

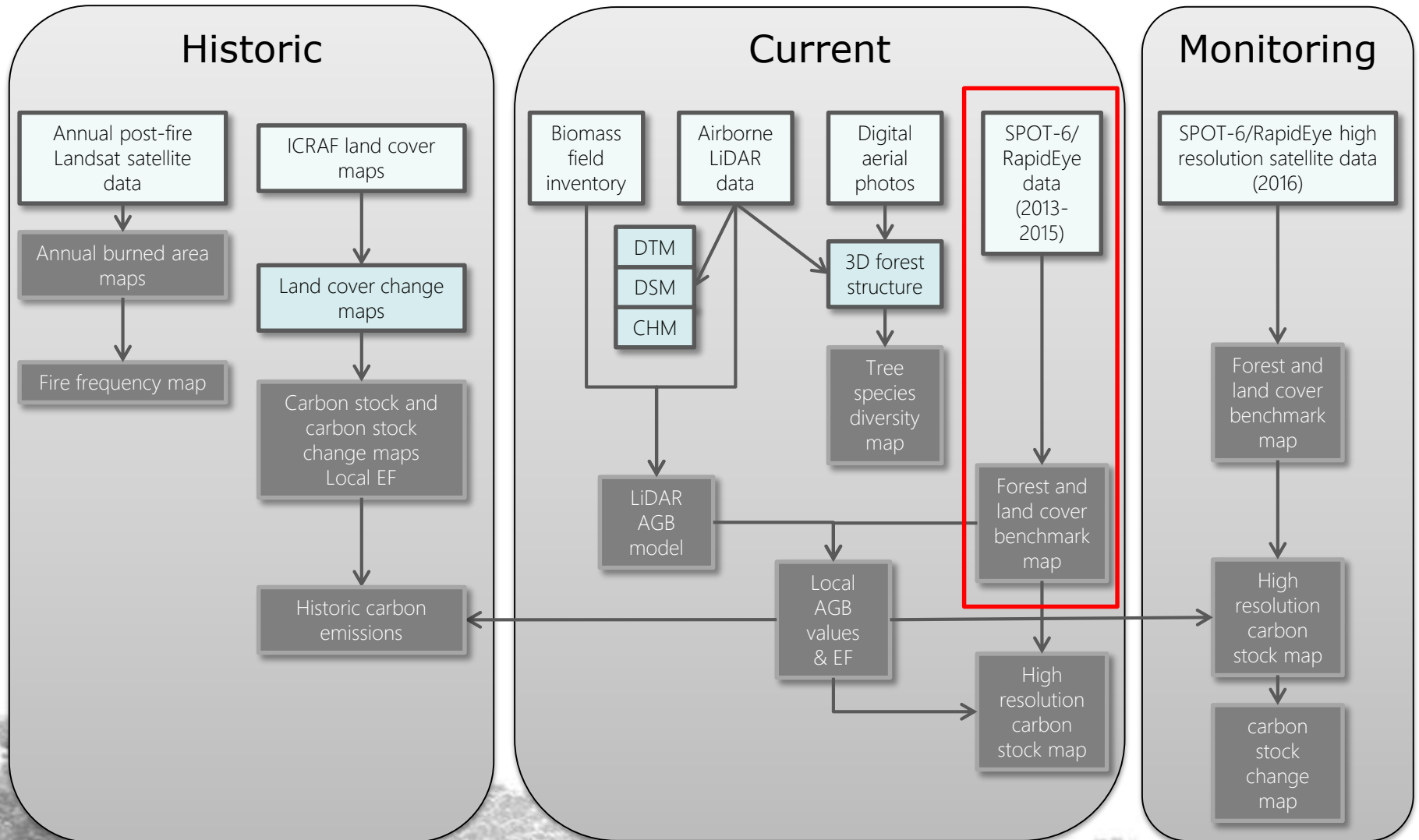
**SURVEY OF BIOMASS, CARBON STOCKS, BIODIVERSITY, AND ASSESSMENT OF THE HISTORIC FIRE REGIME
FOR INTEGRATION INTO A FOREST MONITORING SYSTEM IN SOUTH SUMATRA, INDONESIA**

**Forest benchmark mapping and land cover analysis by
high resolution satellite images
Current status**

**BIOCLIME Workshop
Palembang 21 January 2016**

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Concept of the monitoring system



Outline

- Objectives
- Workflow
- Object-based land cover classification
- Classification scheme and workflow
- Next steps
- Summary and conclusions



Monitoring: Forest benchmark map

Objectives:

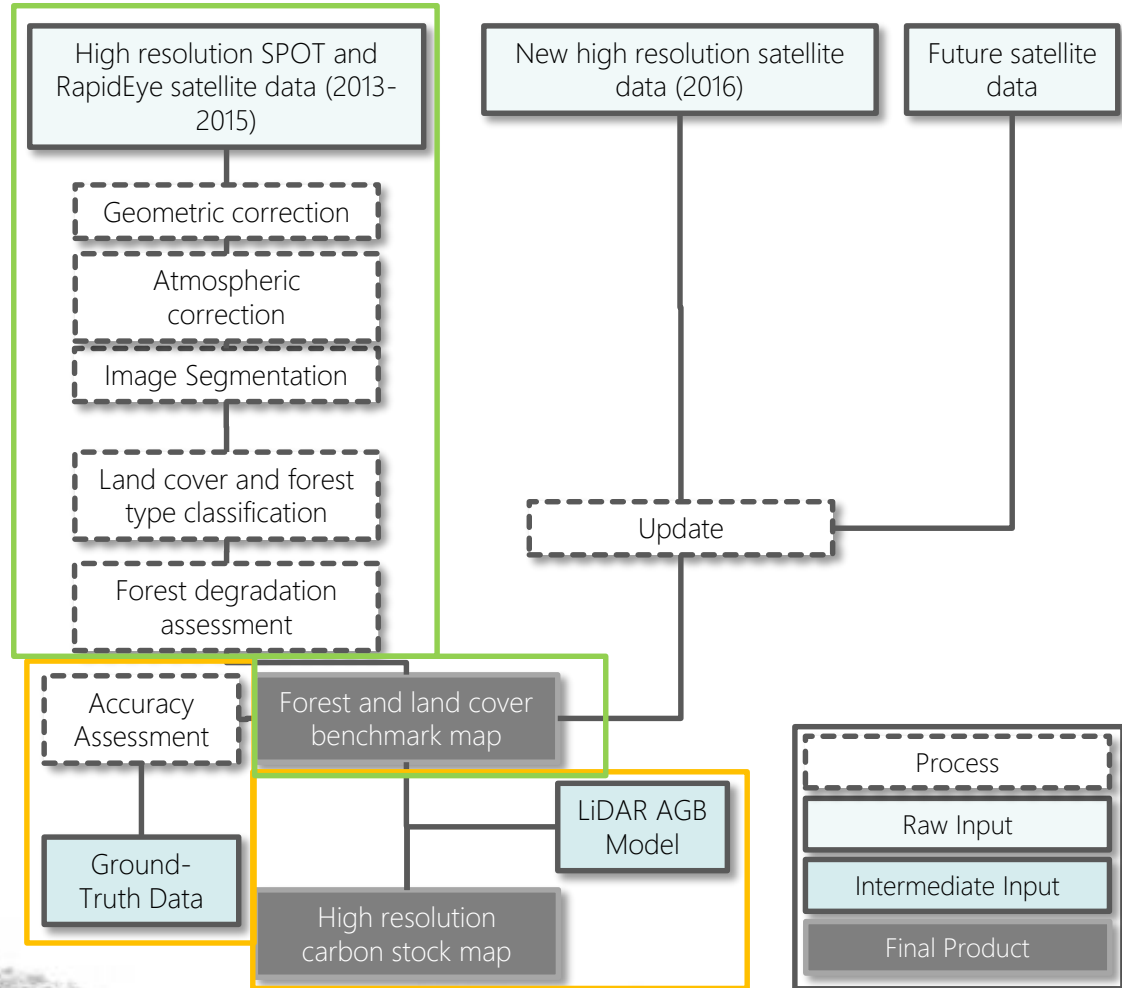
- Process high resolution satellite images (2013 - 2015)
- Create a forest and land cover benchmark map
- Including information of forest types, carbon stocks, forest degradation



