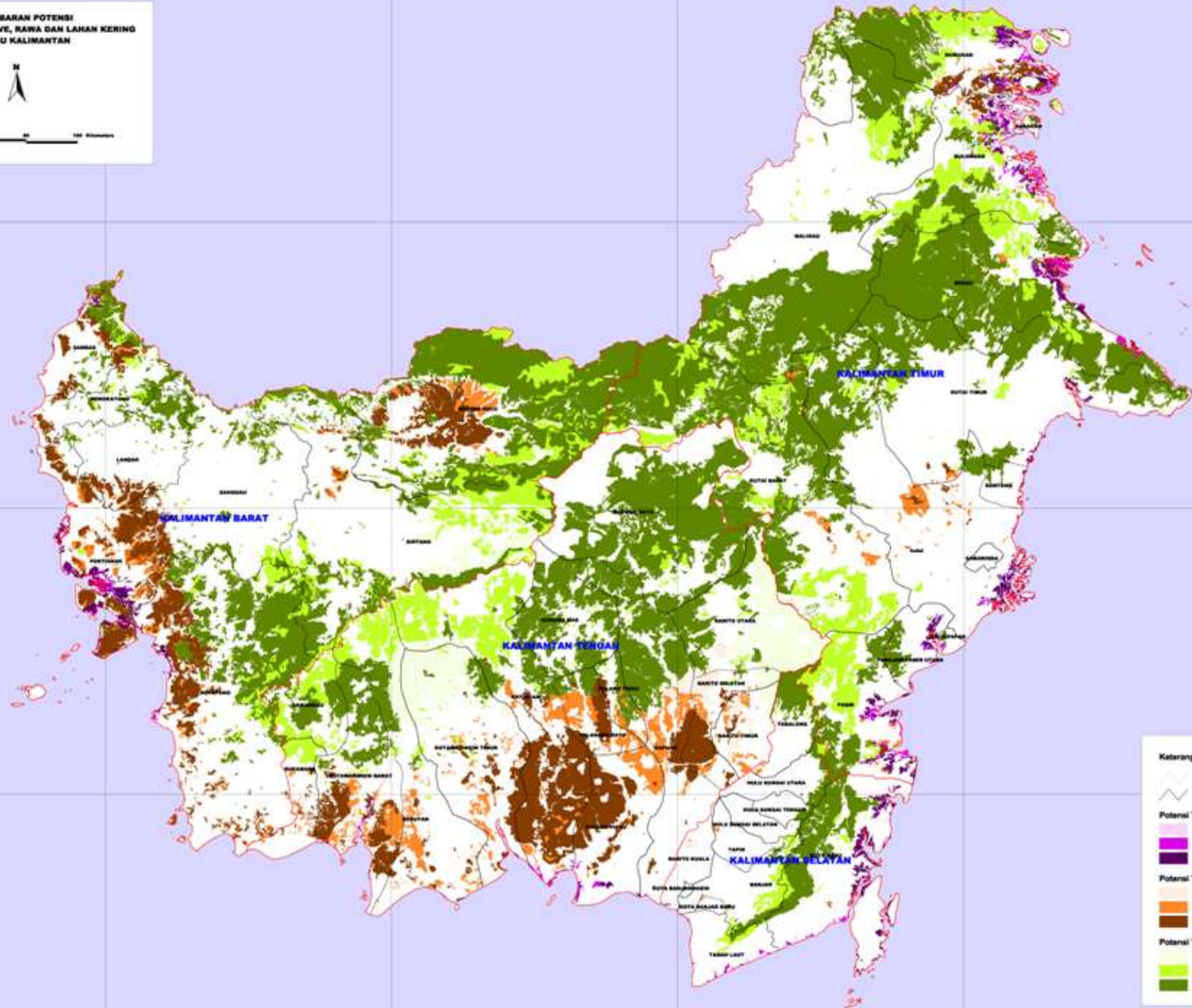
CALCULATION HAD BEEN DONE ON EVERY FOREST TYPE



POTENSI KALIMANTAN



PETA SEBARAN POTENSI
TIPE HUTAN MANGROVE, RAWA DAN LAHAN KERING
DI PULAU KALIMANTAN



Keterangan:

- Batas Provinsi
- Batas Kabupaten

Potensi Tegakan Mangrove

- Jarang (<= 81 m³/ha)
- Sedang (82-171 m³/ha)
- Rapat (>= 172 m³/ha)

Potensi Tegakan Rawa

- Jarang (<= 225 m³/ha)
- Sedang (226-330 m³/ha)
- Rapat (>= 330 m³/ha)

Potensi Tegakan Lahan Kering

- Jarang (<= 287 m³/ha)
- Sedang (288-363 m³/ha)
- Rapat (>= 364 m³/ha)

FOREST RESOURCES MONITORING

- **HIGH RESOLUTION IMAGES (IKONOS, QUICKBIRD)**
- **RADAR (ALOS-PALSAR)**



Human Resources Development

☑ Personnel

- Head Quarter : *< 10 experts*
- Regional Offices : *17 unit*



☑ Capacity building

- Study (*Master, PhD*)
- Training
- Workshop, Seminar (*National and International*)
- Foreign cooperation (*Australia, Japan, EU, US*)



Gracias

Legenda

| | |
|----------------|-------------------|
| [Light Green] | 0-5 or. maha |
| [Yellow-Green] | 5-10 or. maha |
| [Light Green] | 10-15 or. maha |
| [Light Green] | 15-20 or. maha |
| [Light Green] | 20-30 or. maha |
| [Light Green] | 30-40 or. maha |
| [Light Green] | 40-60 or. maha |
| [Dark Green] | 60+ or. maha |
| [Brown] | Non-Forest Land |
| [Pink] | Altitude > 1,000m |
| [White] | No Data Available |

Thank you

