K&C Phase 4 –Status report

Updating Forest Cover and Assessing Aboveground Biomass in Various Tropical Forest Ecosystems from PALSAR-2 Polarizations

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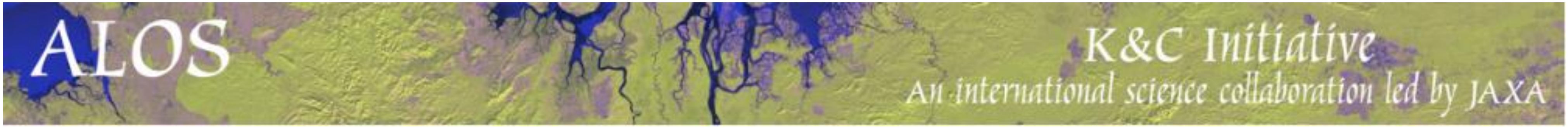
Science Team meeting #23
Tokyo Denki Univeristy, Hatoyama Campus, Saitama Japan, January 18-21, 2017



Project Summary

Kyoto & Carbon Initiative (Phase 4)

TITLE: Updating Forest Cover and Assessing Aboveground Biomass in Various Tropical Forest Ecosystems from PALSAR-2 Polarizations

DURATION: 2.5 years (October 2015 – March 2018)

EXEC. AGENCY: Forest Research Institute Malaysia (FRIM)

STUDY AREA: Peninsular Malaysia

Objectives

i. To develop a robust method for monitoring forest cover in Peninsular Malaysia by using a single PALSAR sensor. This to make sure consistent reporting, which has opportunity to be promoted and employed in **REDD+** implementation.

ii. To conduct a detailed study on the use of PALSAR (especially PALSAR-2) data for retrieving aboveground biomass in three key forest ecosystem in Malaysia, which are inland dipterocarp, peat swamp and mangrove forests.

iii. To develop methods for accurate assessment of aboveground biomass on these forest ecosystems.

Deliverables

The project is aiming at the following deliverables and will producing:

i. An updated forest cover map over the entire Peninsular Malaysia.

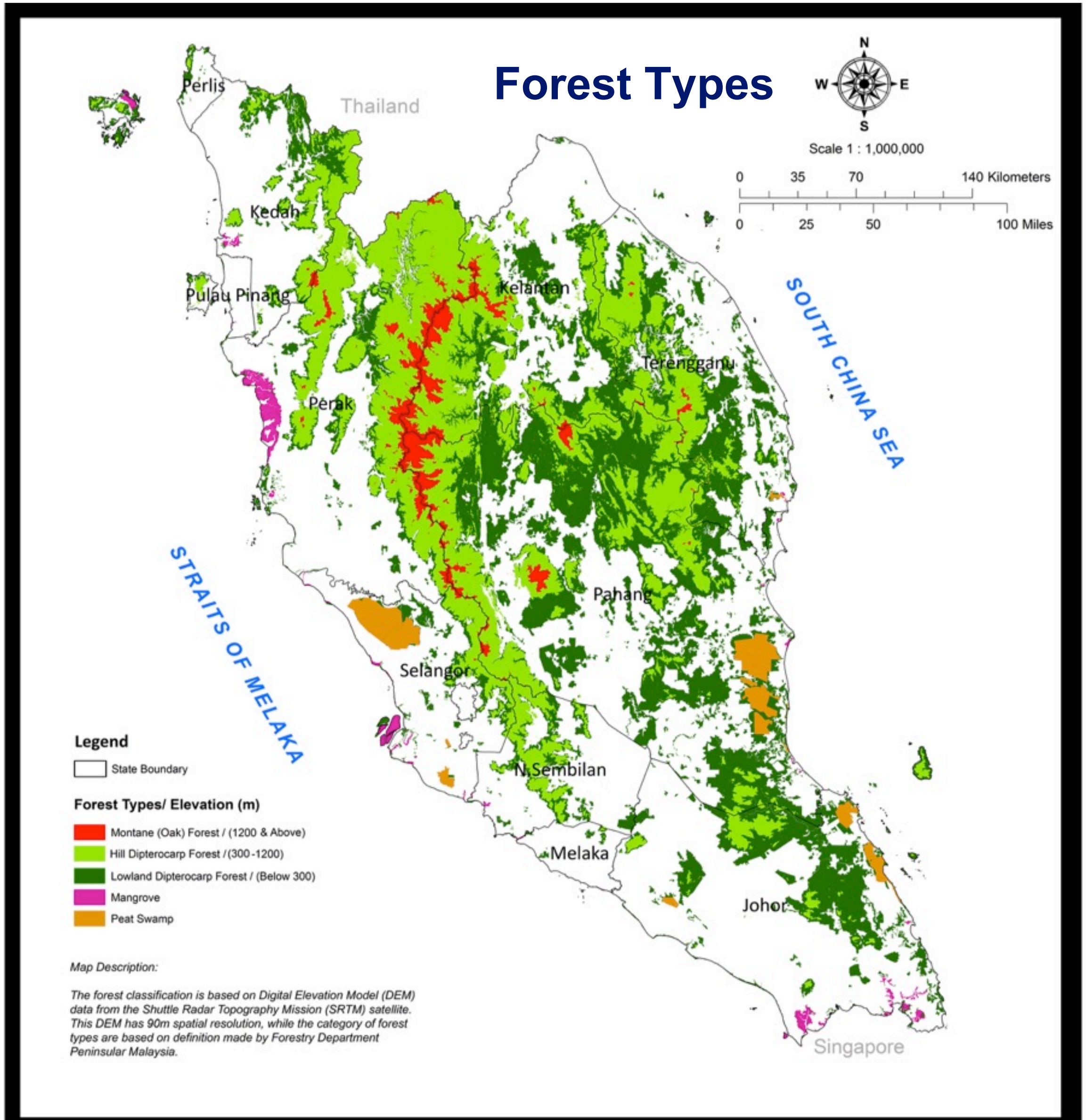
ii. Spatially distributed maps of aboveground biomass in lowland dipterocarp forests (virgin and logged-over).

