Land Cover Change Analysis for Supporting Indonesia's National Carbon Accounting System (INCAS)

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Outline

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2. Method
3. Results
4. The product
3. The Next Program

Background and objective

Forest coverage of Indonsia is about 99.6 million hectars or 52.3% of Indonesia coverage. (Indonesia forestry statistik Book. MoF, 2011)

The rate of Indonesia forest deforestration in 1985-1998 about 1.6-1.8 million/hectars/year (MoF, 2000). This year it is expected about 2.4 million/hectars/year

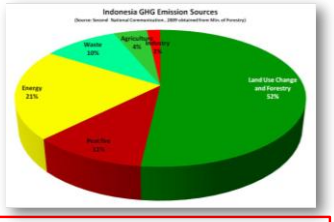
The real world – Central Kalimantan

2000 2009

This region has some big areas of change (top right), some areas of small change (roads centre and left) and cloud in may years.

Why Land Cover Change Monitoring?

Land use and forestry contributed 52% to GHG emission source



- The land sector has been the largest contributor to the nation's greenhouse gas emissions
- Our purpose is to estimate greenhouse gas emissions (carbon) from land use change and forestry.

Land Cover Change Monitoring

Decreasing rates of forest loss, improving forest management and establishing reforestation programs all present opportunities for Indonesia to benefit from international initiatives such as REDD+.

A national system for monitoring and reporting forest change is required for participation in such programs. National policy drivers and international reporting requirements on Monitoring, Reporting, and Verification (MRV) also require such a system.

The initial objective of the LCCA was to map the extent of forested land and the annual changes in the extent for the whole of Indonesia for more than the 10-year period

Land Cover Change Monitoring

For this purpose forest cover is defined as physical land cover irrespective of tenure; as a collection of trees with height greater than 5 metres and having greater than 30% canopy cover. Plantations of oil palm and coconut palm are considered as non-forest. All other land cover is considered non-forest.

LCCA does not produce classifications of forest type from satellite imagery; forest type information in The Indonesian National Carbon Accounting System (INCAS) is provided from MoF during the the biomass and emissions estimation process.

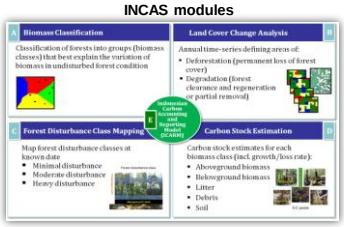
Indonesians has steadly progressed on INCAS

In July 2008, the President of Indonesia and the Prime Minister of Australia signed the Indonesia-Australia Forest Carbon Partnership (IAFCP).

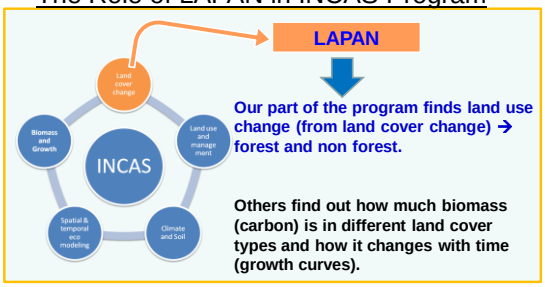
INCAS program (2009-2014) is a key component of the IAFCP.

INCAS is ***designed to provide a comprehensive and credible account of Indonesia's forest-based emissions profile and sinks capacity on an annual basis.***

INCAS modules



The Role of LAPAN in INCAS Program



The Ministry of Forestry (MoF) is the lead GoI partner for the overall INCAS program and leader of the emissions estimation component.

Method

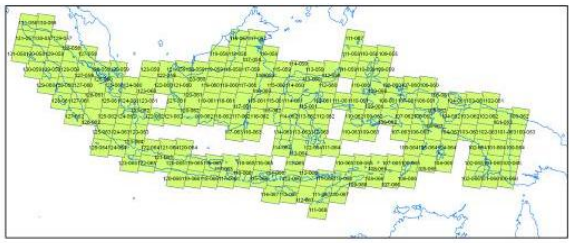
The Data (1)

- **Primary data:**
  - Landsat-5 and Landsat-7
  - Landsat: calibrated with a procedure which incorporates BRDF corrections. Terrain illumination corrections are then applied using SRTM DEM and the C-correction method
  - Processed: cloud cover, mosaicked
  - Source: GISTDA (Thailand), GeoScience Australia, USGS, and LAPAN archives
  - Period: 2000 – 2012

