Government of Central Kalimantan

Government of Indonesia

Government of the Netherlands

Master Plan for the Rehabilitation and Revitalisation of the Ex-Mega Rice Project Area in Central Kalimantan

2007 LAND USE / LAND COVER MAP OF THE EX-MEGA RICE PROJECT AREA IN CENTRAL KALIMANTAN

Technical Review No. 5

OCTOBER 2008

Euroconsult Mott MacDonald and Deltares | Delft Hydraulics
in association with
DHV, Wageningen UR, Witteveen+Bos, PT MLD and PT INDEC

Master Plan for the Rehabilitation and Rehabilitation of the Ex-Mega Rice Project Area in Central Kalimantan

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2007 Land Use / Land Cover Map of the Ex-Mega Rice Project Area in Central Kalimantan

SarVision Netherlands

Government of Indonesia

Royal Netherlands Embassy, Jakarta

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1 Summary

This report presents the final map and legend of the revised land use/cover map for the Central Kalimantan Peat-Land Project (CKPP) area. Methodology and results are presented after including the remarks by Indonesian users and CKPP staff members. Legend is being developed according to the Remote sensing radar sensitiveness and the needs and comments of the users. A Final Map is presented including 22 classes of land cover and land use. Descriptions of the cover classes are included. Discussion is focused on the differences of the new legend compared to the old legend and on the differences between the presented legend and the legend required by the CKPP staff. Accuracy assessment could not be presented due to delays on the delivery of the field data. To the date of issue of this report field photographs were unavailable and some part of the vegetation information was unavailable as well. More time would have been needed for a proper study of the field data and a proper accuracy assessment. Photographs available from the previous field work were used to study the image and the final classified map. Some examples will be given.

2 Objectives

2.1 Assignment Objective(s)

To update the existing land use/cover map of the EMRP area by the integration of new available Radar data (HV polarisation) and field information into the classification. Map accuracy was initially supposed to be part of the assignment but was impossible to complete due to delays in the field data delivery.

2.3 Map Objective(s)

The LULC map over the CKPP area is meant to be used for spatial planning by Local provincial government and the members of the consortium of the Ex-Mega Rice Project area in Central Kalimantan.

3 Project area

The project area is located in the south of Central Kalimantan province (Kalimantan Tengah), Indonesia and consists of the EMRP area as a whole including the so-called blocks A, B, C, D and E, as well as Sebangau National Park (SNP). The provincial capital (Palangkaraya) is located to the northeast of the project area (see *figure 1*). The total mapped area covers approximately 1°30'S – 3°25'S and 113°15'E – 115°E.

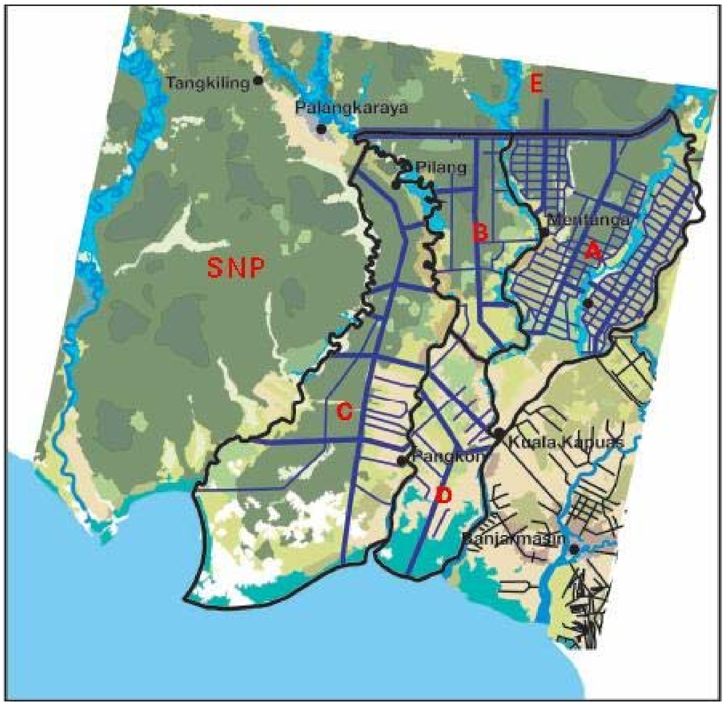


Figure 1. Project area including Sebangau National Park and blocks A-E, canal system and land cover for May 1997 (pre-fire). Dark green: low pole peat swamp forest (PSF); Green: tall PSF; Beige: agriculture and fallow land; Bright green: fragmented PSF and PSF mosaics; Brown green: grass and bushland; Blue green: mangrove forests; Light blue green: pristine swamp forest (periodically inundated); Pale green: dry and swampy grasslands; White: clouds; Blue: rivers. ***Source: modified from Page et al., 2002.***

The area is predominantly flat and characterised by a humid tropical climate with mean daily temperatures varying from 25 to 33°C at sea level, high humidity (85-90%) and a mean annual precipitation of approximately 2,400 mm. Normal dry seasons last from May/June to September. During El Niño-Southern Oscillation (ENSO) years such as 1997 however, the dry season may begin as early as March and last until December.

Land use/cover is dominated by (peat) swamp forest, secondary forests, bushland and grass- and cropland. Most forest has been extensively logged. Shifting cultivation and plantations (e.g. *Jelutung*, *Acacia*) prevail close to the rivers and canals, while large scale paddy rice cultivation is found in block A. Low growing grasses and wild ferns are widely found, the latter particularly in recurrently burnt areas.

Large rivers including the Katingan, Kahayan, Barito and Kapuas rivers and streams provide the main transportation routes and few roads exist. People live in small settlements located along the rivers and a small number of transmigration areas.

The following dynamics strongly influence land use/cover characteristics and their signature in satellite imagery:

- Seasonality – peatland covers most of the project area. During the wet season the peatsoil can be largely waterlogged with water levels rising above the soil surface.

Contrast in satellite imagery between vegetation types is stronger in the dry season.

- Fire influence - much of the project area (blocks A – D in particular) is known to be severely affected by fires on an annual basis during the dry season, resulting in a complex landscape including various stages of post-fire recovery.

4 Material and methods

4.1 Satellite Radar data:

Landsat satellite data
Optical Landsat imagery is most commonly used for land use/cover mapping. Due to persistent cloud cover in the project area however, such imagery is often not available when needed. By chance, a relatively cloud free image of 4 July 2007 over the project area (path-row 118-062) came available and was acquired for the current assignment. Since 31 May 2003, the sensor's scan line corrector failed, resulting in lines of missing data. For this reason a gap-filled image was ordered, produced by USGS using pixel interpolation with selected historic images.

Routine data quality control of the gap-filled image established that cloud cover affected part of block A and the southern section of block C. Significant striping artefacts (e.g. due to cloud covered fill scenes) occurred near image boundaries, particularly problematic for block A. Finally, geometric distortions resulting from the interpolation procedure were reported. Due to these problems, it was decided not to use the Landsat as a basis for map classification, but for reference purposes only.

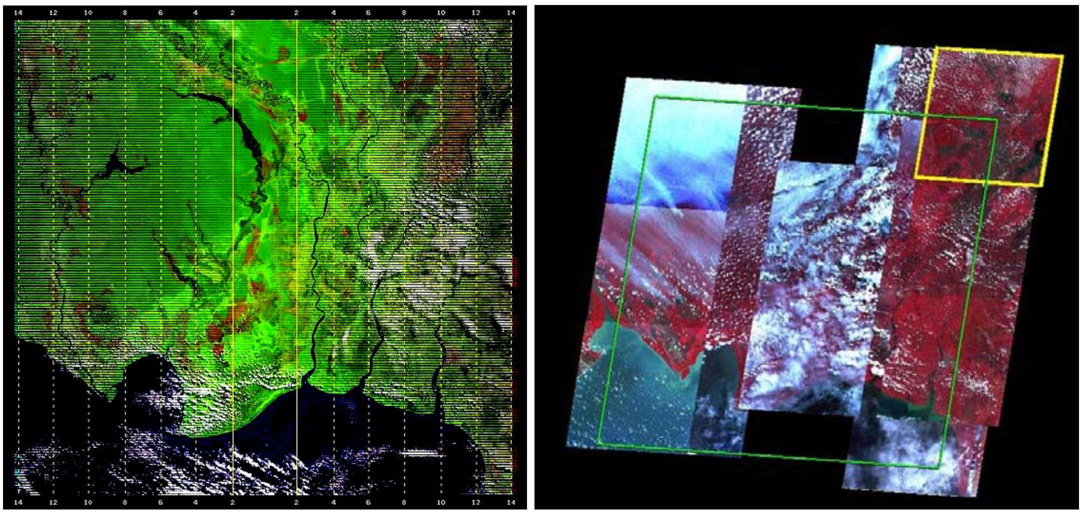


Figure 2 Left: missing data lines in the 2007-07-4 Landsat ETM+ image as a result of permanent satellite sensor failure. Right: Available 2006-2007 ASTER imagery covering the same Landsat scene over the project area (green rectangle). Cloud and haze are shown in white. ***Source: USGS Global Visualisation Viewer [http://glovis.usgs.gov]***

ASTER satellite data

In accordance with recommendations from the provincial government, ASTER imagery was identified as a preferred data source to replace Landsat. However, due to persistent cloud cover, no recent cloud free imagery is available for the project area.

PALSAR

In absence of acceptable optical data, the decision was made to use PALSAR L-band radar data as a basis for map classification. Observation by radar systems is unimpeded by cloud cover.

Within the framework of the ALOS Kyoto and Carbon Initiative, a combination of Fine Beam Dual Polarisation HH and HV (dry period July 2007) 50m resolution and Wide Bean Single Polarisation HH (wet period 2007-02-11) 100m resolution images, were obtained and used for the revision of the CKPP map created in 2007. The CKPP map-2007 was created using multi-date L-band HH data.

The new classification includes L-band HV polarisation, well known to be sensitive to standing biomass and therefore is highly capable to differentiate different vegetation structures and cover types. In radar scientific literature authors have found relations between HV polarisation and biomass for different forest types. Empirical models between radar data and biomass levels have been established for temperate forests (Beaudoin et al., 1994, Le Toan et al., 1992, Dobson et al.,1992), tropical forests (Imhoff, 1995, Hoekman and Quinones, 2000, 2002), boreal forests (Rignot et al., 1994, Ranson et al., 1994), coniferous (Beaudoin et al., 1994, Dobson et al., 1992), deciduous (Imhoff, 1995) and mixed forests (Rignot et al., 1994, Ranson et al., 1994). The use of L-band HV polarisation is also been point out as important for land cover monitoring scenarios by (Hoekman and Quinones, 2000, 2004).

The L-band HH polarisation used for the previous classification is sensitive to both flooding and land cover types, but the influence of flooding can have very strong effects on the cover type classification. The combination of these two polarisations appears to be ideal for Land cover mapping. Combined it contains both the information on Land Cover types (levels of biomass) and the flooding (soil moisture) information. It is expected that the present map will improve the previous classification since the definition of the Land cover legend is directly related to radar sensitiveness. A certain level of understanding of the physical interaction between the radar wave and the terrain is necessary to allow an accurate interpretation of radar PALSAR images.

Polarisation is an important radar wave parameter, there are three main Polarisations available HH, HV and VV. The polarisations used by the PALSAR system are the HH and HV (Table 1). Biomass and Flooding (soil Moisture) are two of the most important terrain parameters that can be detected by radar remote sensing. Increase in biomass levels increases the radar echo (or backscatter) intensity. Biomass levels of around 100-150 ton/ha can be detected by Radar L-band. Above this biomass level the radar image intensity saturates and the radar wave does not penetrate the vegetation well. Below this biomass level, or in open canopies, the effect of flooding (soil moisture) is noticeable. In this case the interaction mechanism is somewhat different. The radar instrument is side-looking and the water surface acts as a mirror. Hence, smooth open water surfaces yield no radar return, i.e. these areas appear black in the image. However, when vegetation is present it causes a second reflection (mainly by tree trunks) in the direction of the radar. This effect is particularly strong for the so-called HH polarisation.