iii. Maps of aboveground biomass on peat swamp and mangroves forests.

iv. Methods and models for estimating aboveground biomass on the lowland dipterocarp, peat swamp and mangroves forest ecosystems in Malaysia.

Project Milestones

No.	Key-milestone	Date of completion (Proposal)	Date of completion (Actual)
i	Maps of forest cover in Peninsular Malaysia of year 2015	June 2015	January 2016
ii	Forest inventory (i.e. ground truth) datasets	September 2015	April 2016
iii	Spatial distribution map of AGB over focus-study area A: CTFS research plot (Changed to Sungai Menyala Forest Reserve)	December 2015	June 2016
iv	Spatial distribution map of AGB over focus-study area B: Logged forest in Dungun Timber Complex.	March 2016	Sept 2016
v	Spatial distribution map of AGB over focus-study area C: Peat swamp forest in South East Pahang.	June 2016	March 2017
vi	Spatial distribution map of AGB over focus-study area D: Kukup Island mangroves, Johor	September 2016	June 2017
vii	Maps of AGB in Peninsular Malaysia of year 2015	June 2017	Sept 2017
viii	Project report	March 2018	March 2018


Forest Types
N
W
E
S
Scale 1 : 1,000,000
0 35 70 140 Kilometers
0 25 50 100 Miles
Thailand
Perlis
Kedah
Pulau Pinang
Kelantan
Terengganu
Perak
Pahang
Selangor
N.Sembilan
Melaka
Johor
Singapore
SOUTH CHINA SEA
STRAITS OF MELAKA
Legend
State Boundary
Forest Types/ Elevation (m)
Montane (Oak) Forest / (1200 & Above)
Hill Dipterocarp Forest / (300 -1200)
Lowland Dipterocarp Forest / (Below 300)
Mangrove
Peat Swamp
Map Description:
The forest classification is based on Digital Elevation Model (DEM) data from the Shuttle Radar Topography Mission (SRTM) satellite. This DEM has 90m spatial resolution, while the category of forest types are based on definition made by Forestry Department Peninsular Malaysia.

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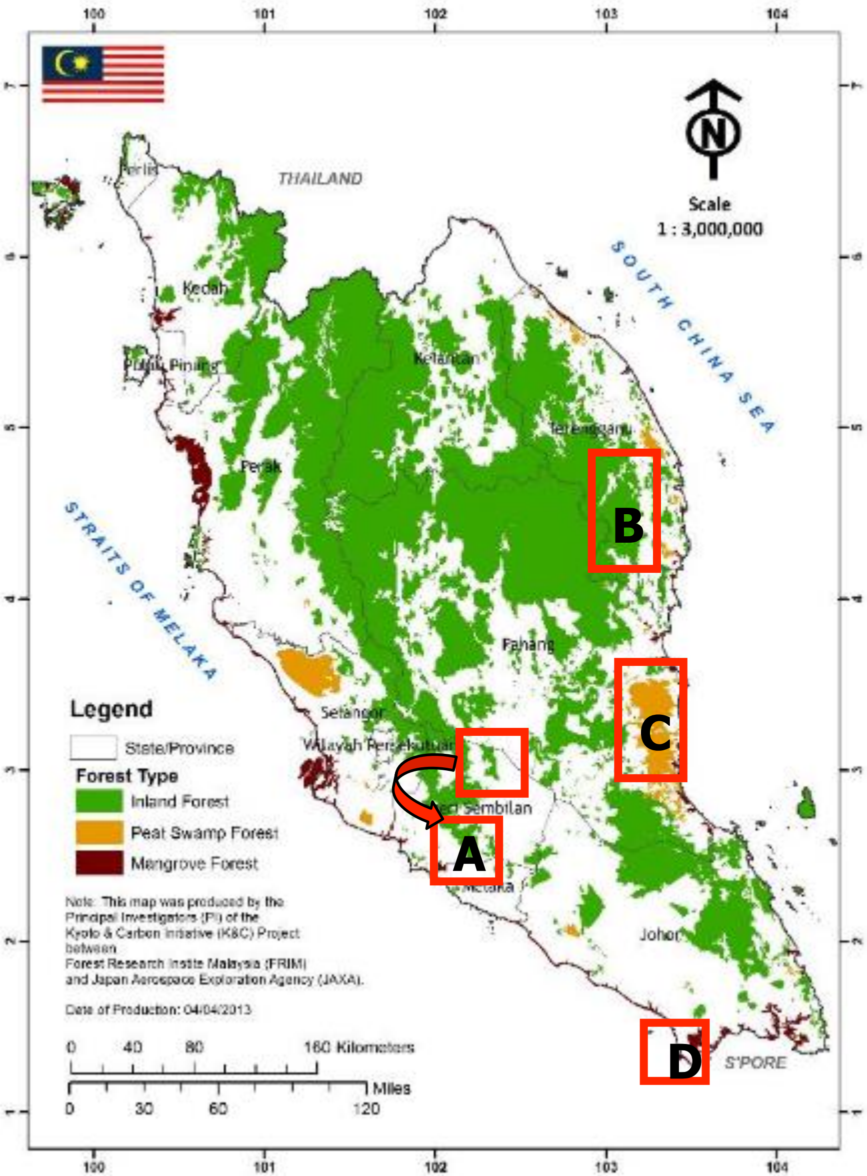
Study Area