Workflow

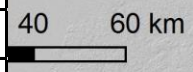


in progress



Used satellite images

AOI	Scene ID	Acquisition date
SPOT-6		
Sembilang	dim_spot6_ms_201407150307149_sen_1132422101	15.07.2014
	dim_spot6_ms_201406210252359_sen_1132423101	21.06.2014
	dim_spot6_ms_201403280255215_sen_1132424101	28.03.2014
Mangrove	dim_spot6_ms_201407150307482_sen_1132425101	15.07.2014
	dim_spot6_ms_201406210252359_sen_1132426101	21.06.2014
KPHP Lalan	dim_spot6_ms_201407150307312_sen_1132427101	15.07.2014
	dim_spot6_ms_201407150307149_sen_1132428101	15.07.2014
	dim_spot6_ms_201403280255215_sen_1132429101	28.03.2014
RapidEye		
Bentayan	2015-07-02T042057_RE5_1B-NAC_22087265_308153	02.07.2015
	2015-06-22T041141_RE5_1B-NAC_22087364_308153	22.06.2015
Benakat	2015-06-27T041634_RE5_1B-NAC_22087400_308152	27.06.2015
Lakitan	2015-06-27T041631_RE5_1B-NAC_22087821_308156	27.06.2015
	2014-06-17T042407_RE1_1B-NAC_22087555_308154	17.06.2014
	2013-08-23T042741_RE3_1B-NAC_22088153_308156	23.08.2013
	2013-06-19T042307_RE5_1B-NAC_22087822_308154	19.06.2013
Dangku	2015-06-27T041623_RE5_1B-NAC_22087002_308151	27.06.2015
	2015-07-23T042348_RE2_1B-NAC_22087008_308151	23.07.2015
REKI	2013-06-19T042253_RE5_1B-NAC_22087098_308150	19.06.2013
Kerinci Sebelat	2013-08-23T042744_RE3_1B-NAC_22088418_308154	23.08.2013
	2013-06-29T043241_RE5_1B-NAC_22088248_308154	29.06.2013



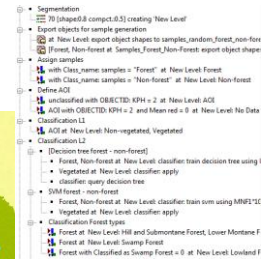
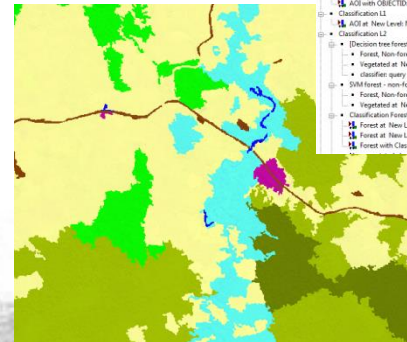
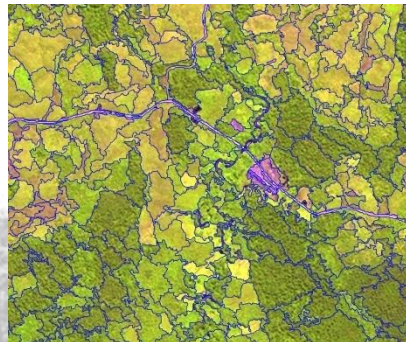
- Geometric correction:
 - Orthorectification using DEM and exterior orientation images (Random Polynomial Coefficients (RPCs))
 - Ground control points from Landsat satellite data
 - 30 m SRTM DEM for terrain rectification (ortho-correction)
- Atmospheric correction:
 - Removal of atmospheric distortions (scattering, illumination effects) induced by water vapor and aerosols
 - Conducted with the Software „ATCOR“

- Hierarchical classification rule-set
- Classification scheme based on Indonesian Standard Classification Scheme (23 Classes), refined for BioDiv and Carbon
- eCognition Software package
- Decision rules, as well as machine learning techniques such as Support Vector Machines