The main system characteristics of the PALSAR are summarised in Table 1.

Table 1. ALOS PALSAR Wide Beam 1 (ScanSAR) and ASAR AP (Alternating Polarisation precision image) characteristics*

	PALSAR WB	PALSAR FB DP
Centre frequency	1.27 GHz/23.5 cm	1.27 GHz/23.5 cm
Image mode	Single polarisation HH (default) or VV	Dual polarisation HH and HV
Incidence angle	24.6 - 27.1°	
Spatial resolution	100m	50m
Swath width	250km	70km

**This mode is suited for direct downlink by international ground stations, enabling the current mapping approach to be implemented, in principle, for tropical peat swamp monitoring worldwide.*

4.2 Reference data

Digital elevation data

Digital elevation data at 90m resolution derived from the Shuttle Radar Topography Mission (SRTM) was used as a baseline for co-registration of all satellite data used, since this dataset will form the basis of hydrological scenarios for the project area.

MODIS and AATSR fire hotspot data

Fire occurrence was confirmed using a previously developed dataset of daily moderate resolution fire hotspot data detected by the MODIS and AATSR sensors from 2004 until mid-2007[1]. Each hotspot detection represents the centre of a pixel of approximately 1 km^2 containing one or more active fires within that pixel. It is important to note that not all actual fires are detected by these sensors due to cloud and smoke cover and intense fires burning when there is no satellite overpass. For example, particular vegetation fires occurring in dry grass or shrub cover may spread fast and burn only briefly and hence go undetected, while peatland fires may burn for several days have a higher chance of being detected.

1 MODIS active fire detection data courtesy of NASA/University of Maryland, 2002. MODIS Hotspot/Active Fire Detections. Data set. MODIS Rapid Response Project, NASA/GSFC [producer], University of Maryland, Fire Information for Resource Management System [distributors]. Data processed by SarVision.
(A)ATSR active fire detection data courtesy of European Space Agency, ESA/ESRIN. ATSR World Fire Atlas [http://dup.esrin.esa.int/ionia/wfa/index.asp]. Data processed by SarVision.

Reference land use/cover maps

A literature review established the existence of several land use/cover maps for the project area, from the period 1997 – 2005 (*annex 1*). This includes the current official maps produced and used by the Indonesian Ministry of Forestry and BAPPEDA, and a tree cover percentage map (0 – 100%) for 2005 developed by the University of Maryland/South Dakota State University using MODIS 500m data.

Ground survey data 2007-2008

New field observations were collected by members of the CKPP consortium, explicitly to create training and validation sets of points useful in this classification process. At the moment of writing this report only part of the field data (without processing) was delivered to SarVision, (May 20-2008). The rest of the data is still not being delivered. Photographs with coordinates were supposed to be delivered to SarVision as an illustration of the vegetation types in the area with explicit examples of the cover percentages. The photographs has not yet been delivered due to some unspecified problems. Photographs with coordinates, obtain during the water survey, in 2007, were used to study the types of vegetation and to have a reference to the cover types occurring on the area. A shape file was created with the locations of the photographs and overlaid with the images and the classifications to give a reference and to create a set of points with a photograph referred to the revised map.

Other reference data

Other reference data includes satellite imagery like Landsat time-series (2000 – 2006) available in the SarVision archive and SPOT 4 and 5 quicklooks. Moreover, georeferenced orthophotographs collected during ultralight overflights in 2005 were used as reference. See *table 2* for a full list of data satellite and reference used.

Table 2. Overview of satellite and reference maps used for the current assignment

Data source	(image) date	Remarks
PALSAR WB HH	2006-12-27 2007-02-11 2007-05-14	Used for classification
PALSAR FB HH-HV	2007-07	Used for classification
Landsat 7 ETM+	Path-row 118 – 062: 2007-07-04 2006-09-03 2005-10-02 2004-06-28 2003-02-15 2001-08-20 2000-07-16 Path-row 118-061 (block E): 2005-10-02	Used for reference
SPOT 4, 5 Quicklooks	SPOT 4 - block E2: 2007-09-29 SPOT 5 - block E1: 2007-09-02	Used for reference
MODIS Tree cover	University of Maryland/SDSU MODIS VCF Tree cover percentage 2005	Used for reference
Fire hotspot data	Database NASA/ University of Maryland MODIS, ESA/ESRIN AATSR hotspots January 2004 – June 2007	Used for reference
Landsat forest mask	SarVision forest non-forest 2005-10-02	Used to assist classification (see section 5)
Reference LULC maps	Ministry of Forestry Peta Penuputan Lahan Provinsi Kalimantan Tengah 2003	Used for reference
	Ministry of Forestry/BAPPEDA Peta Kawasan Vegetasi 2003	
	Bakosurtanal Liputan Lahan 1:250,000 LULC map 2003	
	EU STRAPEAT 1:100,000 LULC map 1997	
	Kalteng consultants LULC map 2003	
	Remote Sensing Solutions Gmbh LULC map 2003	

4.3 Image processing

Pre-processing

All image processing and post-processing was performed using ENVI 4.4 and IDL 6.4 software, including IDL programs and algorithms developed in-house.

PALSAR images were first radiometrically calibrated. As data was received in slant range each individual image was converted to ground range by means of registration to the SRTM elevation data set at 90m resolution. During an extensive ground control point selection process, 250 control points were selected for each image. A 3 degree polynomial transformation was performed resulting in a RMS of less than 0.43. Resulting geo-referenced FB dual polarisation 50m and WB single polarisation PALSAR 100m (resampled to 50m) were stacked and used as the based for the classification process. No speckle filtering was applied as speckle levels are low, having no significant influence on classification results. No topographic correction was performed as the project area is predominantly flat.

Classification

In general, several approaches can be used to produce thematic maps based on satellite imagery:

- Visual interpretation – a human operator broadly delineates areas based on visual interpretation, the traditional way of mapping in many tropical forest countries.
- Supervised classification – a human operator defines the classes selecting reference areas considered representative of each class. The computer is ‘trained’ to use this information to assign pixels to one of the possible classes using a computer algorithm.
- Unsupervised classification – a computer algorithm is used to automatically analyse satellite input data, identifying groups of pixels with similar statistical properties.

For this project, SAR satellite images have been classified using a newly developed unsupervised classification approach (Hoekman *et al*. 2007, Tran *et al*. 2005, Tran 2005). The approach implemented in IDL/ENVI uses an advanced type of spatial mixture modelling and produces a series of classification models.

First, unsupervised clustering is performed to derive class statistics, encompassing a simple region-growing segmentation. Segmentation is followed by model-based agglomerative clustering and expectation-maximisation on the pixels of these segments. Final classification is achieved by Markov Random Field filtering on the original data. The Markov Random Fields approach enables for incorporation of spatial context in image classification. The result is a series of segmented maps, which mainly differ in the number of classes (see *figure 3*).

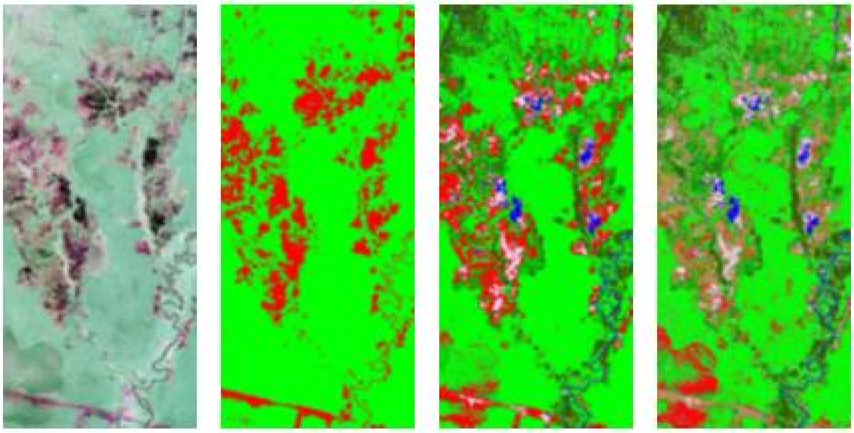


Figure 3. Example series of classification models: input radar image composite (left); model 2 resulting in separation of forest and non-forest (mid-left); model 6 resulting in further separation of water and bare areas (mid-right); and model 12 adding classes such as herbaceous cover, shrub cover and open forest (right).

4.4 Legend development

The legend development process is a combination of the radar based legend (created on the basis of radar sensitiveness) and the user needs. Classes that are statistically detected on the classification procedure are the base for the discussion with the users. The extraction of the radar data (backscatter values) associated to each class is followed by proper backscatter analysis for both HV and HH bands leads to a first radar based legend. A theoretical analysis of the relation between biomass and the radar HV return and the flooding conditions and the radar HH return for both dry and wet period was done based on the radar backscatter values. Backscatter levels were analysed and classes labelled using expert knowledge, the reference data (available LULC maps, MODIS vegetation continuous fields tree cover as well as fire hotspot data, Landsat time-series) and some field survey data (including field and aerial photographs).

We used the definitions of the Indonesian Ministry of Forestry classification System as a general guideline for assigning the preliminary radar based legend to a preliminary LULC classes (*see ANNEX 3*). These classes were discussed with member of the CKPP consortium and also presented at the CKPP Palangkaraya workshop in May 2008. Members of the CKKP consortium presented a Legend to SarVision as a possible useful legend for the restoration processes. (*See ANNEX 2*). This legend was discussed in several opportunities between SarVision staff and CKPP staff. Discussions were focused on reaching a compromise between the radar based legend (cover types that can be detected with radar) and the desired cover legend. In addition discussions were held with the Indonesian partners and they were very pleased to see that the legend of the new revised CKPP-LULC Map could be compared to their own maps. Discussions with the users were very beneficial in the definition of the final legend.

It should be emphasised that vegetation cover thresholds are difficult to assign directly from radar data that is mainly sensitive to forest structure. A certain radar backscatter can result from different vegetation structures or combination of them. Therefore the legend is restricted to basic vegetation structures like Grasslands, Shrublands, Woodlands and Forest. Cover percentages are related to biomass levels as could be detected by the HV polarisation. Croplands and sawahs can easily be detected by spatial context, structure, field knowledge and flooding conditions.

4.5 Validation

There are basically three main types of approaches to validate land cover maps, which should be used together if possible (Strahler, 2002 in Fritz and See, 2004):

- Design-based inference, which involves sampling the map and assessing the accuracy against known values (e.g. using a confusion or error matrix);
- Model-based inference, which focuses on the classification process and measures of reliability that can be inferred from the process itself;
- Confidence building measures, which include looking for obvious errors based on knowledge of the terrain, comparisons with other datasets, etc.