The Data (2)

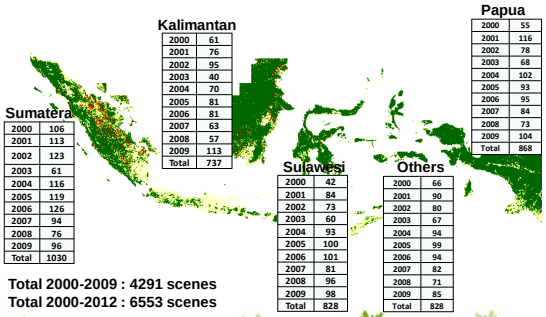
- **Secondary data:**
  - High resolution images GeoEye, Ikonos, Quickbird, and WorldView.
  - Information from local experts with knowledge of regional land cover and land use
  - Ground truth data from local government and BIG

Landsat Path-Row Coverages over Indonesia



- 225 Landsat images to cover Indonesia.
- Up to 5 images (usually 2-3) selected to provide maximum cloud-free area

Landsat Data (2000-2009)



Sumatera

2000	106
2001	113
2002	123
2003	61
2004	116
2005	119
2006	126
2007	94
2008	76
2009	96
Total	1030

Kalimantan

2000	61
2001	76
2002	95
2003	40
2004	70
2005	81
2006	81
2007	63
2008	57
2009	113
Total	737

Sulawesi

2000	42
2001	84
2002	73
2003	60
2004	93
2005	100
2006	101
2007	81
2008	96
2009	98
Total	828

Others

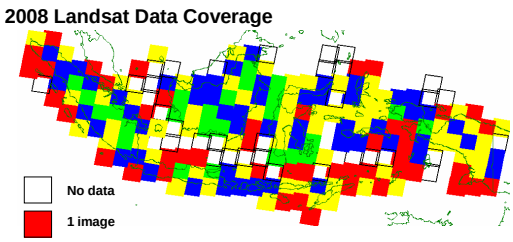
2000	66
2001	90
2002	80
2003	67
2004	94
2005	99
2006	94
2007	82
2008	71
2009	85
Total	828

Papua

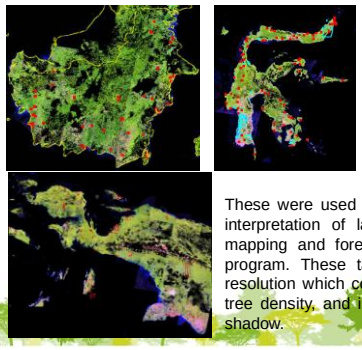
2000	55
2001	116
2002	78
2003	68
2004	102
2005	93
2006	95
2007	84
2008	73
2009	104
Total	868

Total 2000-2009 : 4291 scenes
Total 2000-2012 : 6553 scenes

Scene Selection Results



High Resolution Data



Kalimantan:
53 Quickbird, Ikonos, World View-2, and Geo Eye-1 (2001 to 2010, mostly 2007 to 2009).
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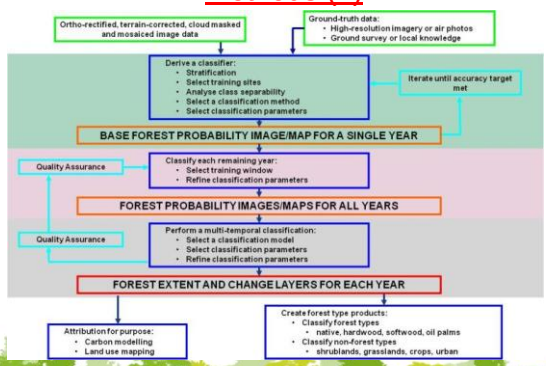
Sulawesi:
79 Quickbird and World View-2 (2006 to 2011)

Papua:
62 Quickbird, Ikonos, World View-2, and GeoEye (2006 to 2011)

These were used for purposes of accurate interpretation of land cover in the forest mapping and forest review stages of the program. These tasks required an image resolution which could provide estimates of tree density, and indications of height from shadow.