Segmentation



Classification

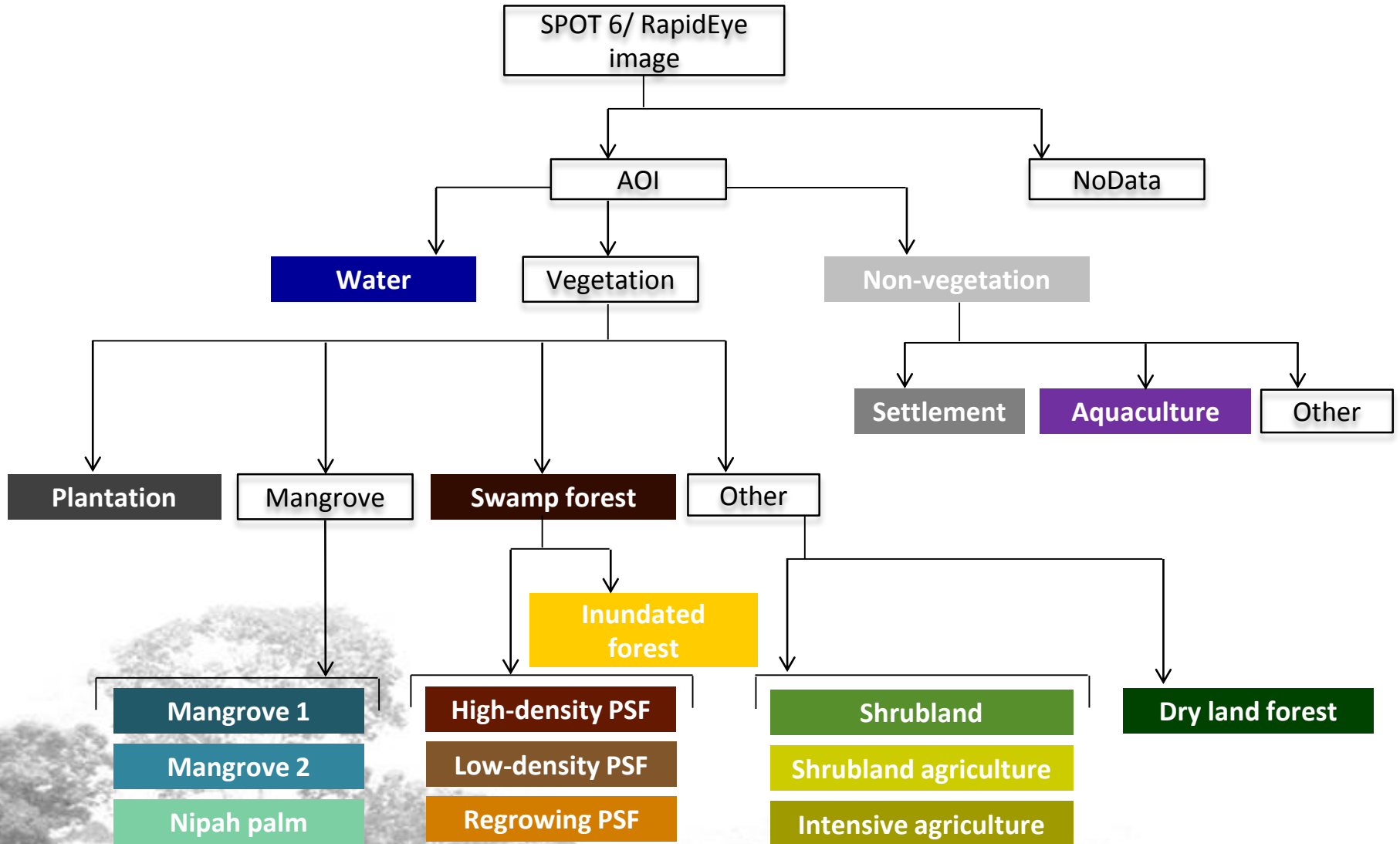


Classification scheme

BAPLAN Classification scheme	Indonesian name	Baplan Code	Bioclimate class	Baplan-enhanced code	Bioclimate Code
Primary dry land forest	Hutan lahan kering primer	2001	High-density Lowland Dipterocarp Forest	2001-1	111
			High-density Lower Montane Rainforest	2001-2	131
			High-density Upper Montane Rainforest	2001-3	141
Secondary/ logged over dry land forest	Hutan lahan kering sekunder/ bekas tebangan	2002	Medium-density Lowland Dipterocarp Forest	2002-1	112
			Low-density Lowland Dipterocarp Forest	2002-2	113
			Medium-density Lower Montane Rainforest	2002-3	132
			Low-density Lower Montane Rainforest	2002-4	133
			Medium-density Upper Montane Rainforest	2002-5	142
			Low-density Upper Montane Rainforest	2002-6	143
Primary swamp forest	Hutan rawa primer	2005	High-density peat swamp forest	2005-1	151
			Permanently inundated peat swamp forest	2005-2	153
			High-density back swamp forest	2005-3	161
			High-density freshwater swamp forest	2005-4	171
			Heath forest	2005-5	181
Secondary/ logged over swamp forest	Hutan rawa sekunder/ bekas tebangan	20051	Low-density peat swamp forest	20051-1	152
			Regrowing peat swamp forest	20051-2	154
			Low-density back swamp forest	20051-3	162
			Regrowing back swamp forest	20051-4	163
			Medium-density Freshwater Swamp Forest	20051-5	172
			Low-density Freshwater Swamp Forest	20051-6	173
Primary mangrove forest	Hutan mangrove primer	2004	Mangrove 1	2004-1	181
			Mangrove 2	2004-2	183
			Nipah Palm	2004-3	184
Secondary/ logged over mangrove forest	Hutan mangrove sekunder/ bekas tebangan		Degraded mangrove	2007-1	182
			Young mangrove	2007-2	185

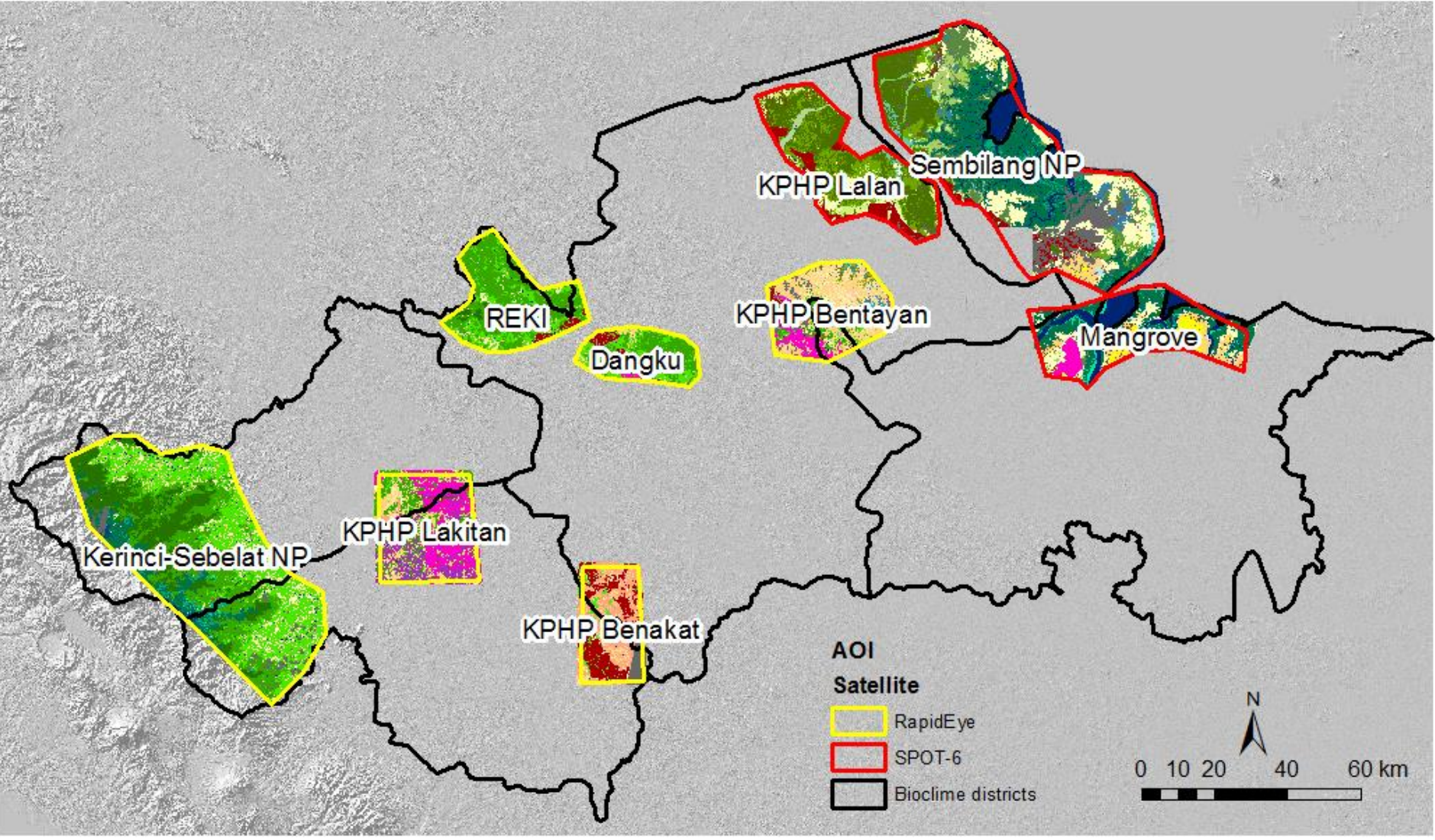
BAPLAN Classification scheme	Indonesian name	Baplan Code	Bioclimate class	Baplan-enhanced code	Bioclimate Code
Mixed dryland agriculture/mixed garden	Pertanian lahan kering campur semak / kebun campur	20092	Dryland agriculture mixed with shrub	20092	210
Tree crop plantation	Perkebunan/ Kebun	2010	Oil palm plantation	2010-1	221
			Coconut plantation	2010-2	222
			Rubber plantation	2010-3	223
Plantation forest	Hutan tanaman	2006	Acacia plantation	2006-1	231
			Industrial forest	2006-2	232
Scrub	Semak belukar	2007	Scrubland	2007	200
Swamp scrub	Semak belukar rawa	20071	Swamp scrub	20071	201
Rice fields	Sawah/ persawahan	20093	Rice field	20093	211
Dry land agriculture	Pertanian lahan kering	20091	Dry land agriculture	20091	212
Grass	Rumput	3000	Grassland	3000	213
Open land	Tanah terbuka	2014	Bare area	2014	300
Settlement/ developed land	Pemukiman/ lahan terbangun	2012	Settlement	2012-1	310
			Road	2012-2	311
Water body	Tubuh air	5001	Water	5001	400
Swamp	Rawa	50011	Wetland	50011	410
Embankment	Tambak	20094	Aquaculture	20094	420

Classification workflow (example)