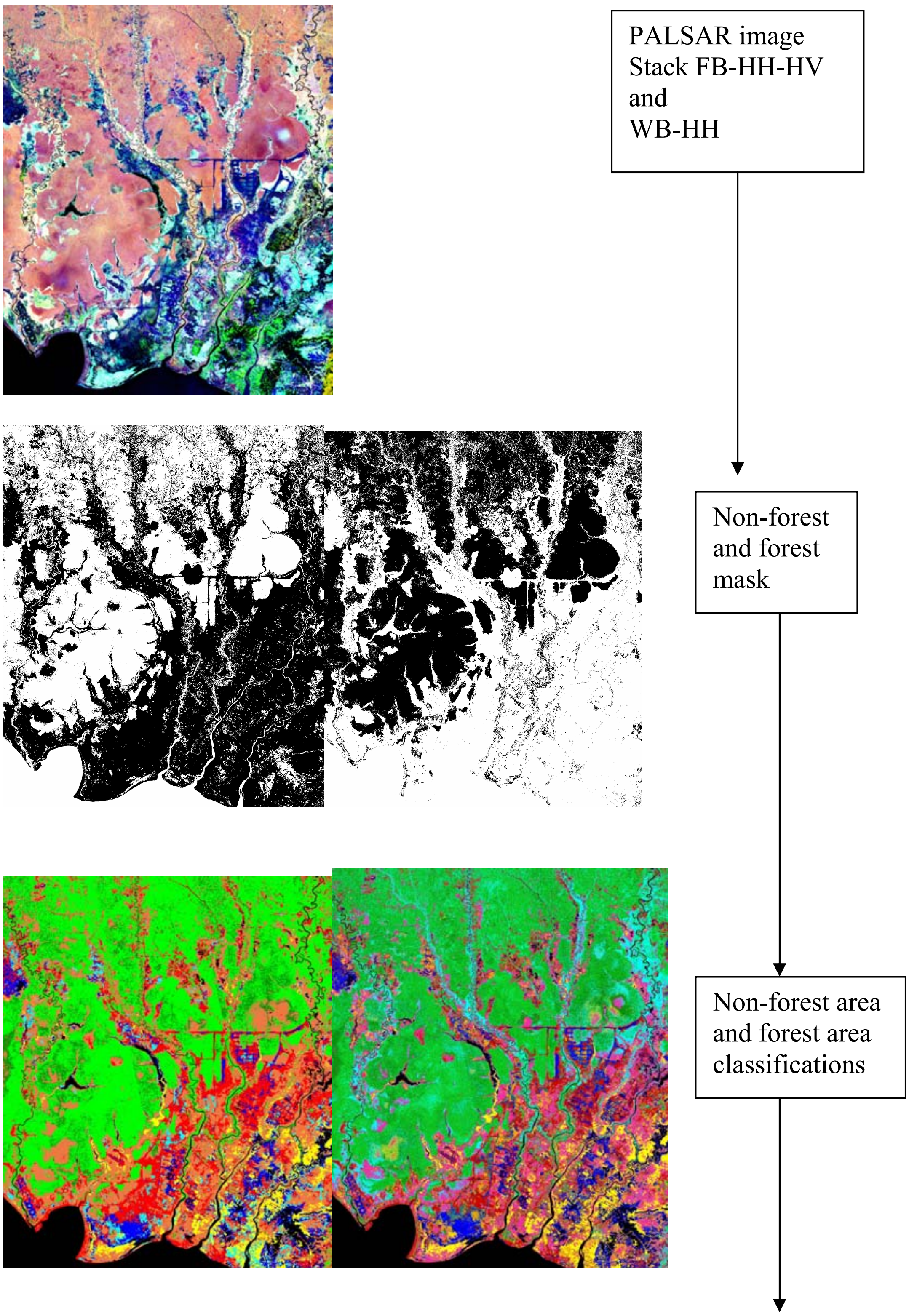
The most common method for reporting overall error for each LULC class is the use of a confusion matrix (Foody, 2001). A confusion matrix contains rows corresponding to the classes and columns corresponding to actual values from the ground or from a reference dataset. The elements of the matrix contain the number of pixels that fall in each class relative to the comparison value. Typically, figures for user accuracy (errors of commission), and producer accuracy (errors of omission) are presented. Finally, the Kappa statistic provides an indication of how well the confusion matrix of a specific classification compares to the confusion matrix of a ‘random’ classification.

For the current assignment initially an accuracy assessment was planed to be done based on the field data and photographs. Nevertheless these data was not completely available at the time of the delivery of this report. The few data that was available was not clear and the photographs of the fieldwork team were not available due to some problems (not specified). This issue was discussed directly with the coordinators of the field work campaign.

5 Results

5.1 Classification results

An initial density sliced classification of the whole PALSAR scene (FBDP and WBSP, 50m resolution) was used to create a forest non-forest mask at 50m resolution. The mask was used to classify the image separately for the forest and non-forest area to maximise the statistical segmentation of the image, using the unsupervised classification approach with the specially designed algorithm for radar images (see section 4.3). Classification results were combined. The resulting combined PALSAR classification contained 24 classes (12 inside the forest mask and 12 inside the non-forest mask, respectively). Both classifications were combined in one file and used as the basic classification for the LULC map. An example of the classification procedure and images resulting from the unsupervised classification approach can be seen in *figure 4*.



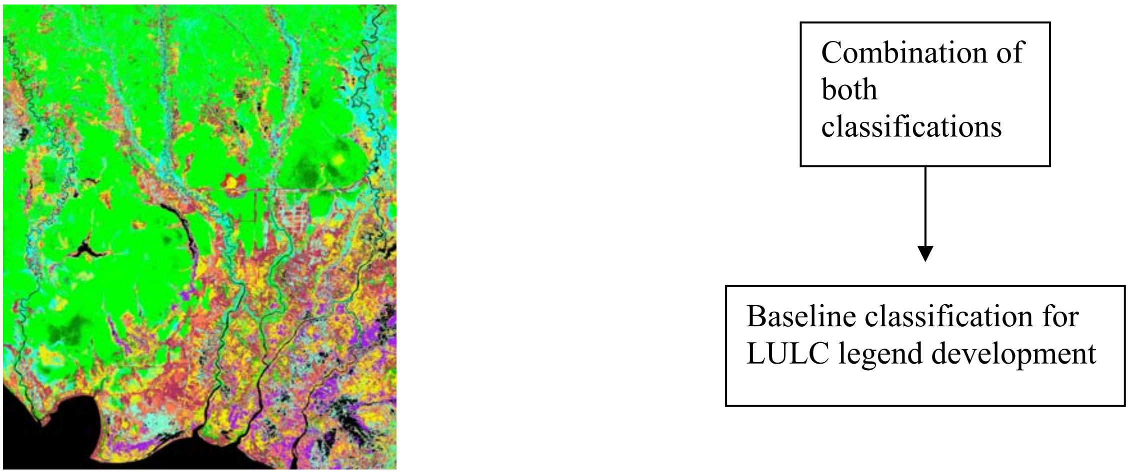


Figure 4. Example of the unsupervised classification procedure using the PALSAR derived forest and non-forest mask separated classifications are created for both forest and non-forest areas and the results are combined in a file to create a final map of 24 classes.

5.2 Legend development results

Radar data was extracted from the 24 classes and analysed in order to create a radar based legend. The 24 classes resulting from the processing were analysed according to the backscatter extractions from the HH and HV polarisations of the FBDP (dry period) and the HH polarisation of the WBSP (wet period). Histograms showing the distribution of the pixels for the different classes of the non-forest classification are shown in figure 5.

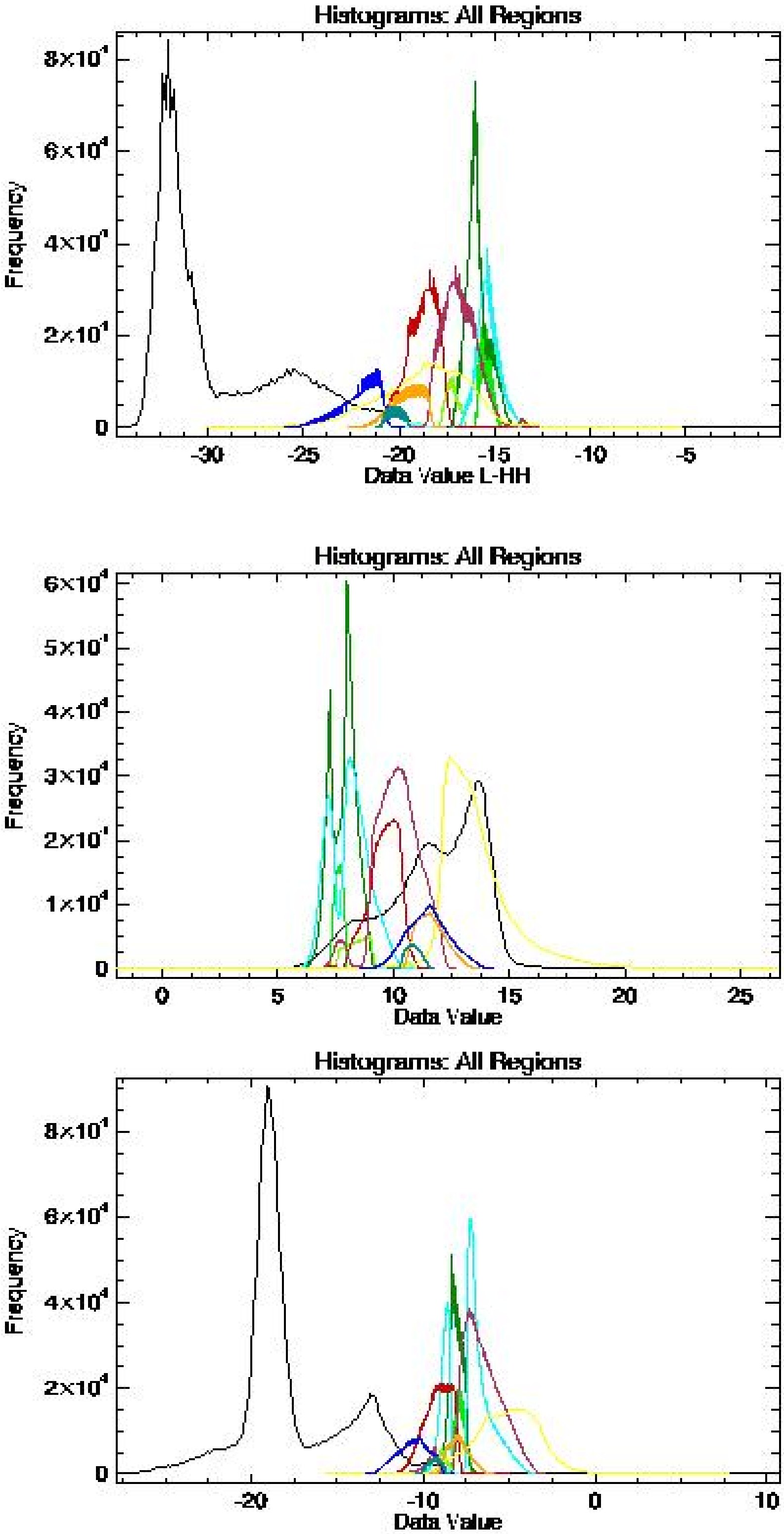


Figure 5: Example of the distribution of the backscatter for pixel corresponding to the 12 classes of the non-forest unsupervised classification. Top histogram correspond to the distribution of the pixels for classes in the HH polarisation (wet period) and the second and third one correspond to the HV and HH polarisations (dry period.) respectively.

Backscatter analysis

Table 3 shows the results of the backscatter values (mean backscatter and standard deviation) for the 24 classes with the initial class name.

Table 3. Mean and standard deviation of the extracted backscatter for HH HV (FBDP) and HH (WBDP)- levels for the different classes found on the PALSAR classification mosaic for 24 classes.