Focus Area K&C Phase 4

A. CTFS Research plot (Virgin lowland dipt.)

B. Dungun Timber Complex (production area lowland and hill dipt.)

C. Pekan Peat swamp forest

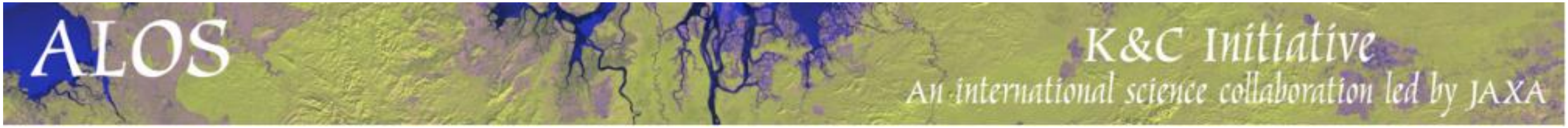
D. Kukup Island National Park (mangrove forest)

Data sharing

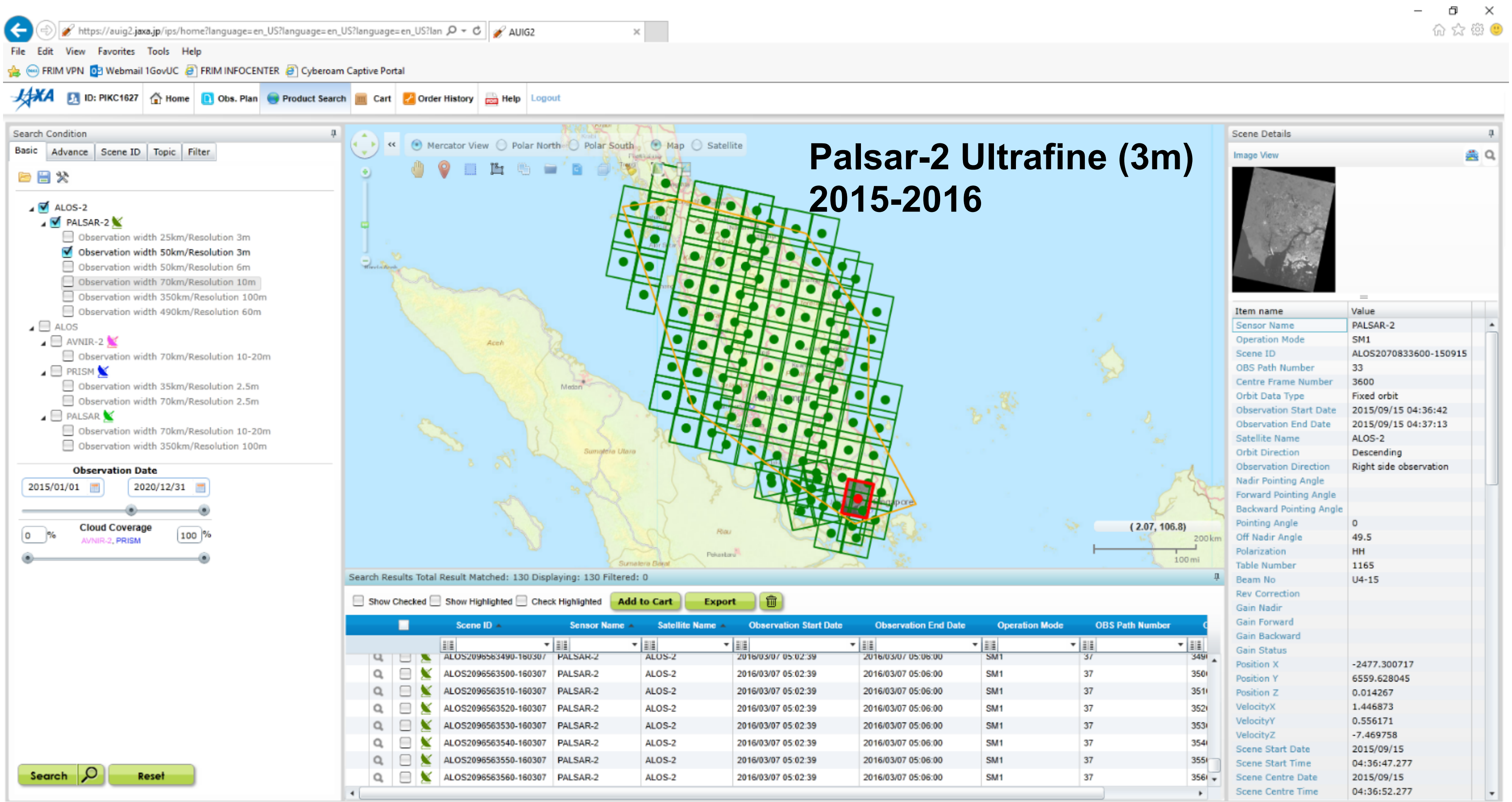
Types of forest	Natural Forest				Total samples
	Sungai Menyala Forest Reserve	Dungun Timber Complex	Peat swamp forest	Kukup Island mangrove forest	
No. of Sampling Points	50 (50 ha)	60 (108,000 ha)	60 (200,000 ha)	60 (500 ha)	230