CLASS	FEATURE	ALGORITHM
AOI	Mean band values	$\bar{R}, \bar{G}, \bar{B}, \overline{NIR}$
Water	Blue-NIR difference	$\bar{B} - \overline{NIR}$
Vegetation	Blue/Red ratio, mean Blue	$\frac{(\bar{B} - \bar{R})}{\bar{B} + \bar{R}}$
Plantation	Green-Red difference	$\bar{G} - \bar{R}$
Mangrove	Green-Red difference HSI sat.	$\bar{G} - \bar{R}$ HSI saturation (R,G,B)
Mangrove 1 & 2	Mean NIR, G NIR/Blue ratio	\overline{NIR}, \bar{G} $(\overline{NIR} - \bar{B}) / (\bar{B} + \overline{NIR})$
Swamp forest	Green-Red difference	$\bar{G} - \bar{R}$
High & low-density	Green-Red difference Anthocyanin eNDVI	$\bar{G} - \bar{R}$ $1000 * (1/G) + (1/\overline{NIR})$ $(R - \overline{NIR}) / \overline{NIR}$
Scrubland	HSI hue HSI intensity	HSI hue (R,G,B) HSI intensity (R,G,B)

Results: Land cover map



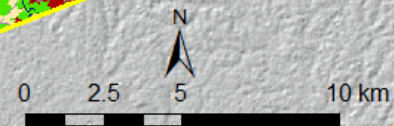
Results: Land cover map

PT REKI

Land cover class

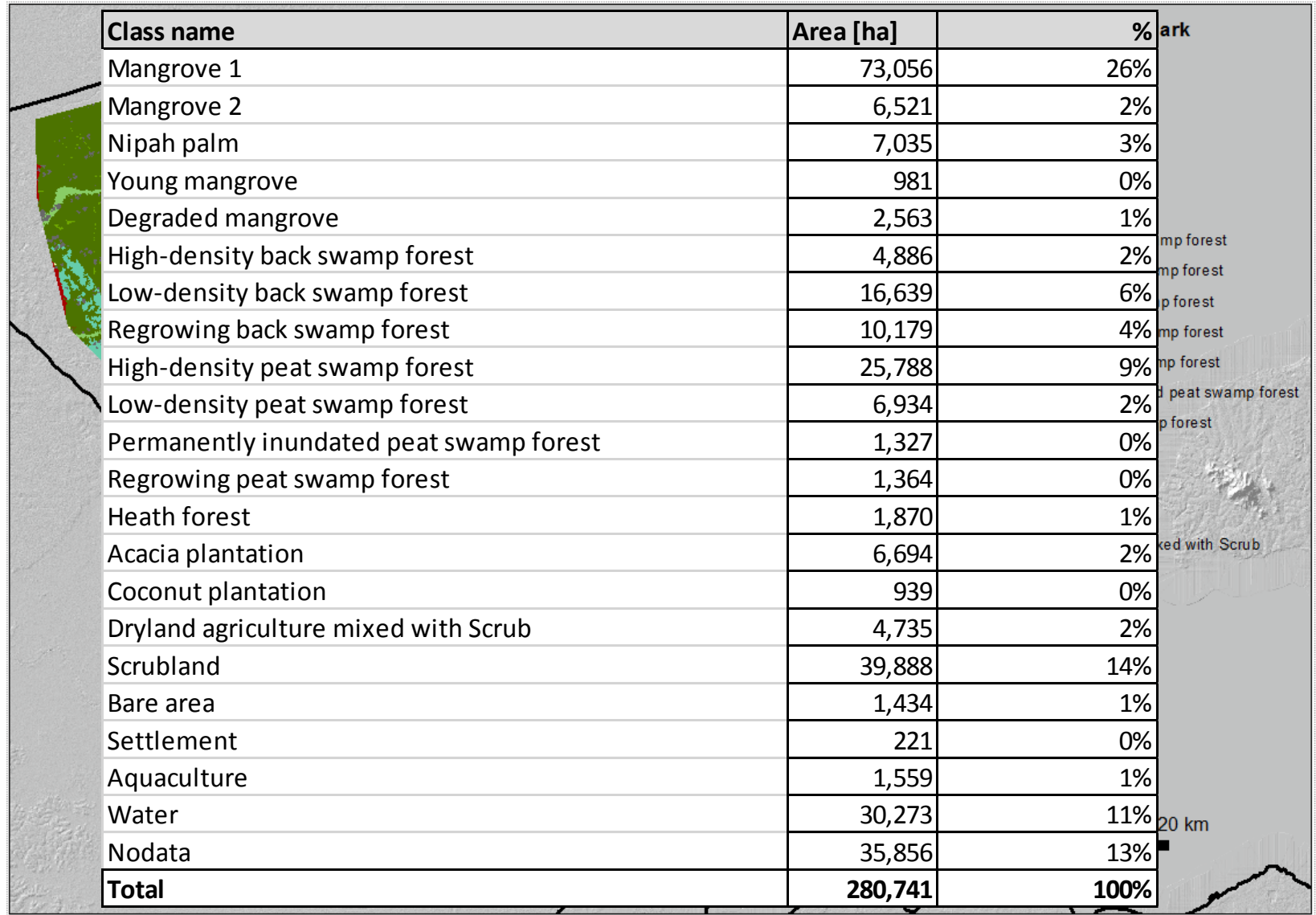
- High-density Lowland Dipterocarp Forest
- Medium-density Lowland Dipterocarp Forest
- Low-density Lowland Dipterocarp Forest
- Acacia Planta
- Rubber
- Dryland Agric
- Dryland Agric
- Scrubland
- Bare area
- Road
- Wetland
- Water

Class name	Area [ha]	%
High-density Lowland Dipterocarp Forest	2,528	3%
Medium-density Lowland Dipterocarp Forest	46,849	63%
Low-density Lowland Dipterocarp Forest	16,402	22%
Acacia Plantation	2,308	3%
Rubber	78	0%
Dryland Agriculture mixed with Scrub	819	1%
Dryland Agriculture	2,084	3%
Scrubland	1,998	3%
Bare area	104	0%
Road	613	1%
Wetland	2	0%
Water	368	0%
Total	74,152	100%