	HH-dry		HV-dry		HH-wet	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
0	-17.82	2.92	-29.62	3.37	-14.54	3.40
1	-7.60	0.27	-15.27	0.32	-7.28	1.95
2	-7.90	0.40	-16.20	0.66	-7.35	2.04
3	-8.71	0.26	-17.38	0.27	-7.85	2.07
4	-6.72	1.08	-15.17	0.57	-6.60	2.19
5	-8.55	0.18	-19.10	0.22	-8.19	2.40
6	-9.13	0.79	-18.75	0.85	-8.34	2.21
7	-6.55	1.16	-16.80	0.93	-6.13	2.35
8	-5.03	1.79	-18.65	2.35	-6.97	4.44
9	-7.93	0.59	-19.57	0.81	-8.32	2.71
10	-10.57	0.87	-22.07	1.01	-10.50	3.21
11	-9.34	0.34	-20.19	0.37	-9.02	2.51
100	-8.37	1.42	-16.92	1.57	-7.79	4.36
101	-7.69	0.50	-15.77	0.14	-9.40	0.23
105	-7.84	0.21	-15.52	0.13	-8.04	0.16
106	-8.74	0.35	-17.27	0.31	-7.57	0.92
107	-7.82	0.15	-15.52	0.10	-8.88	0.20
108	-7.70	0.14	-15.46	0.10	-10.05	0.24
109	-7.88	0.16	-15.47	0.13	-6.82	0.25
110	-7.83	0.16	-15.51	0.12	-7.55	0.15
111	-9.05	0.29	-16.82	0.46	-9.91	0.80
112	-8.68	0.31	-16.47	0.30	-10.76	1.28
113	-7.86	0.22	-15.43	0.25	-6.22	0.26
114	-7.98	0.42	-15.72	0.51	-8.05	1.49

The backscatter values were analysed for the 24 classes according to the biomass levels and flooding conditions as could be detected from HV and HH polarisation. Table 4 shows the associated biomass levels for each of the classes and the flooding conditions that could be derived from the backscatter values according to expert knowledge. In this case some classes were merged, like classes 101 and 107 were merged to class 112, based on the spatial distribution of the classes and the low number of pixels. This table is the first approach to understand the type of vegetation structure related to each of the classes.

Table 4. Biomass and flooding conditions associated to each of the classes. This table gives the first indication of the vegetation structure and flooding conditions related to each of the classes.

Class initial ID#	Biomass	Flooded in rainy period	Flooded in dry period
0	Very very low or none	+	+
10	Very very low	+	
11	Very low		
9	Very low		
5	Low		
6	Low		
3	Medium		
8	Low	+	+
106	Medium		
100	Medium		
111	High		
112 (101-107)	High		
7	High	+	+
2	High		
114 (105-110)	Very high		
108	Very high		
1(109-113)	Very high	+	+
4	Very high	+	+

The final step into the definition of the legend is the confrontation of the filed knowledge (filed data) and the classes. In this case use is been made of personal observations during field campaigns and field photographs available from the CKPP water survey in 2007. In addition the available LULC maps, the Indonesian regulations for Land cover Legend definition and the discussions with the CKPP staff members. The final legend is presented in table 5 and the final map is presented in figure 6. The Indonesian Legend used by the ministry of Forestry is used parallel to the defined legend as a reference for the Indonesian partners. It can be seen that there are many classes that are not represented in the revised CKPP map legend and there are also classes from the CKPP revised legend that have no correspondence with the Indonesian legend. These aspects are still subject of discussion. Description of each land cover type is presented in the following section.

Table 5. Final legend and class numbers for the classified PALSAR image. Colour correspond to map in figure 6. Names in Indonesian correspond to the legend used by the Ministry of Forestry

Final class	Colour	Indonesian legend	Revised map legend
16		Rawa	Sedges
8		?	Grassland + ferns
7		?	Shrubland (cover<10%)
6		Belukar	Shrubland (cover 11-50%); flooded or non-flooded
4		?	Shrubland (cover >50%); non-flooded
5		Belukar rawa	Shrubland (cover >50%); flooded
12		Hutan Rawa sekunder or degraded	Low pole forest (cover >10%)
13		?	Low pole forest (cover 1- 10%)
3		?	Woodland or degraded vegetation (cover 1-10%) degraded forest
2		Hutan Rawa primer	Peat swamp forest (cover >11%)
1		?	Riverine-Riparian forest (cover >11%)
20			Swamp forest (cover>11%)
11		Tanah Terbuka	Burnt area; burnt trees
10		Tanah Terbuka	Burnt area; burnt shrubs and bare
15		Hutan Mangrove primer	Mangrove (cover >11%)
14		Hutan Mangrove sekunder	Mangrove (cover1-10%)
-		Pemukiman	Urban
19		Pertanian lahan kering-Perkebunan	Dryland agriculture
21		?	Tree crops
18		Sawah	Sawah
9		Water	Open water
17		Tambak	Fish ponds

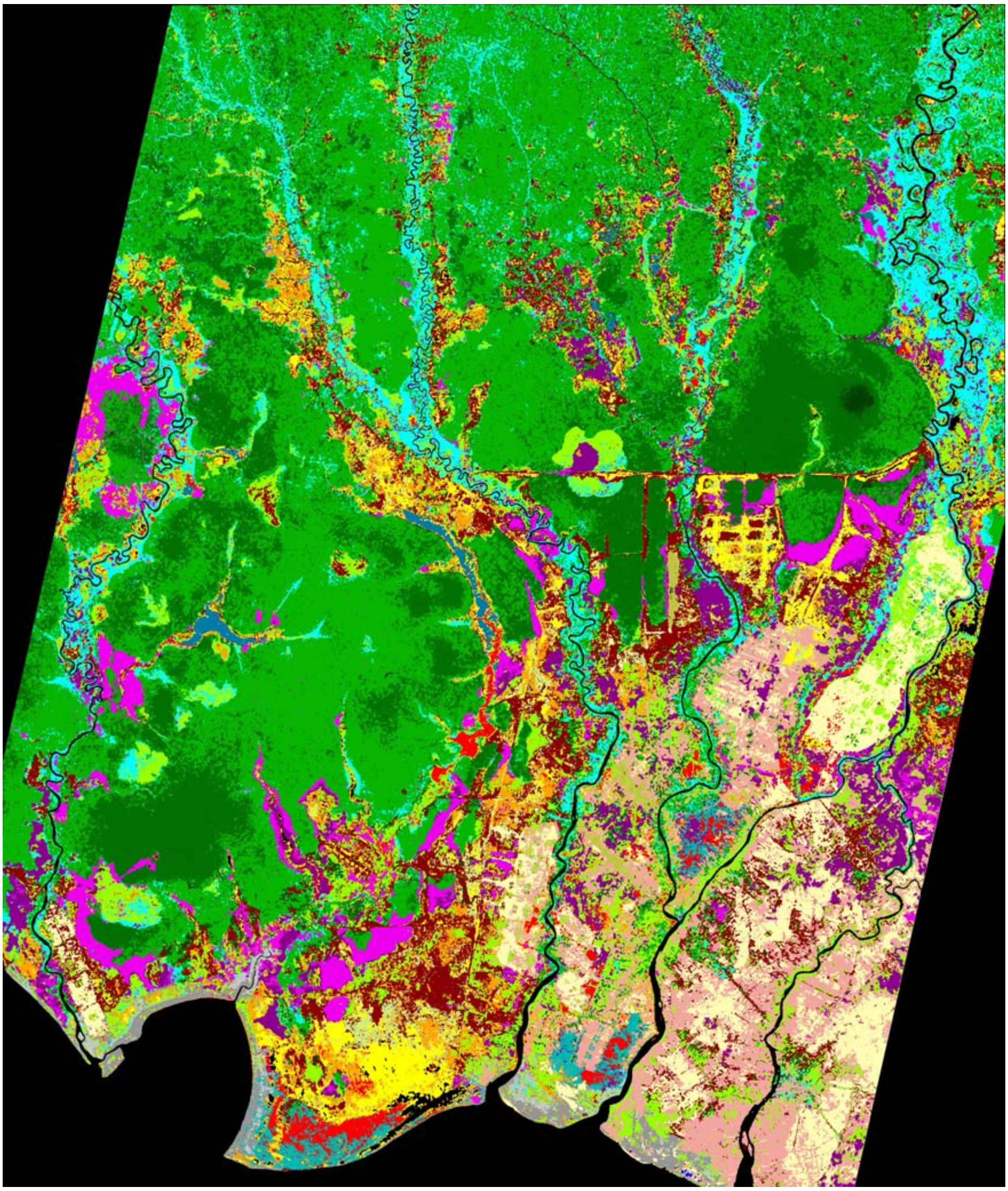


Figure 6. Final Map of the revised version of the Land cover /use map for the EMRP CKPP area. Colours of the Map correspond to legend in table 6.

5.3 Description of final classes for the reviewed Land cover /use map.

Descriptions of the cover types on the reviewed Land cover/use map are presented below. In brackets bold the corresponding class number and in *italic-normal* the corresponding legend on the previous 2007-CKPP map, based only on L-HH data. Descriptions are based on field observations by SarVision staff and on the available photographs taken during the 2007 CKPP field campaign. For some of the classes the locations of the CKPP LULC revised map and the CKPP LULC-2007 map are similar especially for the forest classes although differences in the labelling are due to the new introduced cover percentages (based on biomass levels detected by the L-HV polarisation). The addition of HV polarisation allowed the differentiation of classes especially in the non-forest area, related to biomass levels and flooding resulting in more shrubland classes.

Sedges (16): *(Regularly flooded herbaceous cover).*
Regularly flooded areas including sedges such as (e.g. *Thorachostachyum spp*) and pandans (e.g. *Pandanus spp*) (Page et al, 1999).

Grassland + ferns (herbaceous) (8): *(Grassland and ferns).*
The main layer consists of closed to open herbaceous vegetation. Vegetation cover is >50%. The height is in the range of 0.3-3m. The class includes large areas dominated by ferns in previously burnt areas and grasslands (*Alang alang*).

Shrubland (cover<10%) (7): (*no corresponding class in previous map)*.
This class has a shrub cover not higher that 10%. Rest of the cover can be high herbaceous or Ferns.

Shrubland (cover 11-50%) flooded or non-flooded (6): (*no corresponding class in previous map)*.
This class has a shrub cover between 11-50%. The rest can be herbaceous vegetation.

Shrubland (cover >50%) -non flooded (4): (*Shrubland and forest regrowth).*
The main layer consists of broadleaved evergreen closed to open vegetation. Vegetation cover >50%. The height is in the range of 0.3-5m. This class includes re-growing tree cover. For example in previously burnt and collapsed low pole and mixed swamp forest.

Shrubland) (cover >50%) –flooded) (5): *(Regularly flooded shrub cover).*
The main layer consists of broadleaved evergreen closed to open shrubs. Vegetation cover is >50%. The height is in the range of 0.3-5m. More information is needed about this specific type. The class likely includes many dead dry trees. Flooding duration is estimated on more than 4 months a year.

Low pole forest (cover >10%) (12): *(Lowland evergreen broadleaved forest, low pole swamp forest).*
Tree cover >11%, broadleaved evergreen occurring in elevations <1000m above sea level. This forest type has small diameter trees reaching height up to 25m but with a lot of under-canopy, areas are seasonally flooded and peat can be waterlogged or

sometimes flooded in pools, (e.g. Page et al, 1999). More advanced coding is needed, technically coded as aquatic; (peat) swamp forest, fresh or brackish water.

Low pole forest (cover 1-10%) (13): *(no corresponding class in previous map).*
This type of Vegetation is located in the peat domes with tree cover not exceeding 10%. Corresponds to open vegetation with standing low pole tress and shrubs. It is regularly flooded with waterpools between the open vegetation.

Woodland or degraded vegetation (cover 1-10%) (3): (*Forest mosaics, degraded).*
Vegetation with tree cover not higher that 10%, tree cover includes forests that have been degraded by fire and intensive logging over several years or tree regrowths and high shrubs.

Peat swamp forest (cover >11%) (2): **(***Lowland evergreen broadleaved forest (mixed swamp forest)).*
Tree cover, closed to open (cover >15%), broadleaved evergreen elevation <1000m. Upper canopy layer is tall and stratified, with a second more open layer (Page et al, 1999). More advanced coding needed, technically coded as aquatic; (peat) swamp forest, fresh or brackish water.

Riverine-Riparian Forest (cover >11%) (3): (*Swamp forest and woodland (Riverine))*
The main layer consists of broadleaved evergreen closed to open woodland on temporarily flooded land. The crown cover is >11% and tree height can reach 40m. This class is intermediate between freshwater swamp forest on mineral soil and peat swamp forest (Page et al. 1999). Due to its similar structure and more readily detectable water seasonality under the canopy, Forest regrowth in previously burnt and collapsed peat swamp forest types is (mis)classified as Riverine.