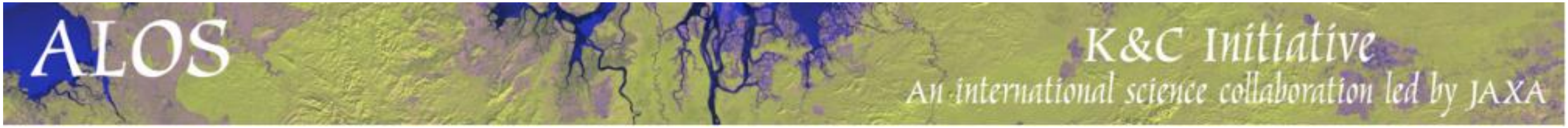
Data will be collected on the ground and will be stored in digital shapefile (.shp) in point format. Each point will contain geographic location, forest types, basal area information, date of ground thruthing, and aboveground biomass.

All maps produced from this project will be also delivered to JAXA.



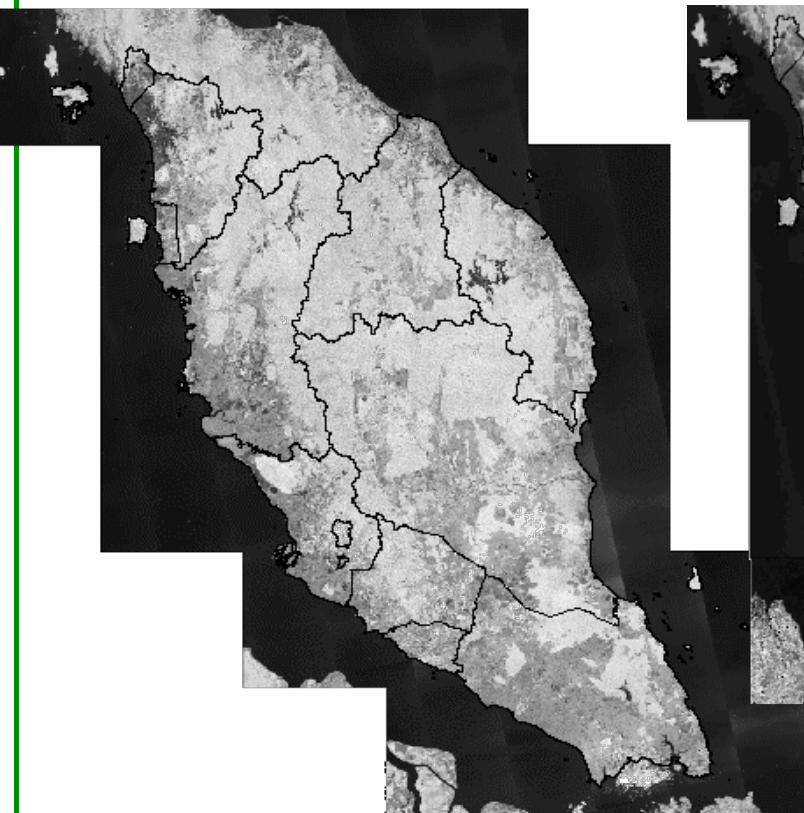
Palsar-2 Ultrafine (3m) 2015-2016



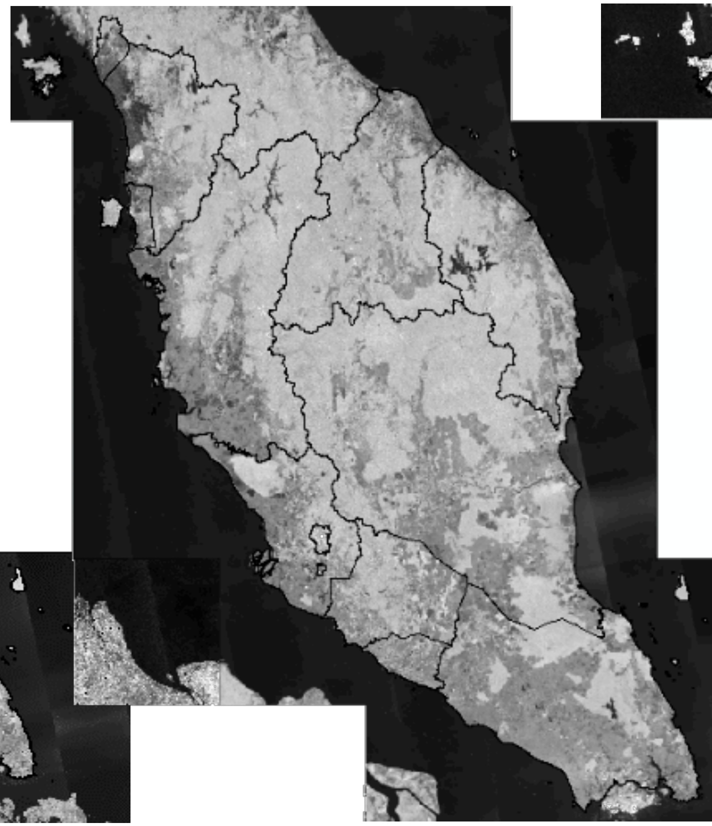


Forest cover mapping & Deforestation detection