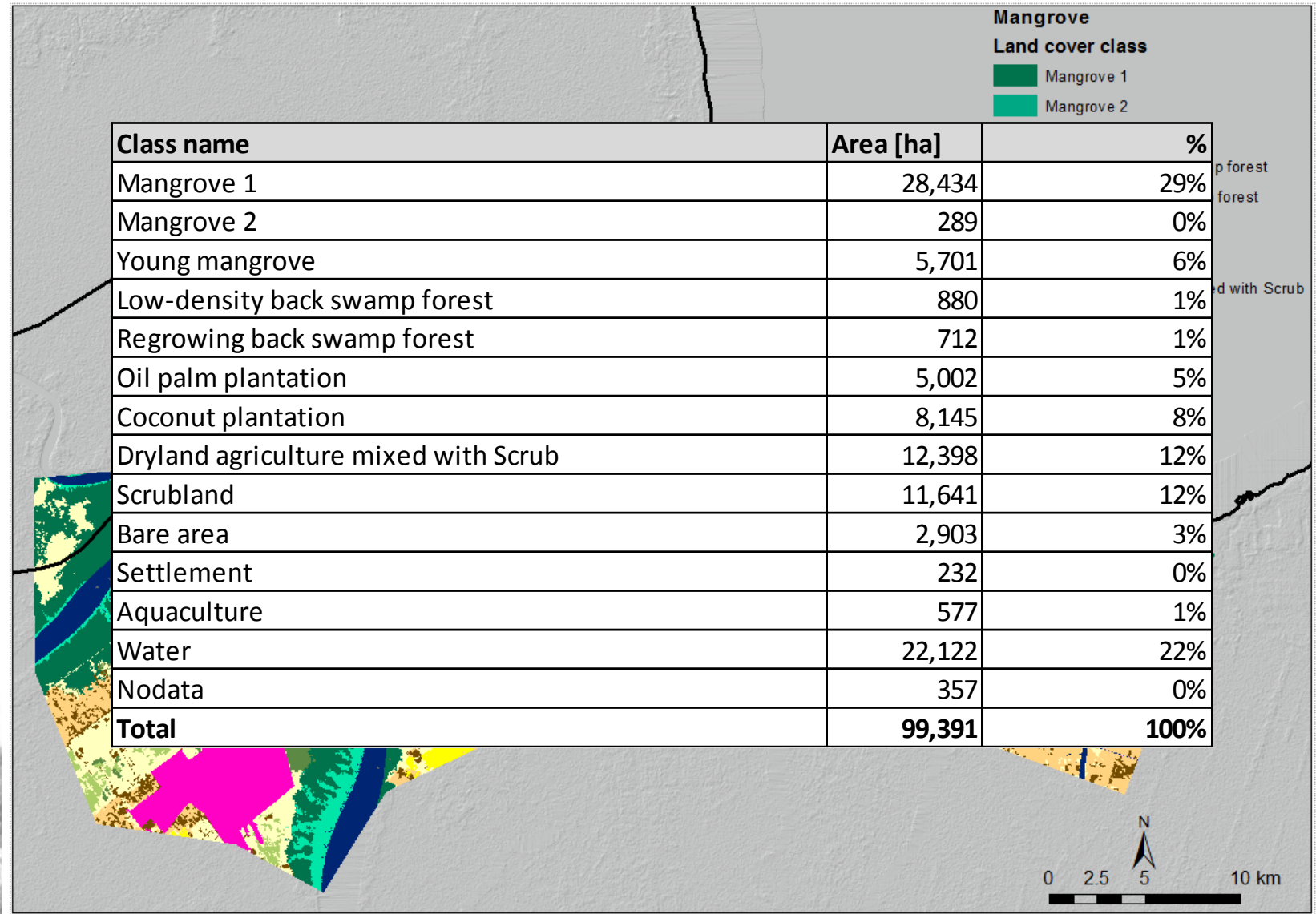
Dangku

Results: Land cover map

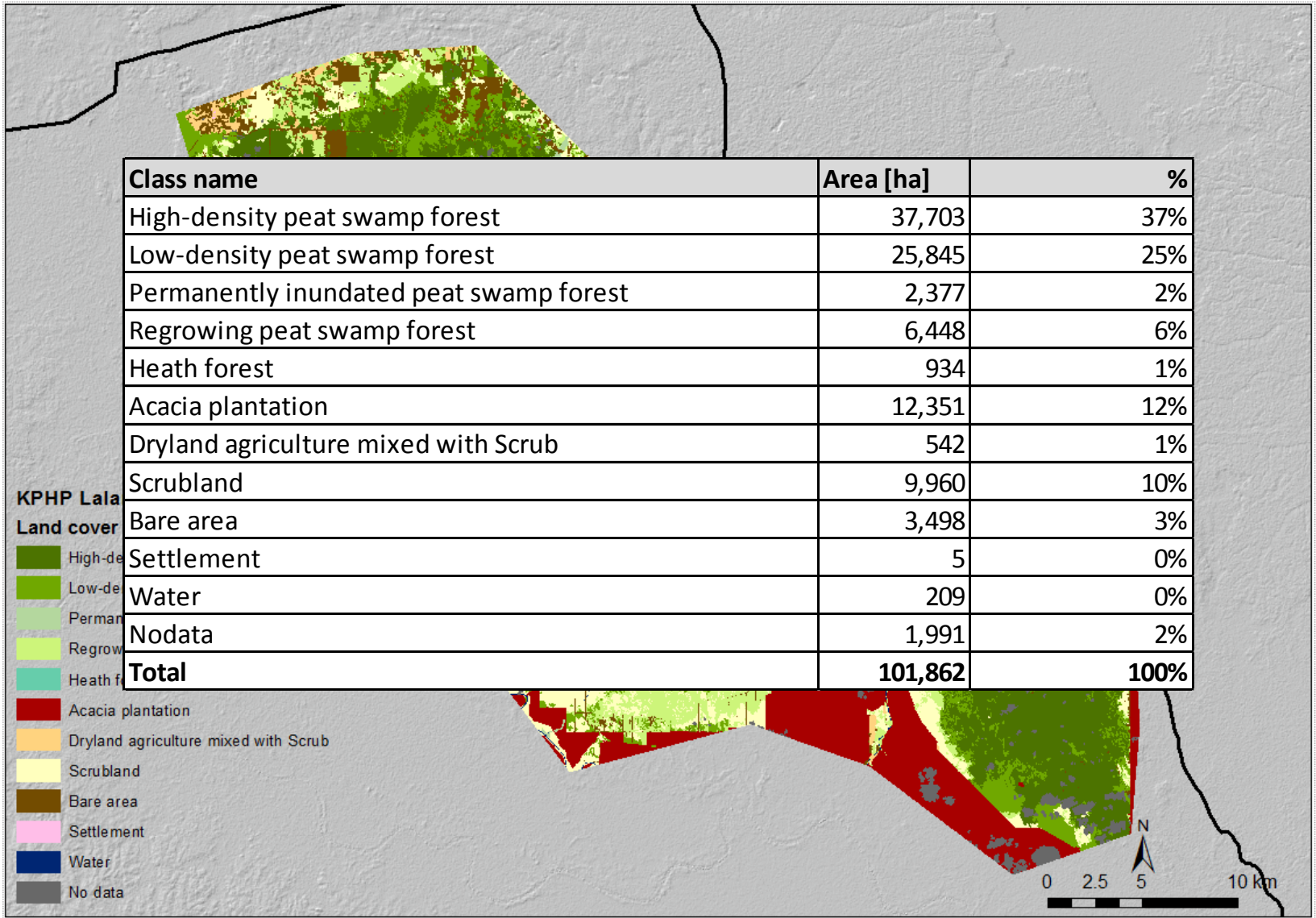


Class name	Area [ha]	%	mark
Mangrove 1	73,056	26%	
Mangrove 2	6,521	2%	
Nipah palm	7,035	3%	
Young mangrove	981	0%	
Degraded mangrove	2,563	1%	
High-density back swamp forest	4,886	2%	mp forest
Low-density back swamp forest	16,639	6%	mp forest
Regrowing back swamp forest	10,179	4%	p forest
High-density peat swamp forest	25,788	9%	mp forest
Low-density peat swamp forest	6,934	2%	peat swamp forest
Permanently inundated peat swamp forest	1,327	0%	p forest
Regrowing peat swamp forest	1,364	0%	
Heath forest	1,870	1%	
Acacia plantation	6,694	2%	ked with Scrub
Coconut plantation	939	0%	
Dryland agriculture mixed with Scrub	4,735	2%	
Scrubland	39,888	14%	
Bare area	1,434	1%	
Settlement	221	0%	
Aquaculture	1,559	1%	
Water	30,273	11%	20 km
Nodata	35,856	13%	
Total	280,741	100%	