Swamp forest (cover >11%): *(not present in previous legend but mentioned in report Heath forest (kerangas)).*
Is known to occur to the north of block E and SNP. It is a distinctive lowland evergreen broadleaved forest type dominated by small diameter trees with a tree cover higher than 11%, occurring on sandy soils of poor fertility, often subject to water stress (either drought or water-logging). It is now included as a distinct forest type in the map since the forest fragments of the 2007-CKPP LULC map were overlaid with the peat depth map available for the area (CKPP-project, 2007). Forest fragment outside the depth peat areas were labelled as swamp forest.

Burnt area- burnt tress (11): (*Tree cover, burnt).*
The main layer consists of closed to open trees. Recently burnt, dead/dry trees standing over green new growth vegetation (stems, canopy cover lost). Burn severity unknown and precise burnt date between 2006 and 2007.

Burnt area- burnt shrubs and bare (10): *(Shrub cover, burnt).*
The main layer consists of closed to open shrub dry by burning with remaining or regenerating vegetation (stems, leaf cover lost), although biomass levels are lower

than for the tree cover, burnt class. Sometimes areas are completely bare depending on burn severity.

Mangrove (cover >11%) (15): *(Mangrove forest).*
The main layer consists of broadleaved evergreen mangrove trees over tidal flooded terrain. The crown cover is higher that >11%. The height is in the range of 5-20m.

Mangrove (cover (1-10%) (14): *(Mangrove forest).*
The main layer consists of broadleaved evergreen mangrove trees over tidal flooded terrain with tree cover lower than <10%. The height is in the range of 5-20m with open canopies and low biomass.

Dry-land agriculture (19): *(Cropland – dry land agriculture).*
Terrestrial, cultivated and managed areas. The herbaceous vegetation cover is artificial and requires maintenance. It is characterised by the periodic removal of the (semi)natural vegetation cover and cultivated crops are managed and/or (partly) harvested at the end of the growing season. This areas are been edited using field information and secondary remote sensing observations (Landsat imagery and an specific colour composite of the radar images. The colour composite of figure 7 shows the areas of dry agriculture in both bright-blue and red. Still the difference between them is unknown and more field data is necessary.

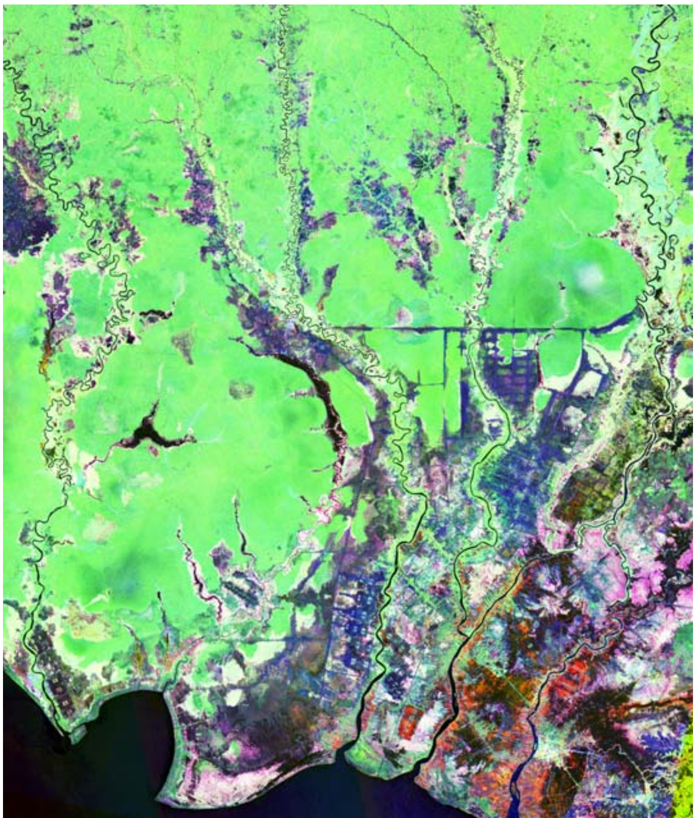


Figure 7: Colour composite of the HH-HV and HH PALSAR L band polarisations. Areas in rex and light-bright blue correspond to dry agriculture.

Tree crops (21): *(Mixed cropland and plantations).*
Vegetation cover includes perennial cash-crops plantations such acacia, oil palm, but also tree or shrub cover. Cultivated and managed terrestrial, trees or shrubs/ herbaceous.

Sawah (18): *(Cropland – rice paddy fields).*
Aquatic, cultivated and managed areas. The herbaceous vegetation cover (graminoids), are grown in irrigated or temporarily flooded (rice) areas.

Open water (9): **(***Water bodies).*
Water bodies, permanent, including sea.

Fish ponds (17): (*not corresponding class in previous map*).
Areas of artificial or man made water bodies use for fish farming.

Urban areas (-):
Edited manually, assisted by a settlement GIS shape file available from Bakosurtanal. In the large agricultural area in block C distinct square areas classified as shrub cover were recoded to urban. The land cover consists of artificial surface(s); built up area(s) including cities such as Palangkaraya.

The following classes have not been included in the final legend:

- Bare areas (bare rock and sands). Area coverage of primarily non-vegetated areas containing low vegetation cover during at least 10 months a year. Known areas of bare sand do occur for example upstream near block E, including sand mining sites. These locations have likely been classified as grassland or cropland.

- Artificial surfaces and infrastructure. Roads, logging roads and rails, canals, small villages etc were not including in the classification since much of the classes are smaller than the pixel size (spatial resolution) of the images. Vectors available for this features are been overlaid and used for the printing of the final map.

5.4 Validation results

Quantitative accuracy assessment presented major problems. Analysis of the ground survey data established the following problems preventing the data to be used for reliable quantitative accuracy assessment:

CKPP-2007 field campaign

- For accessibility reasons, the ground sampling scheme was biased to locations at (the banks of the) main canals only, missing out representative areas for specific LULC classes. Sampling in portions of blocks C and E and Sebangau National Park Mawas reserve and immediate surroundings is limited.

- No advanced LULC survey sheet incorporating attributes such as canopy cover percentage etc. could be used. Input to the field survey sheet vegetation section was provided based on the assumption that laypeople were to survey vegetation characteristics only as a by-product of a primarily hydrological survey.
- Classes included in the ground survey sheet are ambiguous, and most importantly, different from the classes ultimately used for the image classification of the final map.
- Analysis of field reports and accompanying field photographs showed a large variation in surface area considered as representative, ranging from a few m^2 near the banks of the canal to hundreds of m^2 perpendicular to the canals. Visibility at survey locations appeared highly variable, hence ground data scale of observation did not match map pixel size (50 x 50m) and not necessarily correspond to the GPS location (sometimes GPS locations falls over the canal) so is difficult to decide which is the right photo to be use as a reference.
- Field observations of dominant vegetation suffer from subjectivity; hence the survey observations can not be considered ground 'truth'. This is illustrated in *figure 8* and related *table 6* below, in which available ground survey locations and field photographs are reviewed for an area in block C. While field observations record grassland for all locations, the field photographs and final radar map classification identify other vegetation types.

  Only a limited number of field photographs could be made available before the assignment deadline. More photographs should be analysed to select representative samples.

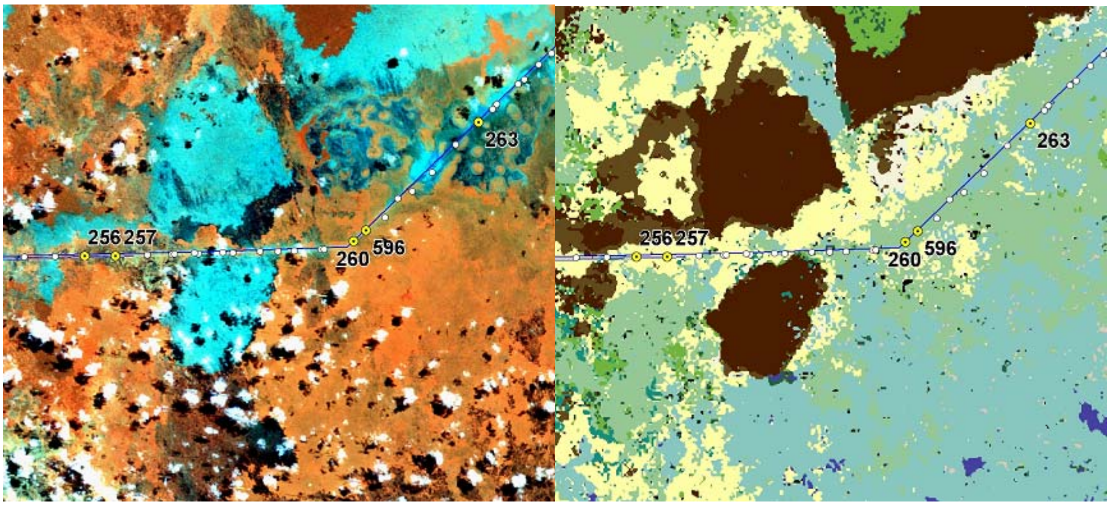


Figure8. Ground survey locations and locations with preliminary field photographs made available labelled with id-numbers) plotted on the Landsat 2007 reference image (RGB 457, left) and the final radar map classification (right)

Table 6. Examples of comparisons of field photographs with dominant vegetation reported, and map classification result from the CKPP field campaign 2007.

Photograph	Field observation	Classification result	Remarks
FID 256 	Grassland	Grassland and ferns (herbaceous)	Herbaceous cover (grassland) is indeed found directly on the banks, but it is not possible to observe the dominant vegetation for a representative wider area beyond the banks. Note lines of banana (*Musa spp.*) trees are visible.
FID 257  Grassland	Grassland	Grassland and ferns (herbaceous)	Again, visibility is limited to only a few meters from the bank. Field observation records grassland as the dominant vegetation type, but cultivation of agricultural crops such as banana (*Musa spp.*) and cassava (*Carica papaya*) is evident.
FID 596 	Grassland	Shrubland and forest regrowth	Although the field survey reports the area to be grassland, on the field photographs dense shrub cover is clearly visible. The area is classified as Shrubland and forest regrowth in the final map. Note other available photographs at this location also show shrub cover with dead trees (poles without crown cover)

FID 263 	Grassland	Regularly flooded shrub cover	Again, the field survey reports grassland at this location, while the field-photographs clearly show shrub cover as well as many dead trees. The final map has the area classified as Regularly flooded shrub cover.

CKPP-2008 field campaign

Field observations acquired during the April 2008 field campaign were delivered too late considering the time frame of this report. The main problem with the field data set, was that the photographs were not available at the time the rest of the field data records were delivered. Therefore the field data information of the data sheets could not be corrected of an observed ambiguity. In the original field-record, each observation needed to be adapted to one of the final classes of the CKPP revised map based on the vegetation cover percentage and the photograph, without the photograph this adaptation was not possible. This process was not part of SarVision task, it was a very time consuming exercise not considered in the budget.

Nevertheless a list of points with corresponding photographs and map classes were made as a reference using the available photographs of 2007. This list is presented as a separated file.

Use of other available maps as validation

To the best of our best knowledge, none of the existing LULC maps available for the EMRP project area have been properly validated quantitatively (or qualitatively). The 2003 map produced by Remote Sensing Solutions (http://www.informus.de/gsefm_resources/Documents/GSEFM_T2_S6_Ph1_RSS_MAS I.pdf) is an exception, but in this map the relevant classes including 'bush land, forest mosaics, shifting cultivation, secondary forest, shrubs, and regrowth following cultivation' have all been simply aggregated into just one broad class. This precludes the use of this reference map for quantitative comparison.