Methods (1)

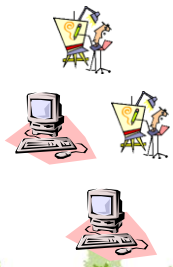


Each step in the processing there is a quality assurance (QA) process to check that the method has been correctly applied and that the results meet required accuracy standards

Methods (2)

Three-stage process:

1. The creation of a 'forest base' probability image for a chosen single year → CVA method (Campbell & Atchley, 1981; Cacetta et al, 2007; Furby et al, 2010)
2. 'Match' the data for other years to the 'base' to create forest probability images for all years
3. Perform multi-temporal processing and create final products → CPN : Lauritzen, 1992; Kiiveru=I & Cacetta, 1998; Furby (2000),…



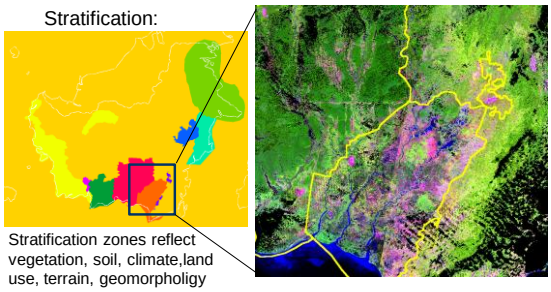
Making of Forest Base

The process are;

1. Producing Forest base probability
   a) Set "base year" from available Landsat imagery , supply high resolution image
   b) stratification
   c) training sample for analysist
   d) deriving indices
   e) manually setting thresholds
   f) iteration until sufficient accuracy is obtained
   g) mosaicing probability images

Making of Forest Base (Stratification)

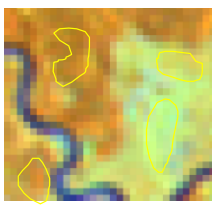
Stratification:



Stratification zones reflect vegetation, soil, climate,land use, terrain, geomorpholigy feature associations.

Digitised directly from the imagery.

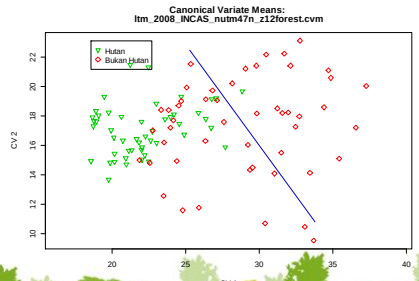
Making of Forest Base (Training Sample)



Use high resolution imagery, local expert, or ground truth to locate training samples of forest and not forest cover

Making of Forest Base (Derive Indices)

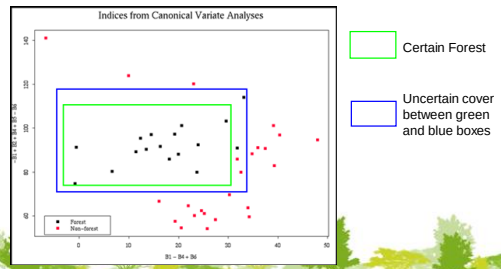
Canonical variate analyses are performed using the training data to derive suitable indices for discriminating between forest and non-forest cover.



Making a Forest Base (derive indices)

This targeted approach allows optimal indices to be derived for each stratification zone, rather than applying common indices over the whole country.

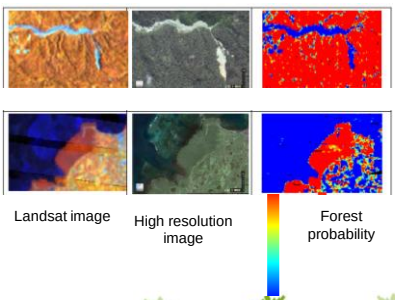
The better the indices separate forest and non-forest cover, the smaller the uncertain region



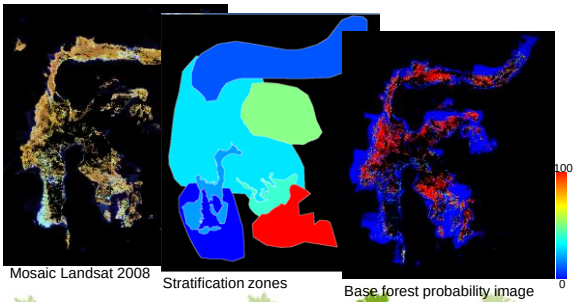
Making a Forest Base (setting threshold)

As well as defining the edge of these three partitions of the image, the thresholds determine the probability assigned to each pixel. Pixels with index values in the certain forest spectral region are assigned a probability of forest cover of one (100%). Pixels with index values in the certain non-forest region are assigned a probability of forest cover of zero. Pixels with index values in the uncertain spectral region are assigned a probability of forest cover between .