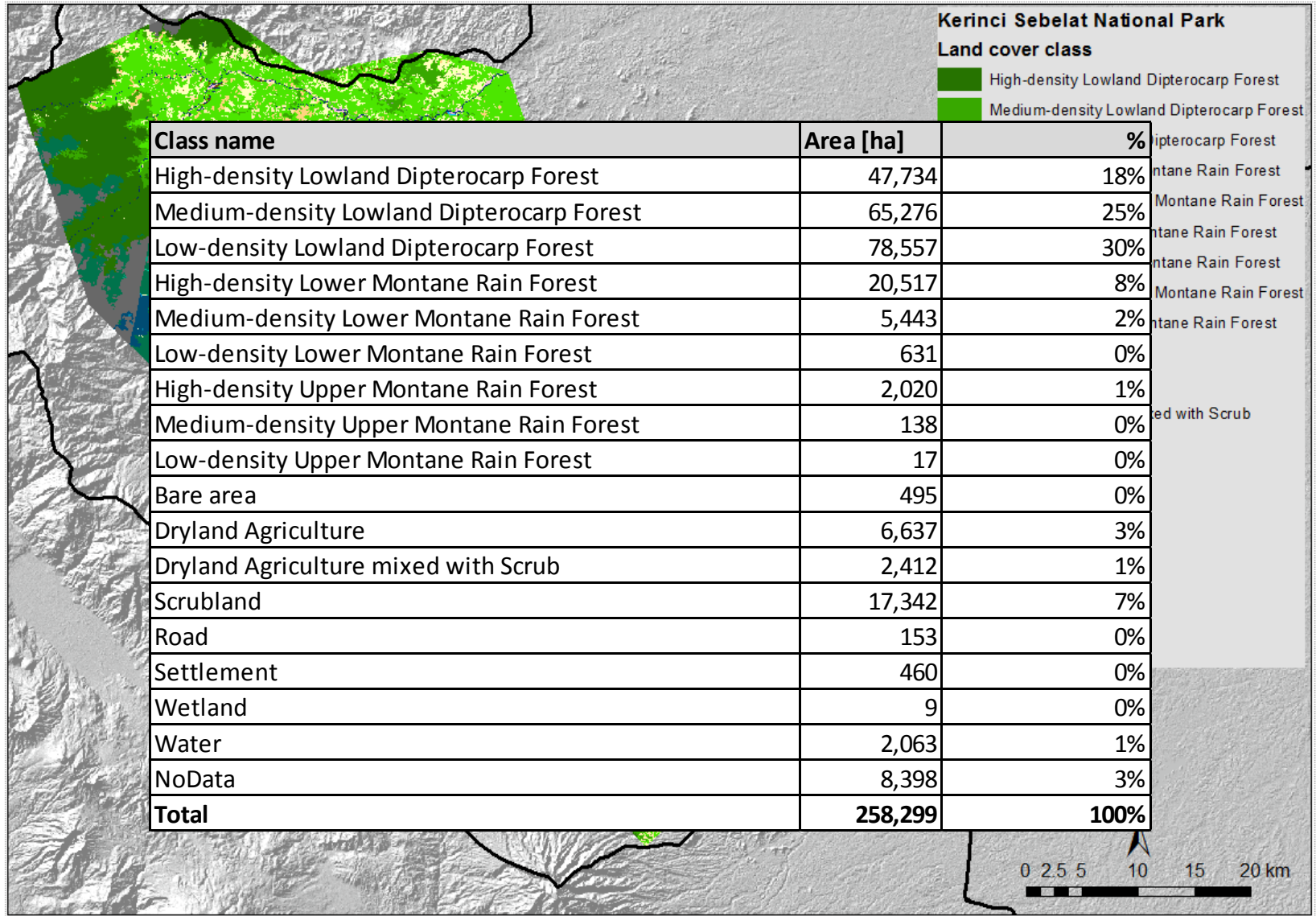
Results: Land cover map



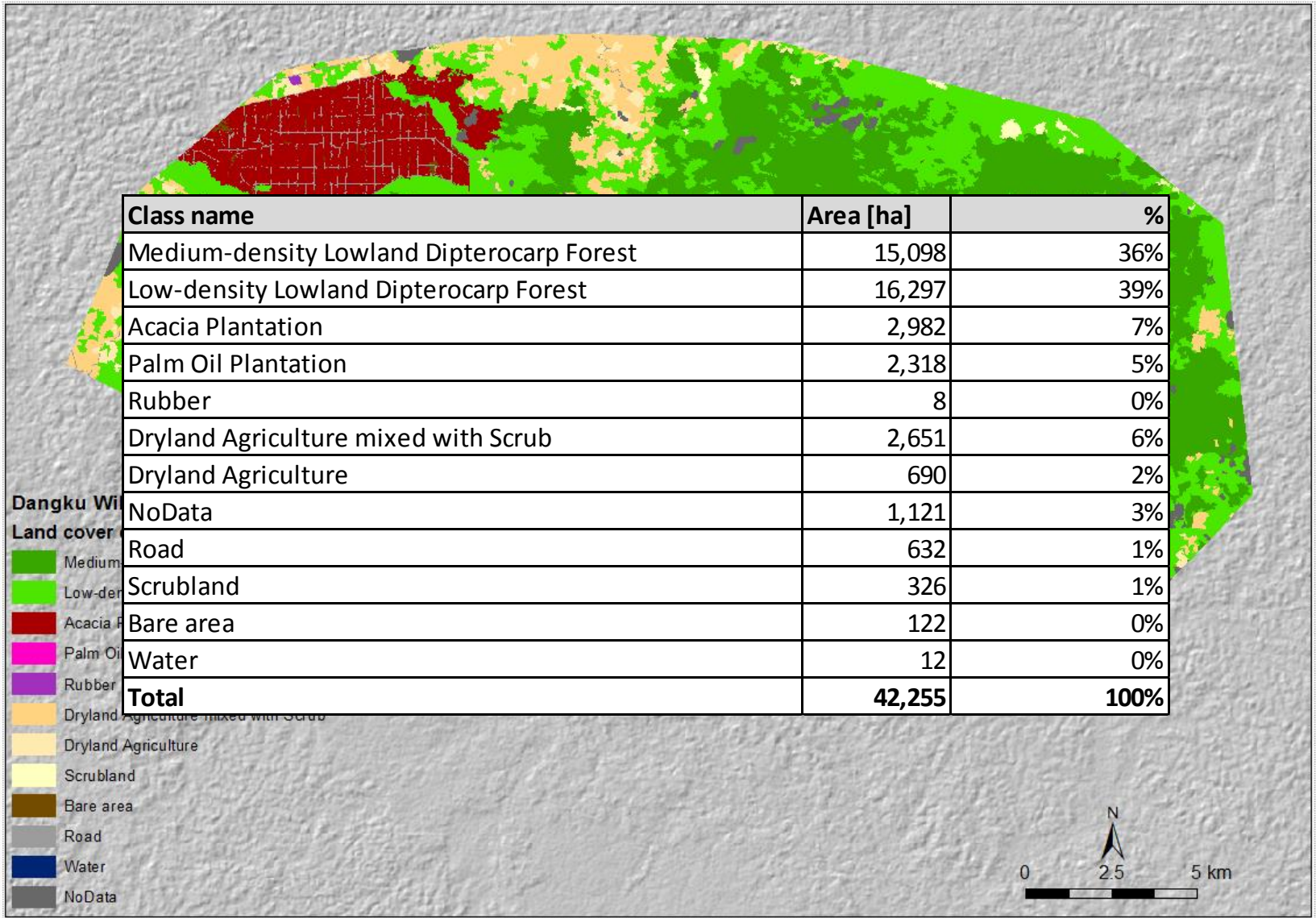
Results: Land cover map



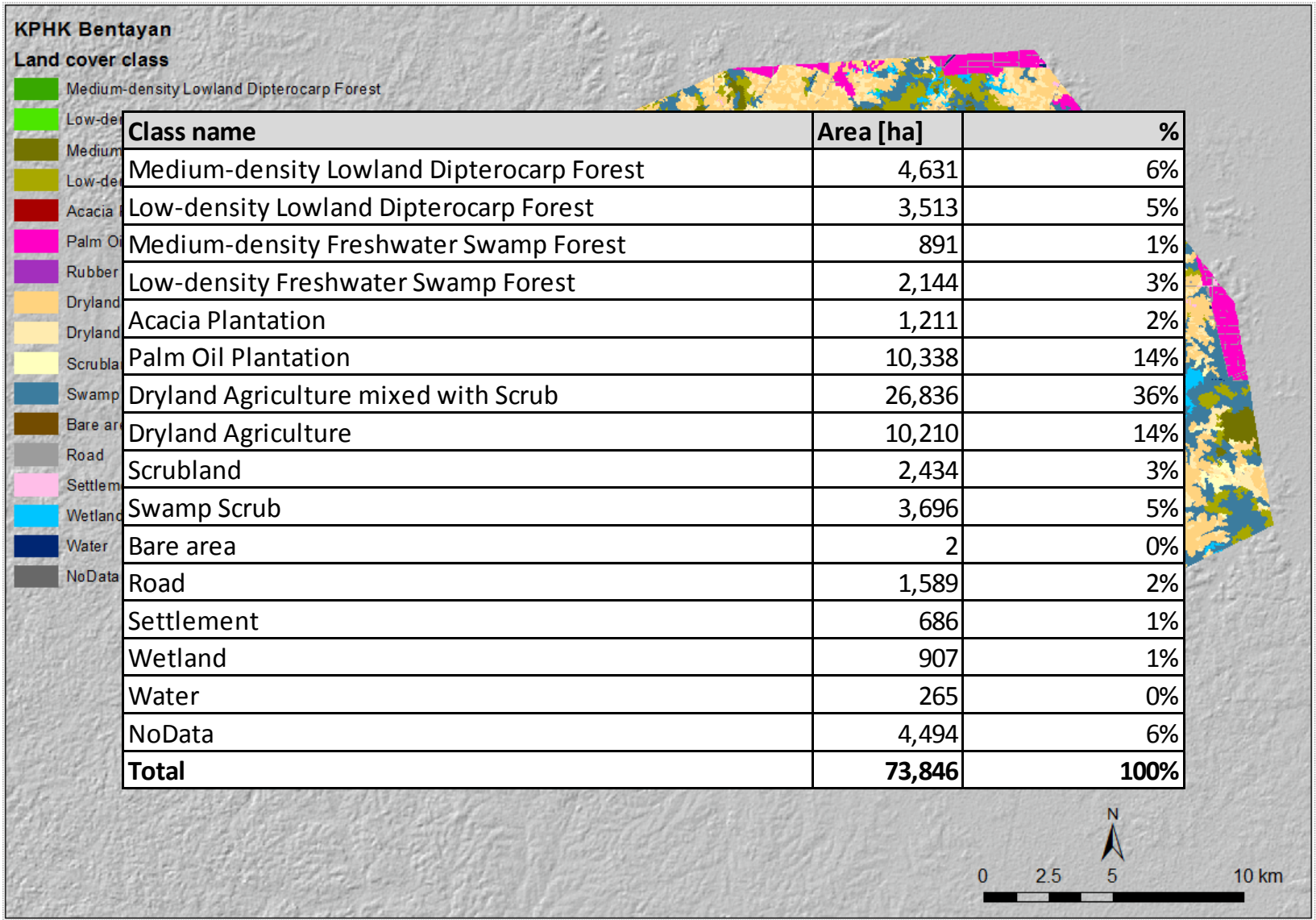
Results: Land cover map



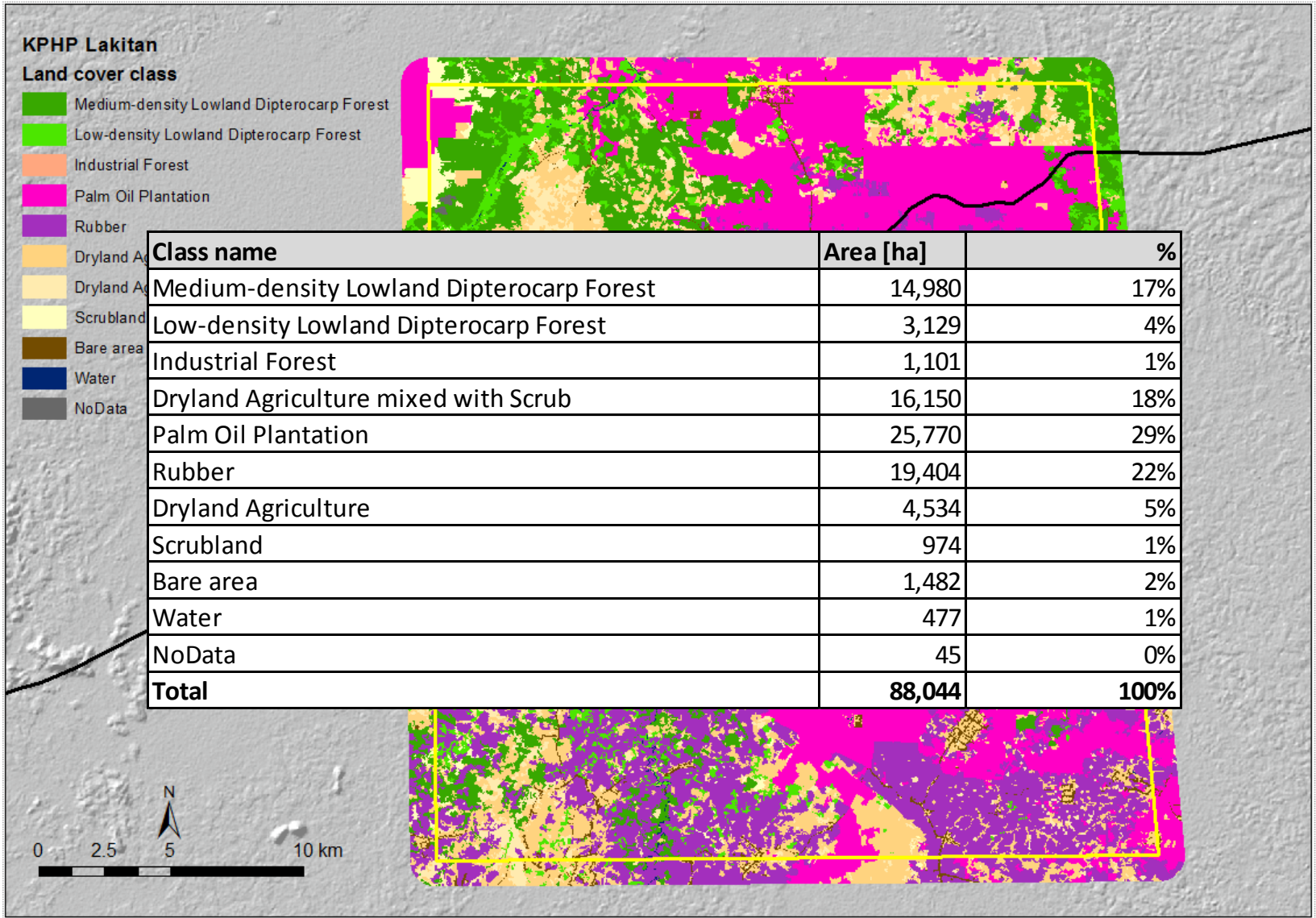
Results: Land cover map



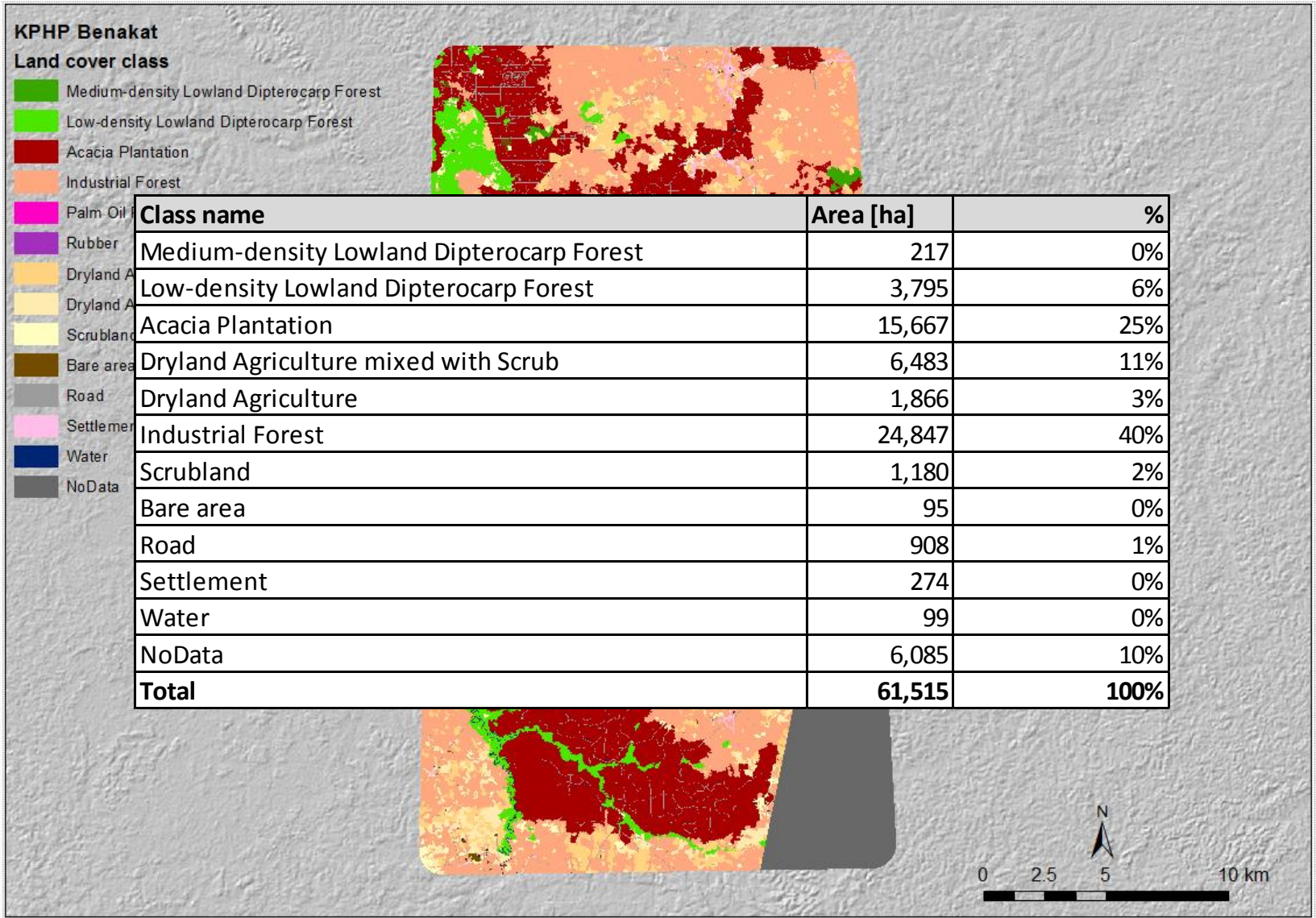
Results: Land cover map



Results: Land cover map



Results: Land cover map



Next steps: Validation of the land cover map

Ground truth data:

- First field survey in 2015 collected approx. 400 ground truth points
- Data collected includes vegetation type, growth height and canopy cover