Proper qualitative confidence building based on a systematic comparison of the final map with reference LULC maps is not possible either as it remains unknown how reliable the reference maps are. The following observations can be made based on thorough visual inspection (see also annex 2):

- Cropland areas, both dry-land agriculture and rice paddy fields correspond well with most maps.

- Interestingly, the low pole swamp forest class corresponds with the primary swamp forest class of the Ministry of Forestry and MoF/BAPPEDA 2003 maps (note that neither of these maps identifies the class consistently). This is because the government nomenclature is based on the visual interpretation of Landsat, by which low pole forest appears as very dense, undisturbed forest. One may argue the use this ecological terminology (primary – secondary) is subjective and inconvenient. The location and respective labelling of Pole forest in this map was based on publish scientific information (Page et al. 1999).

- The Riverine-Riparian forest and forest mosaics, degraded classes correspond with the STRAPEAT 1997 and particularly the MODIS tree cover 2005 maps. Patches are identified as ‘wet forest’ on the Bakosurtanal 2003 map. The classes and respective areas in blocks A - E are however missing in both the government maps. The mid-2007 LULC map for the first time provides a sufficiently cloud free view of the most southern section of block C.

6 Discussions

In the creation of Land use/cover map from remote sensing data, the process of legend definition is of major importance. The definition of the legend has to be done according to both the remote sensing image sensitivity and the desired legend (from the users). The first aspect is given by both spectral and spatial constraints of the RS system. If the RS system is not sensitive to a certain class or the spatial resolution is to course in order to distinguish certain details, then certain classes can not be mapped, despite the wish of the user. The discussions should be based on both aspects and should be done in early stages of the project. The following discussions will deal with these two aspects. First the improvements and differences of the actual map compared to the previous 2007-LULC CKPP map due to the difference on the input data. After discussion on the confusion between some classes will be made framed on radar sensitivity. In addition, some discussions on the differences between the final legend and the desired legend by the CKPP staff members will be done, explaining both, disagreements and agreements. Additionally we will discuss about the legends to be used in the near future to bring this type of maps into the international arena using international agreed legends for the support of international conventions.

6.1 Discussion on the reviewed map improvements and comparison with the 2007 LULC CKPP map.

The legend of the revised map differs from the previous CKPP legend basically on the definitions of cover percentages. In both cases the natural vegetation is classified according to structural classes (grasslands, shrubland and forest) and the crops are divided into sawahs, dry agriculture and tree crops. Burnt areas are included in both cases. As well as the mangrove vegetation and the Riparian-Riverine forest. The additional use of the HV polarisation allows the definition of biomass classes within each of the vegetation types which was associated to cover percentages, after the study of the field photographs. Scrublands, natural low pole forest and mangrove forest could be divided according to cover percentages (or biomass levels).

An improvement is the distinction of the class "swamp forest". The differentiation of this class was the result of the interactions with the CKPP staff members. They insisted that by overlaying the forest map with the peat depth map it should be possible to differentiate the flooded swamp forest occurring over mineral soils. This input was like a piece of information missing for the radar interpretation. The areas that are labelled as "swamp forest" are areas that radar could distinguish very well for being flooded both in the dry and the wet period. The lack of field information prevented the labelling of this class as a different one. Now these areas of forest cover are well differentiated and included in the reviewed map.

The definitions of the dry agriculture class has also improved. The additional information given by the HH polarisation in the dry period helped in the differentiation of this class. In the previous map this class was very difficult to be distinguished using only wet period data and therefore this class was imported from the ASAR classification.

The information on the tree crops was edited manually in the areas where it was known to occur. These classes correspond to vegetation areas where trees are being planted. In this case radar can not recognise the pattern (as can be seen by Landsat) and confuses the class with grassland, shrubland or woodland depending on the development stage of the vegetation.

6.2 Discussion on the confusion between some classes.

- Burnt areas are confused in some cases with Riparian-Riverine flooded forest.
According to the radar this two classes can be confused due to radar saturation effects, resulting in a high return value in both cases. In the case of the flooded forest this effect is produced by the double bounce of the wave interacting first with the water and then with the trunks (or vice versa) before returning to the radar. When flooded forest or shrubs looses its canopy due to fire while stems remain, the resulting second backscatter reflection appears very similar. The inclusion of dry season HH data have improved this confusion.

- Shrubland regularly flooded cover class
More (field) information is needed to accurately define areas classified as regularly flooded shrub cover (likely with many dead trees). The area is both impacted by large scale flooding and fire. Burning events over peatlands are known to cause depressions where water may stagnate.

- Tree crops and plantations under represented
Acacia plantations have a backscatter signature similar to shrubland and forest regrowth. Field survey data shows that many areas planted with acacia have been confused with shrubland and forest regrowth. Moreover, several large scale (oil palm) plantations have been developed during 2006. These areas have been classified as cropland due to the removal of vegetation and subsequent burning of, mostly, shrub and herbaceous cover. Plantations can be identified in the Landsat reference image by the layout of the planting blocks (drainage canals). These plantations may be visually delineated and merged with the final map.

Another under representation is due to the forest enrichment with rubber trees occurring specially in the forest along the rivers. This enrichment activity can not be distinguished by the radar therefore can not be labelled as a tree crop and not explicitly mentioned. Nevertheless if field information is gathered specifically, then some manual editing could be done to the map.

-Grasslands and/or ferns can be confused with shrublands*:* Grasslands and ferns (Alang Alang) class can be confused with the shrubland classes especially when the herbaceous vegetation is high (up to 2-3 m) or very dense. In this case the biomass levels can be confused to the biomass levels of shrublands.

- Confusion between shrubland classes: The shrubland classes of different cover percentages can be confused with each other. This confusion can be the result of two different effects, the sensitivity of radar to flooding conditions and to vegetation structure. The return of the radar is affected simultaneously by both flooding and structure (biomass) several possibilities can generate the same return value. In the case of this map the biomass (HV return values) was the more important decision factor to separate the classes then the flooding conditions. As a result of changes in the water regimes these classes can change and therefore classes could be grouped. They were left in this way in order to maintain the information captured by the radar.

6.4 Discussion on the use of the desired legend by the CKPP staff and the actual legend.

Several meeting and conversations were held between members of the CKPP staff and the technical SarVision staff in order to reach some levels of understanding about the possible legend, according to the radar sensitivity and resolution and to the desired legend required for spatial planning. These discussions gave important input on the definition of the final legend despite the fact that there was not a total agreement on both the definitions of the classes and the possibilities for matching the desired legend with the radar sensitivity. Details will be explained.

The desired legend proposed by the CKPP staff is presented in ANNEX 2. In general the discussions were centred around the possibilities to include some cover percentages for the different vegetation types. In addition some extra classes (like Swamp forest, or *Pandanuss sp*. vegetation) were required as well as detail definition on tree crops.

The main disagreement was about the definition of forested land. According to the FAO a forest is an area with a tree cover higher that 10%. This definition supports the differentiation between shrubland, woodlands and forest. In the case of the CKPP desired legend a differentiation needed to be made between shrubland with tree cover 1-10%, shrubland with tree cover 11-50% and shrubland with tree cover higher that 50%. This was going to produce a double class labelling of the classes according to us: a shrubland with cover less than 10% (which is woodland) will be confused with a forest with cover less than 10% (which by definition is also woodland). In addition a shrubland with tree cover higher than 11% will be by definition a forest, which will fall into the forest class and not the shrubland class.

According to radar sensitivity and to our understanding of forest cover and adopting the definition of forest given by the FAO we have defined 3 main groups:

1. The shrublands (with different level of shrub cover i.e. different biomass levels: assuming that the increase in biomass is produce by the increase on shrub cover).
2. The woodland or degraded vegetation with a tree cover 1-10% and a forest cover with tree cover higher than 11%.
3. The forest (several types with cover >11%).

In addition more detailed information was asked on the definition of tree crops. This information can be detected by RS images like Landsat or SPOT which finer resolution (less than 30 m) allows the detection of the crops. For the radar (50m resolution) this class is not detectable because it is classified as grassland or shrubland. Nevertheless observations of tree crops detected on the Landsat image of 2007 were edited by hand and included in the map.

The addition of the class “swamp forest” was also a good result of the conversations for the legend definition, as was explained elsewhere.

Pandanus sp. vegetation was not defined by the CKPP members. An example location was not delivered to us, therefore we could not investigate the possibility to be detected.

We asked the CKPP members to deliver a photograph exemplifying each of the cover classes that they require for the legend. This delivery has not occurred yet, they reported some problems with the photographs.

6.5 Discussion of the actual legend in the frame of the international legend format.

The reviewed LULC map legend gives possibilities to be redefined using the FAO/UNEP Land Cover Classification System (LCCS) coding, if detailed field information is provided. More specific coding of classes using LCCS classifiers is needed, in particular for peat swamp forest classes. An official translation process has started to harmonise the government thematic map classes with the FAO LCCS.

Refinement of the LULC map should take these developments into consideration where applicable.

In the future considerations should also be made in the adoption of IPCC (International Panel for Climate Change) legends having in mind the possibilities to compare information between countries and the standardisation of classes and land cover definitions for the payment of carbon credits and environmental services. For the adaptation of the new reviewed legend to other legends including the Indonesian legend the remarks presented in ANNEX 4 should be considered.

7 Concluding remarks and recommendations

The use of 50m resolution dual polarisation (HH/HV) PALSAR radar data in the classification gave improvements on the classification of the classes. Although HH polarisation is sensitive to biomass, HV polarisation is more sensitive to biomass and less affected by flooding conditions, balancing the information and allowing the main entrance of the legend to be the biomass level. Furthermore, flooding duration is a key parameter that can be mapped using HH polarisation and that has an influence on the definition of the cover classes. The inclusion of dry season imagery have further improved results since it allows the differentiation of areas that are not flooded during the dry period.

- It is highly recommended to further use the field data collected in 2008 after proper systematisation and adaptation according to the legend of this map. This set of data appears to be very interesting but requires further work before it can be applied for the validation of the map.

The mapping assignment shows that land cover changes are very dynamic, significant forest areas having been lost to fires since 2005 and shrub areas are been re-burnt. This occurs mostly near forest edges, but especially around remaining small pockets of forest. About half of the remaining forest areas in block C are now lost. The same applies to block A.

- It is recommended to collect some more ground or aerial survey data for specific areas. For example, no information on vegetation is available for extensive areas including the southernmost section of block C, provisionally classified as “Shrubland flooded cover”. Many dead trees may remain in the area that burnt severely as recent as late 2006. Moreover, flooding duration remains unknown over large areas.

- It is recommended to carry out full validation and refinement of the map by both Indonesian counterparts and the EMRP Master Plan members. Available ground survey observations are unreliable. The full dataset will come available in the near future and a new validation dataset should be developed carefully assessing all photographs available.

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Annex 1 Reference LULC maps

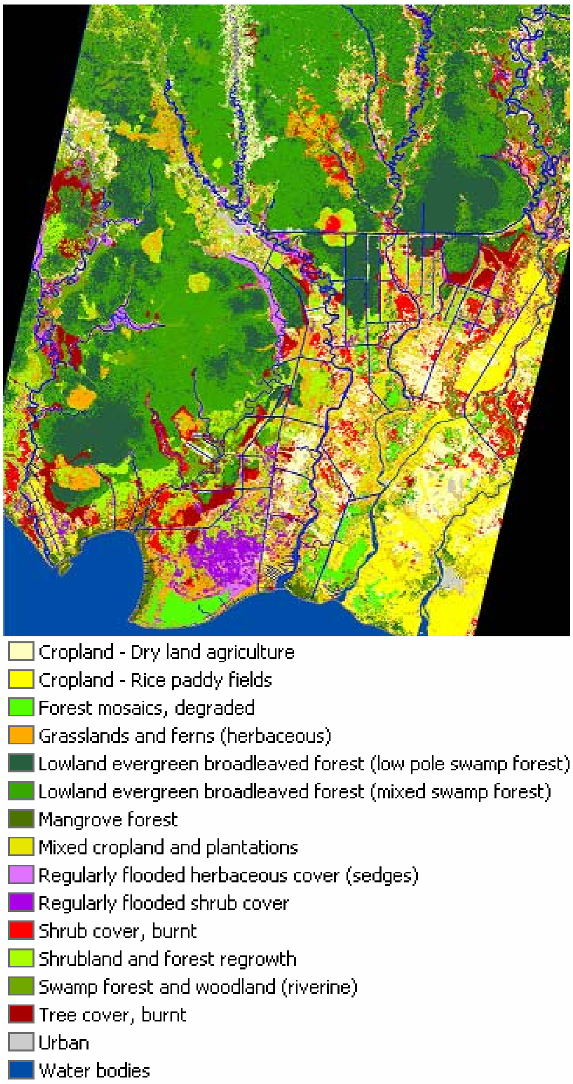

Figure A-1. Final LULC map SarVision June 2007.