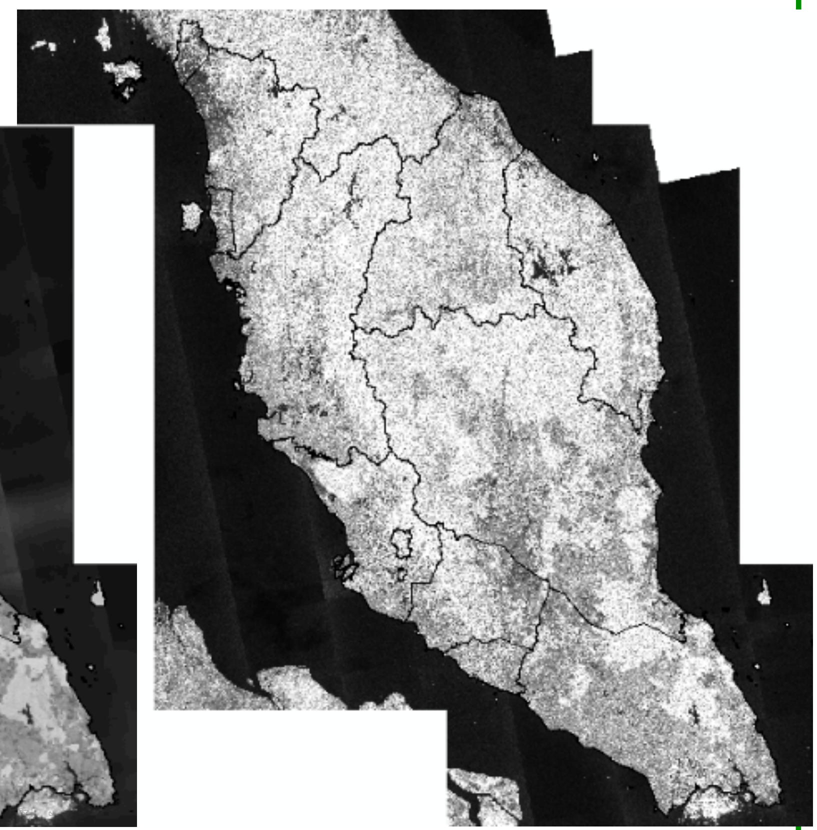
Palsar Mosaic 2007

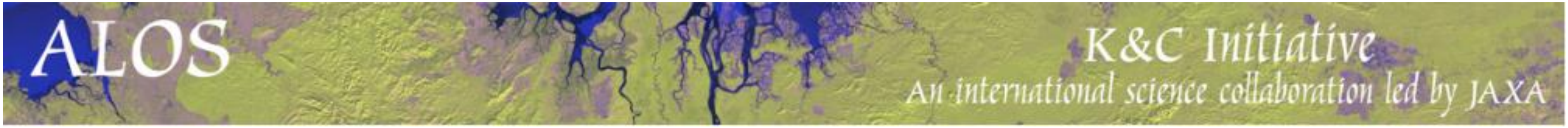


Palsar Mosaic 2010

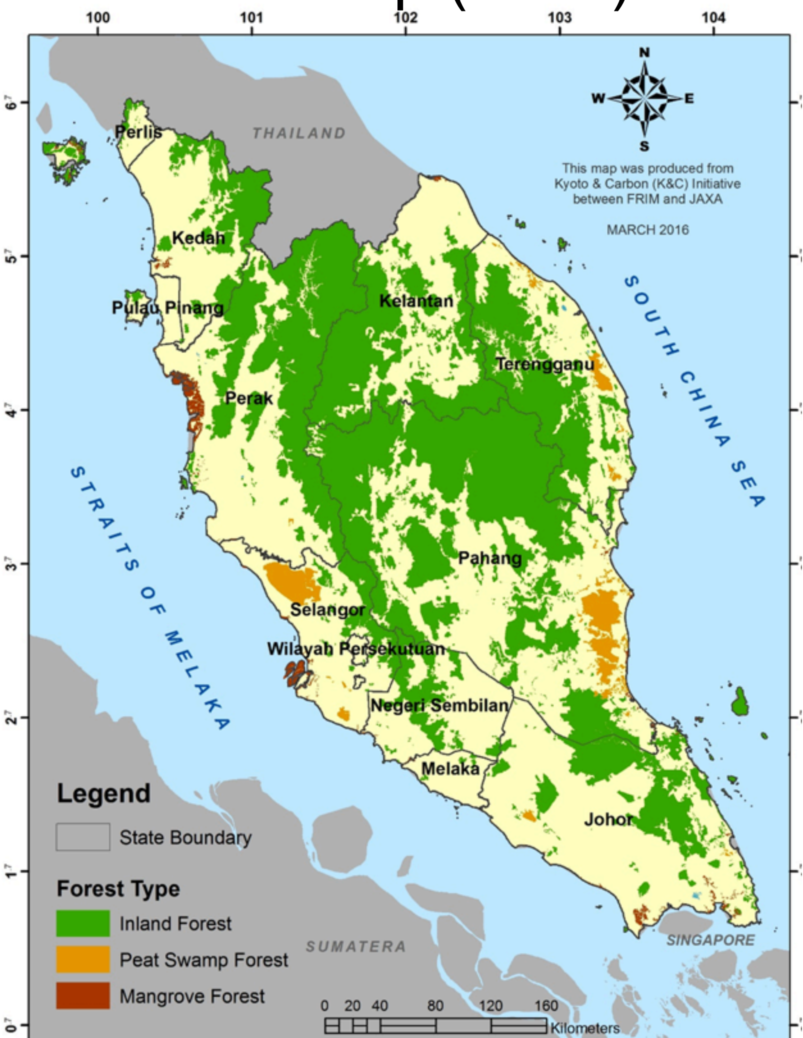


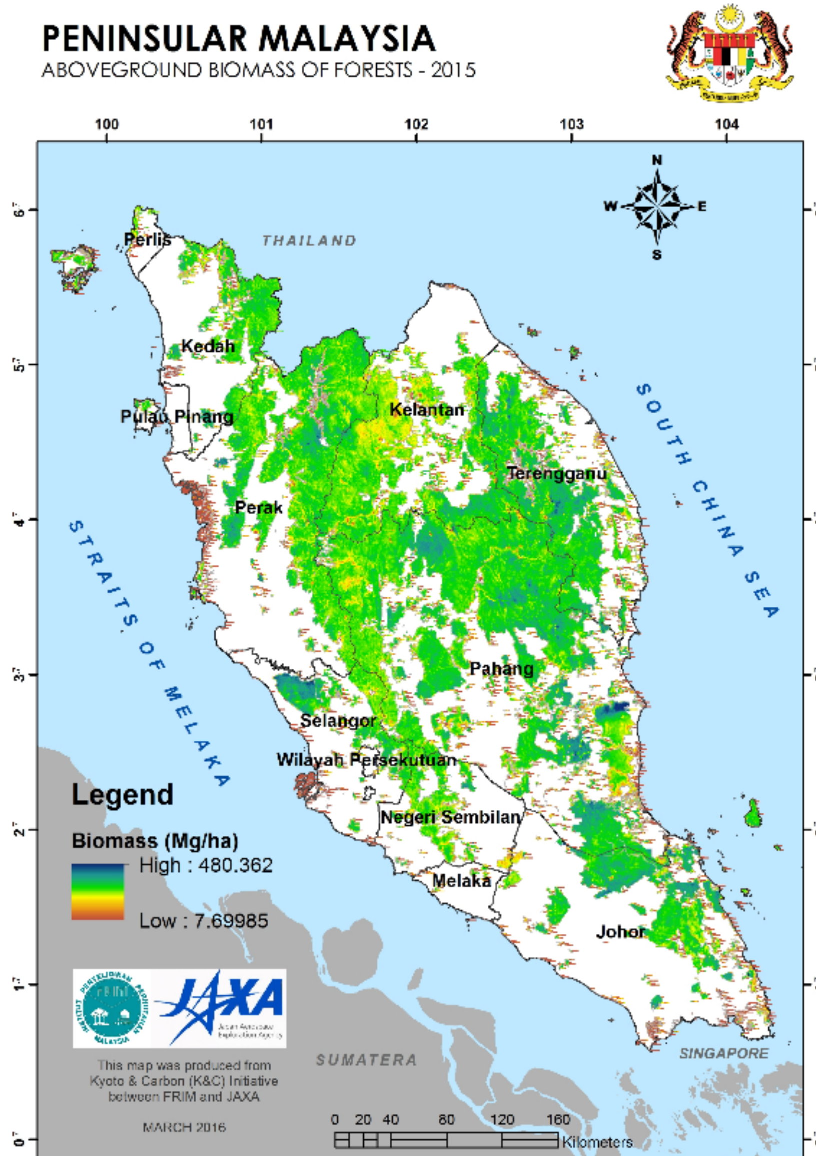
Palsar-2 Mosaic 2015





Updated Forest Cover and Biomass Map (2015)