Making a Forest Base (QA)



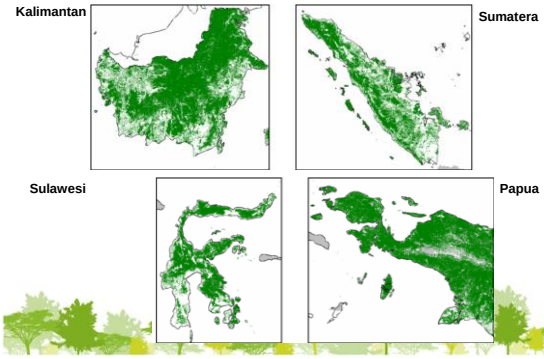
Making a Forest Base (Base Mapping Result)



Mosaic Landsat 2008 | Stratification zones | Base forest probability image

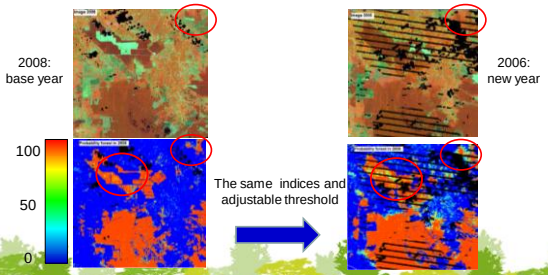
The results of the base mapping for Sulawesi, produced from base year 2008

2008 forest extent "base" map



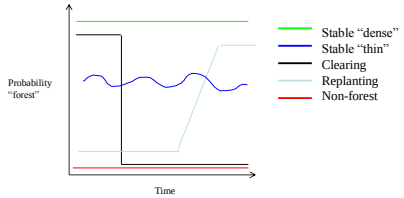
Matching: forest classification for other years

- Matching finds thresholds that minimise the difference between the base probability image and the probability image for the new image.
- Automation reduces the processing time (and hence costs) and increases the temporal consistency of the products obtained.



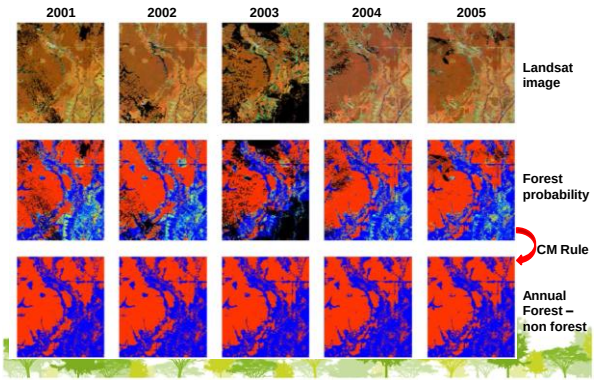
Multi temporal classification (Rule)

Uses the temporal trends in the probabilities of forest cover to
- resolve the uncertain spectral region; and
- more accurately detect genuine change.

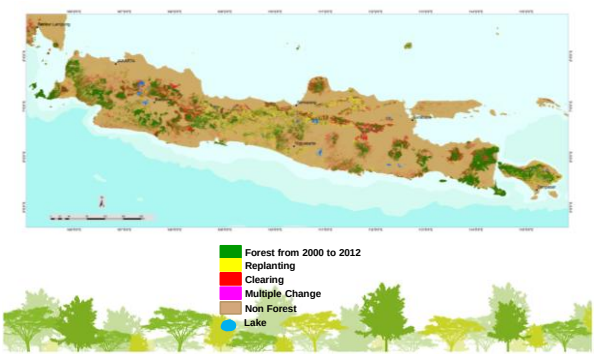


Schematic diagram of temporal patterns of probabilities over time for forest and non-forest cover, and for clearing and regrowth of forest.