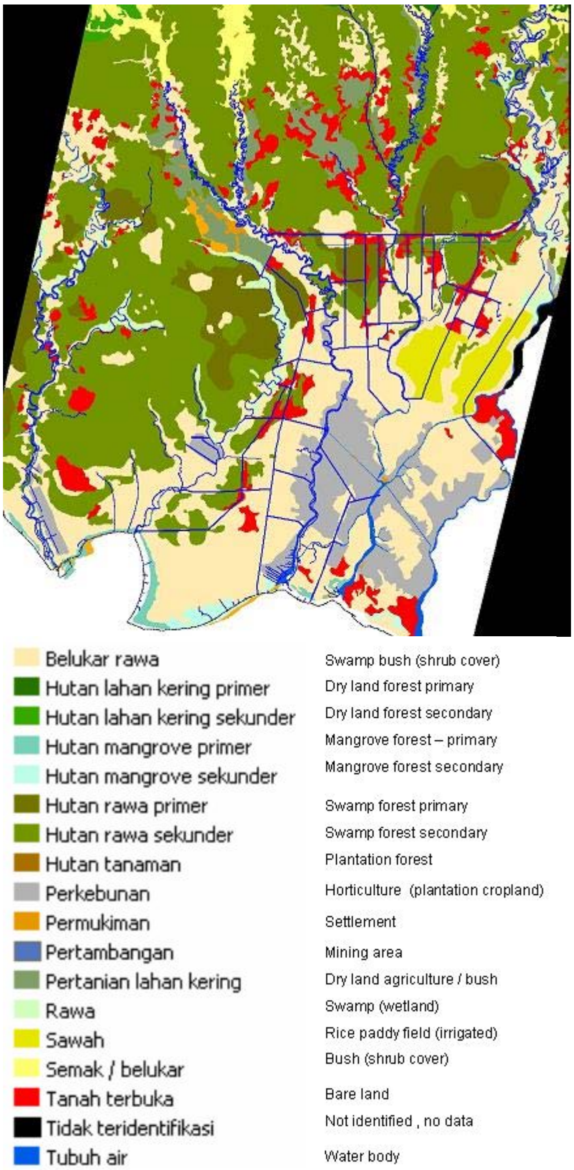

Figure A-2. MoF/BAPPEDA official map 2003.

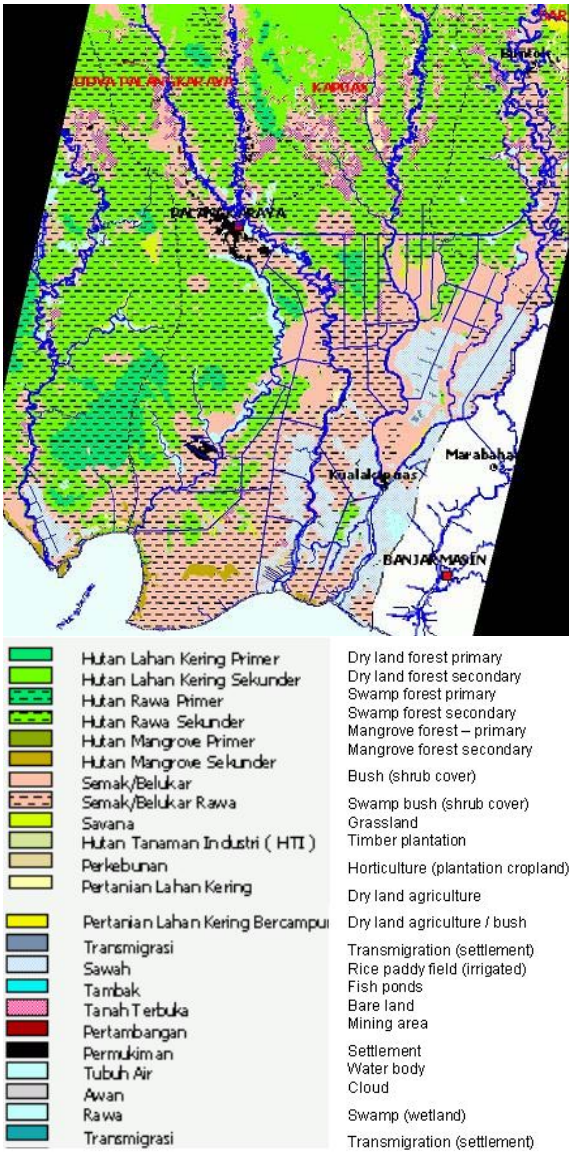

Figure A-3. 2003 Indonesian Ministry of Forestry official map 2003.

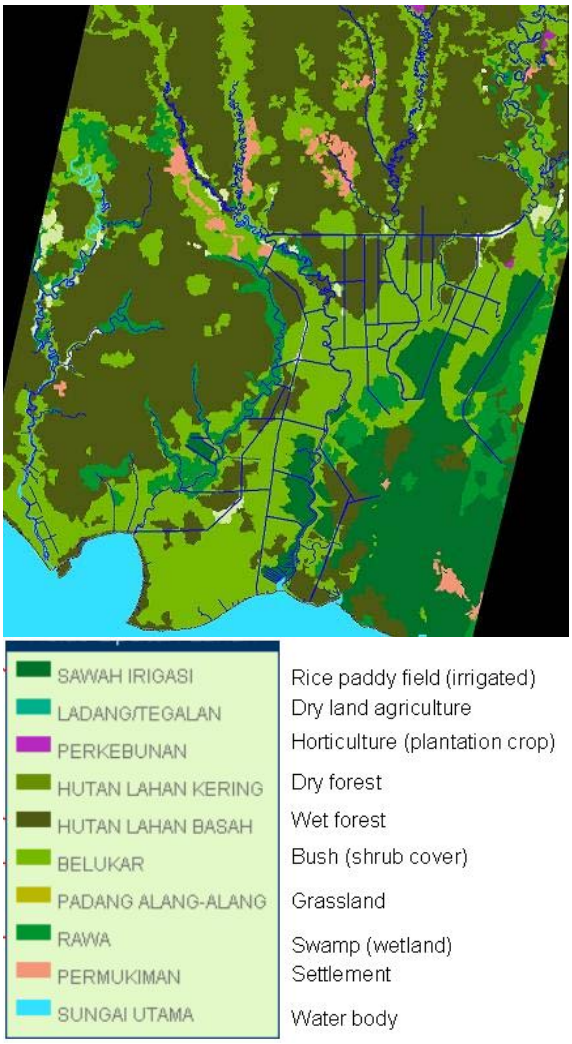

Figure A-4. Bakosurtanal Liputan Lahan 1:250,000 map 2003.

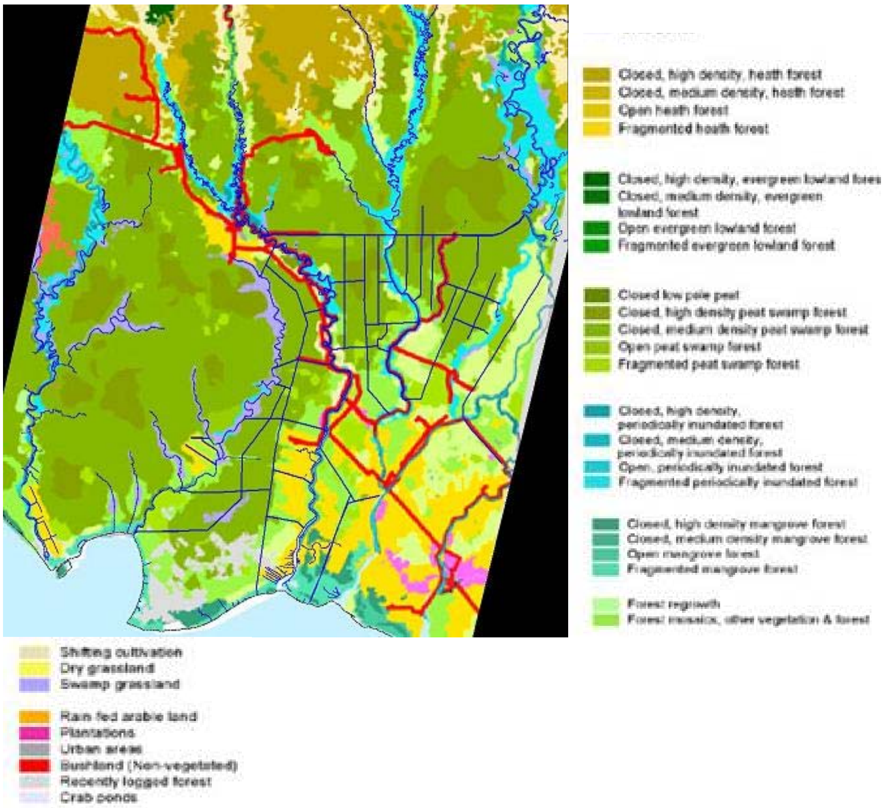

Figure A-5. EU STRAPEAT Siegert et al. map 1:100,000 1997.
Source: www.strapeat.alterra.nl/download/florian.siegert1.ppt

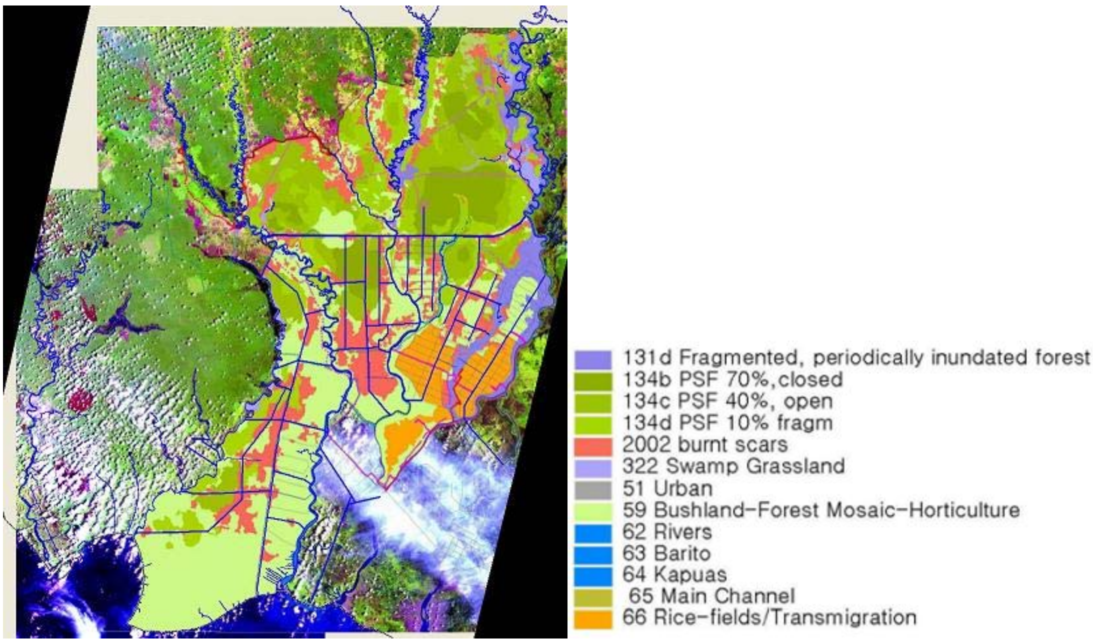

Figure A-6. Kalteng consultants Boehm et al. map 2003.