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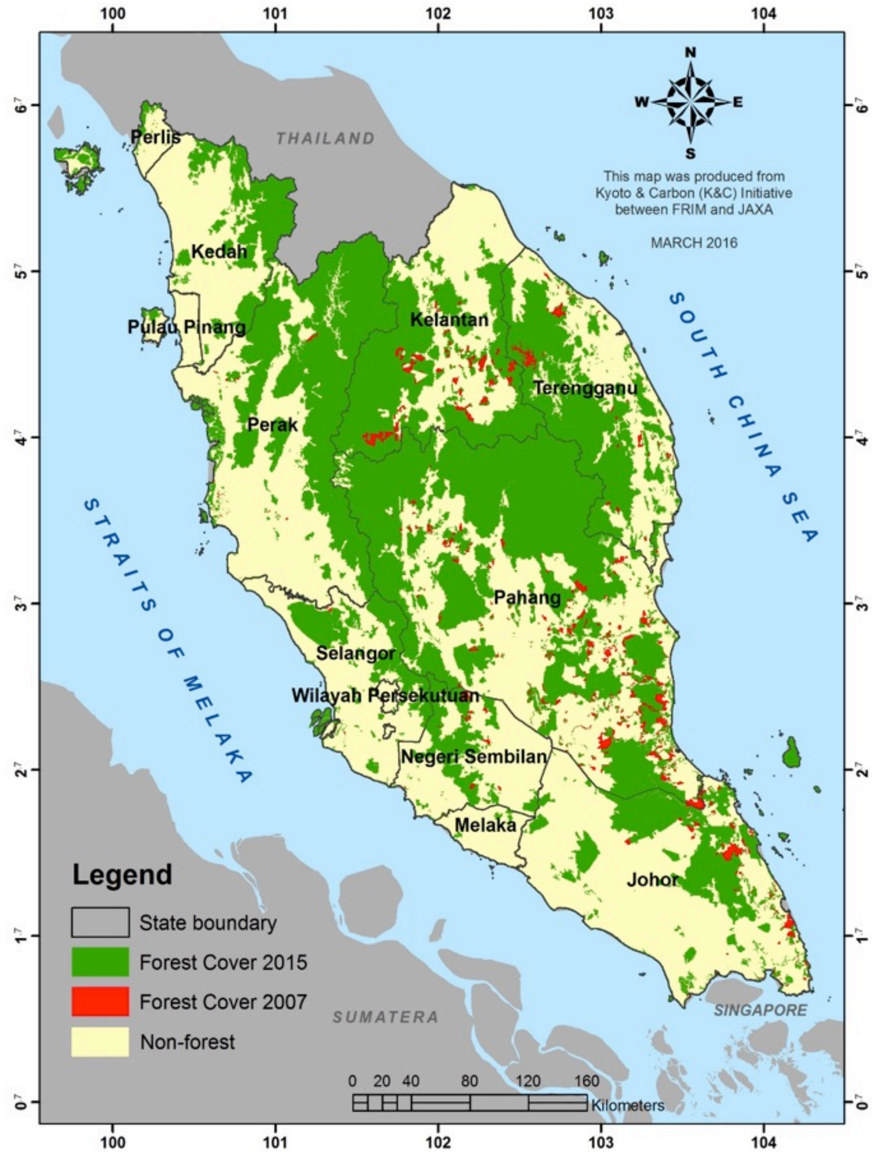
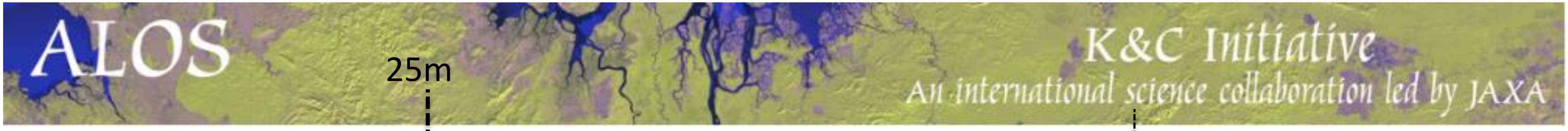
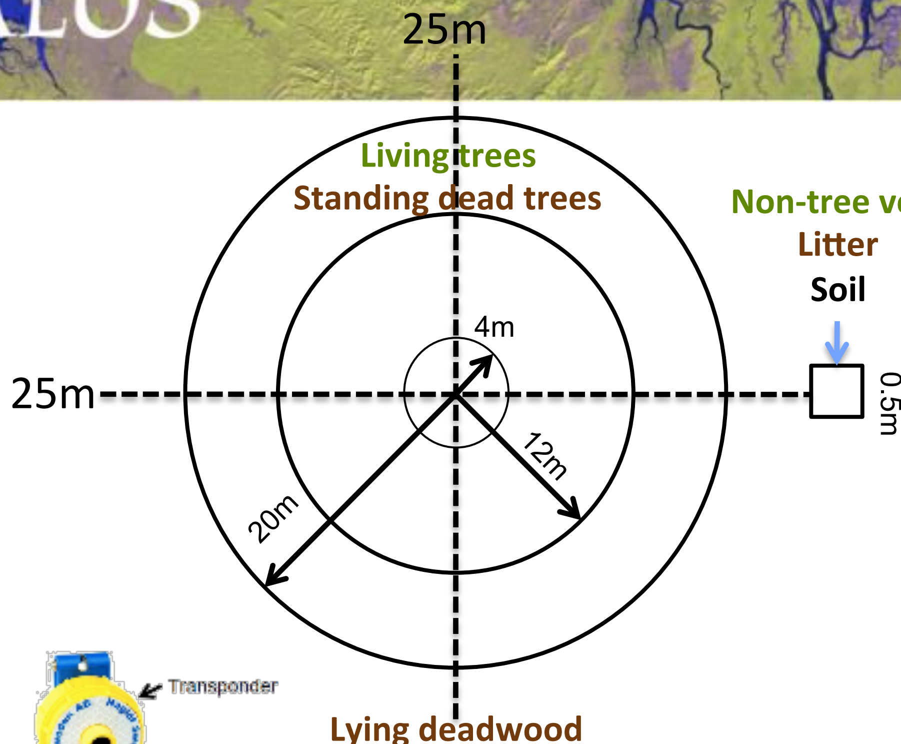
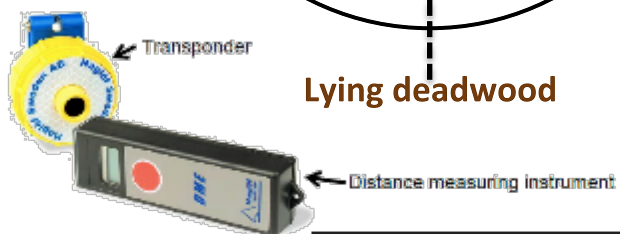
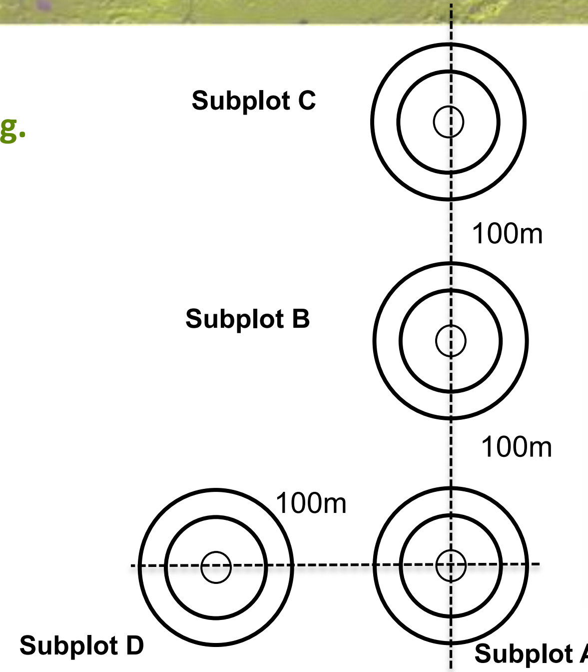
Map showing spatial distribution of changes of forest cover in Peninsular Malaysia between years 2007 and 2015