- Aerial photos from the LiDAR survey will be analysed for additional ground truth
- Another survey planned for 2016, incorporating drone (UAV) data

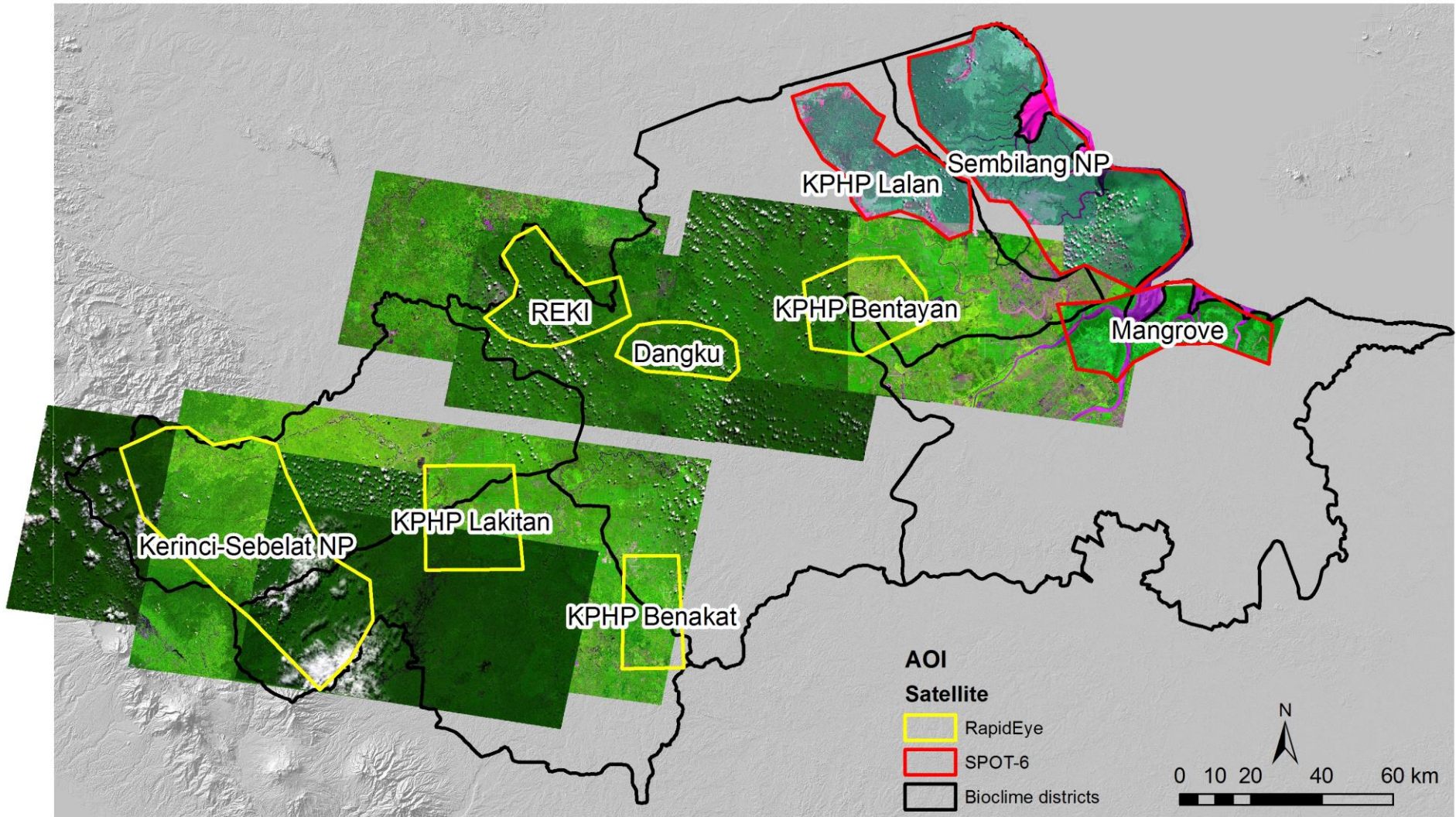


Next steps: Calculation of high resolution carbon maps

- Overlay with aboveground biomass model (from LiDAR)
- Calculation of locally adjusted biomass values/ Emission Factors (EF)
- Estimation of total carbon stock in project areas by stratify and multiply approach



Next steps: Monitoring land cover change



- Processing of first point in time complete
- Classification scheme adjusted for Bioclimate, but fully compatible to MoFor/ BAPLAN maps
- Image acquisition for 2016 already tasked in order to increase chances for successful acquisition (RapidEye)



An aerial photograph of a river meandering through a dense, lush green forest. The river flows in a series of large, sweeping loops, creating a complex, winding path. The surrounding forest is thick and vibrant green, with some areas appearing slightly more yellowish-green, possibly due to the lighting or the type of vegetation. The overall scene is a beautiful natural landscape.

Thank you for your
attention

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