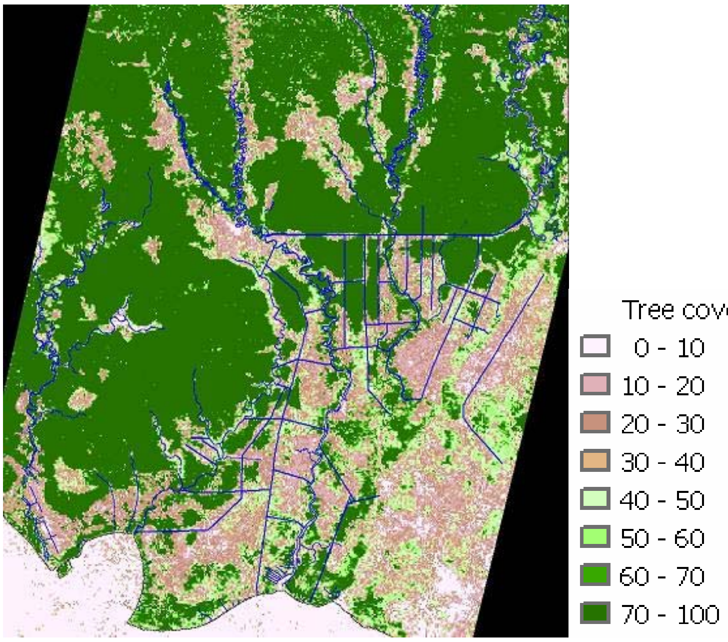

Figure A-7. Tree cover percentage MODIS Vegetation Continuous Fields 500m University of Maryland, South Dakota State University

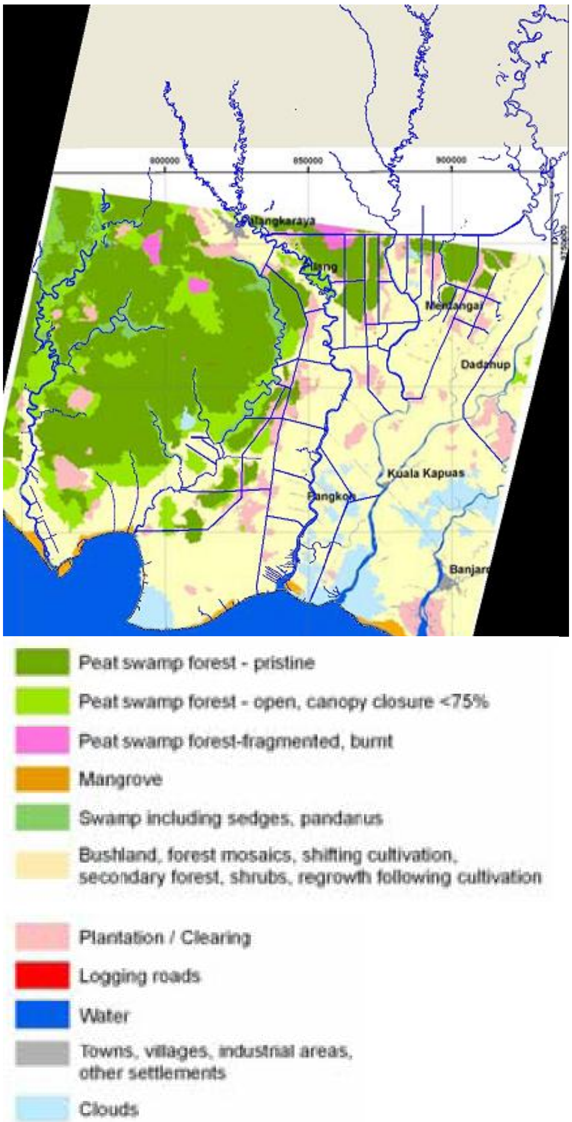

Figure A-8. Remote Sensing Solutions Gmbh map 2003
Source: http://www.informus.de/gsefm_resources/Documents/GSEFM_T2_S6_Ph1_RSS_MASLI.pdf

ANNEX 2-Proposed Legend for revised LULC map

	main type	*subtypes*	*notes*
(Semi-) natural habitats			
1	Water body	1a. Rivers & lakes, more-or-less permanent	Already in legend
		1b. Freshwater ponds	
		1c. *Tambak*	
2	Sedge-, grass and fernland	2a. periodically inundated	Already in legend (1 type)
		2b. not regularly inundated	
3	Shrubland	3a mixed shrub cover 1-10%	In legend as shrub cover, burnt; no densities
		3b mixed shrub cover 11-50%	
		3c mixed shrub cover >50%	
		3d *Pandanus* swamps	large expanses in heavily degraded PSF areas (regularly/to permanently flooded)
4	Shrubland with trees	4a woody species cover 1-10%	In legend as shrub cover with forest regrowth; no densities
		4b woody species cover 11-50%	
		4c woody species cover >50%	
5	Swamp forest	5a. tree cover 1-10%	
		5b. tree cover 11-50%	
		5c. tree cover >50%	
6	Peat swamp forest	6a. tree cover 1-10%	
		6b. tree cover 11-50%	
		6c. tree cover >50%	
		6d pole forest	various densities?
7	Riparian forest		no density types, as too narrow to discern
8	Mangrove forest	8a. tree cover 1-10%	
		8b. tree cover 11-50%	
		8c. tree cover >50%	
		8.d nipah	
Converted habitats			
9	Settlements		
10	Dryland agriculture		
11	Sawahs		
12	Tree crops	12a. Oil palm	
		12b. Rubber	
		12c. Mixed tree crops	
		12.d Sago	
		12.e Coconut	

ANNEX 3 Guidelines-technical standards and regulation for mapping following regulations of the Indonesian Ministry of Forestry.

Santoso, I., and A. Hinrichs, 2000. Forest mapping for land use planning and sustainable forest management in Indonesia. GTZ, East Kalimantan, SFMP Document No. 5a (2000)

Technical standards and regulations for mapping relevant to land use planning are defined in the following Government Regulations and Guidelines of the Ministry of Forestry (Santoso and Hinrichs, 2000):
a) "*Peraturan Pemerintah No. 10 tahun 2000 tentang Tingkat Ketelitian Peta untuk Penataan Ruang Wilayah"* ("Government Regulation No. 10/2000 for Spatial Planning Map").
b) "*Petunjuk Penyajian dan Penggambaran Peta Kehutanan Ditjen INTAG, 1995*" ("Forest Mapping Guidelines by Directorate General of Forest Inventory and Land Use Planning"*)*

The current map has been developed in compliance with these regulations, taking into account:

- Map accuracy must meet 'accuracy' requirements primarily related to map scale: At the provincial level 1:250,000 scale maps should be used for relatively large provinces such as Central Kalimantan (1:100,000 to 1:50,000 for smaller provinces), at the *kabupaten*/district level 1:100,000 scale maps are required for large districts.
  Note: according to BAPLAN the common scale the Indonesian Ministry of Forestry uses for the development of base maps is 1:100,000.
- Map content for any thematic (land use/cover) map is not regulated. However, it is noted that thematic maps should be based on the theme classification and specification by the institutions concerned (i.e. the Ministry of Forestry).
- Maps for spatial planning should be delivered using the National Geodetic Datum (1995) and UTM Projection System.

Note: land *use* map content is more related to utilisation zones and infrastructure rather than land cover. Forest use allocation rather than cover type is mapped, e.g. production forest. This can not be derived from satellite imagery.

INTAG classification legend of 23 classes

Indonesian	English
Penafsiran untuk penutupan lahan/vegetasi dibagi kedalam tiga klasifikasi utama yaitu Hutan, Non Hutan dan Tidak ada data, yang kemudian masing-masing diklasifikasi-kan lagi secara lebih detil menjadi kelas-kelas sebagai berikut :	*The land cover is divided into three main categories namely forested, deforested, and no data. And then in detail into many class as below :*
Klasifikasi Hutan terdiri dari :	*Class forested consist of :*
▪ Hutan lahan kering primer ▪ Hutan lahan kering sekunder ▪ Hutan rawa primer ▪ Hutan rawa sekunder ▪ Hutan mangrove primer ▪ Hutan mangrove sekunder ▪ Hutan Tanaman (Industri HTI)	▪ *Primary dry land forest* ▪ *Secondary dry Land forest* ▪ *Primary swamp forest* ▪ *Secondary swamp forest* ▪ *Primary mangrove* ▪ *Secondary mangrove* ▪ *Plantation forest*
Klasifikasi Non Hutan terdiri dari :	*Class non-forested consist of :*
▪ Semak/Belukar ▪ Belukar rawa ▪ Pertanian lahan kering campur semak ▪ Perkebunan ▪ Pemukiman ▪ Pertanian lahan kering ▪ Rawa ▪ Savanna ▪ Sawah ▪ Tanah terbuka ▪ Tambak ▪ Transmigrasi ▪ Pertambangan ▪ Bandara	▪ *Slash* ▪ *Swamp bush* ▪ *Dryland Agriculture mixes slash* ▪ *Horticulture* ▪ *Occupation* ▪ *Dryland agriculture* ▪ *Swamp* ▪ *Savannah* ▪ *Wet paddy* ▪ *Open land* ▪ *Fishpond* ▪ *Transmigration* ▪ *Mining* ▪ *Airport*
Klasifikasi Tidak Ada Data terdiri dari :	*Class no data consist of :*
▪ Tertutup awan ▪ Tidak ada data	▪ *Cloudy* ▪ *No data available*

ANNEX 4. Technical aspects considered in the workshop May 2008.

1. Three are differences in the classes presented in the previous map and in the revised map. The main difference is the association made of the backscatter values with the vegetation structure given by the information present in the HV polarisation, that was absent in the previous classification. The inclusion of this polarisation gives an advantage in the interpretation of the unsupervised classes and allows a relation to biomass levels and consequently to vegetations structures. The analysis of the flooding in the dry and wet period for each of the classes allows the understanding of the water level dynamics and gives extra information to the definition of the vegetation types. These two aspects are important improvements for the land use/cover map and should be taken into account when trying to compare the legend from the previous map to the present map. Though some of the classes correspond exactly not all of them are identical.
2. The differential study of the water level and soil moisture in both dry and wet period can give an indication of the type of agriculture (dry or irrigated or sawah. An indication should be given on the water regimes used in these types of agriculture in order to define more clearly the difference between these two classes.
3. According to the Indonesian legend there are three types of dry land agriculture (horticulture, dry land agriculture-slash and dry land agriculture). Please give more detail differentiation between them. According to what can be seen with radar only one class can be detected.
4. Riverine-Riparian forest is not present in the Indonesian legend. Please give input on the definition of the class that can well be detected by radar classification.
5. According to the Indonesian legend the low pole forest as described by Sue Page is named as primary peat swamp forest. To our knowledge both peat swamp forest described in this revised legend are primary but differ in the structure due to water regimes and peat depth. Please discuss about the naming of the final class.
6. Description of the human activities around Banjarmasin. Is sawah or irrigated agriculture or both?
7. In the EMRP area, the forest around the river contains two different classes. Is this difference due to forest enrichment (rubber trees) or forest degradation?
8. if possible, give some biomass values for the different land cover classes.
9. In the mangrove area two different type of vegetation can be distinguished that can be associated to different biomass levels, can that be related to degradation?
10. Please give a description of regeneration processes after burning for the first time and second time. This is important for the study of the vegetation dynamics and as an input for the monitoring process.

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