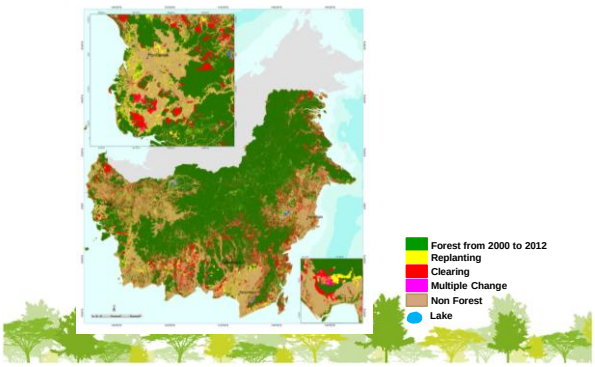
Multi temporal classification (process)



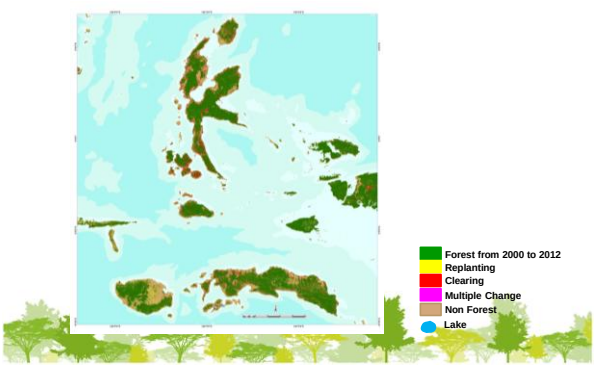
Forest loss and gain for 2000-2012 at Java



Forest loss and gain for 2000-2012 at Kalimantan

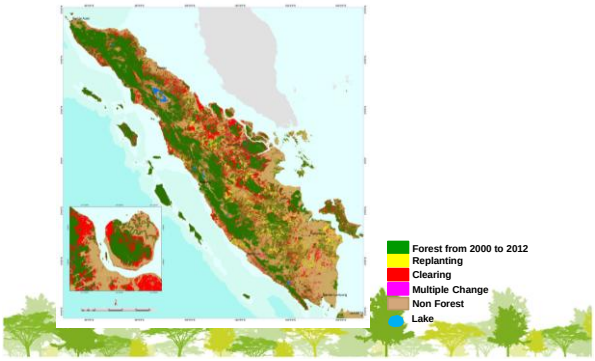


Forest loss and gain for 2000-2012 at Maluku

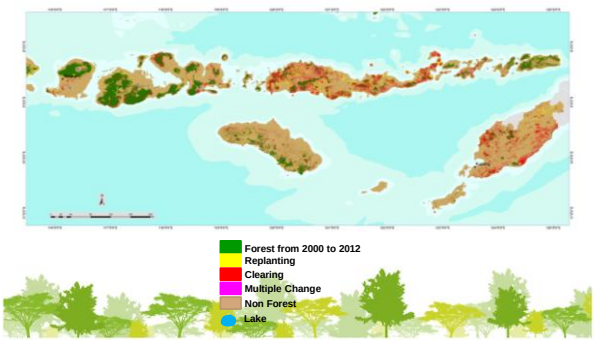


Forest loss and gain for 2000-2012 at Papua

Forest loss and gain for 2000-2012 at Sumatera



Forest loss and gain for 2000-2012 at Nusa Tenggara



Forest loss and gain for 2000-2012 at national scale Indonesia

Total forest loss and gain 2000-2009 at national scale from the LCCA. Dark green indicates areas that were always forest from 2000 to 2009, red shows forest loss between 2000 and 2009 while yellow indicates forest gain in the same period. [source: INCAS poster, Workshop on Earth Observation Satellite Data to Support REDD+ Implementation in Indonesia, February 2014]

The Product

1. LAPAN has been available mosaic Landsat data for Sumatera, Kalimantan, Java Sulawesi, Nusa Tenggara, Maluku, and Papua the period of 2000-2012
2. LAPAN had finished LCCA product for all of Indonesia, since 2000 to 2012 as input for the next process regarding the calculation of biomass

The Next Program

By the middle of 2014, annual forest extent and change products for Indonesia from 2000-2012 will have been produced. The effort to initiate the program and to process this historical data has been considerable, but from the middle of 2014 the program will move to a single-year 'annual update' mode where much less effort is required. There is a commitment by LAPAN to continue the processing to produce an update using 2013 data. Discussions around extending the time series back to 1990 are ongoing.

Thank you
for your kind attention