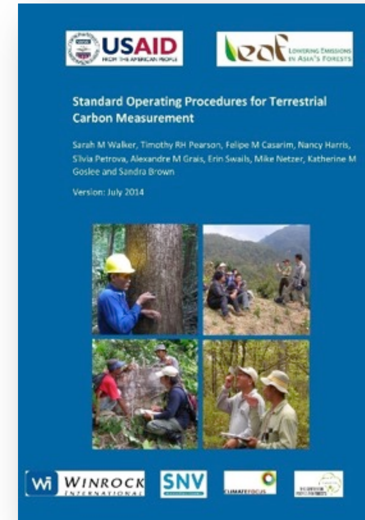










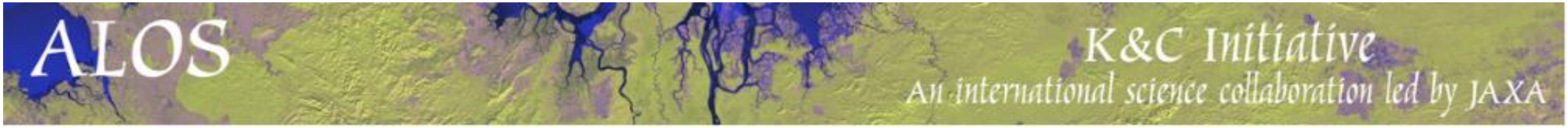


Sample plot design

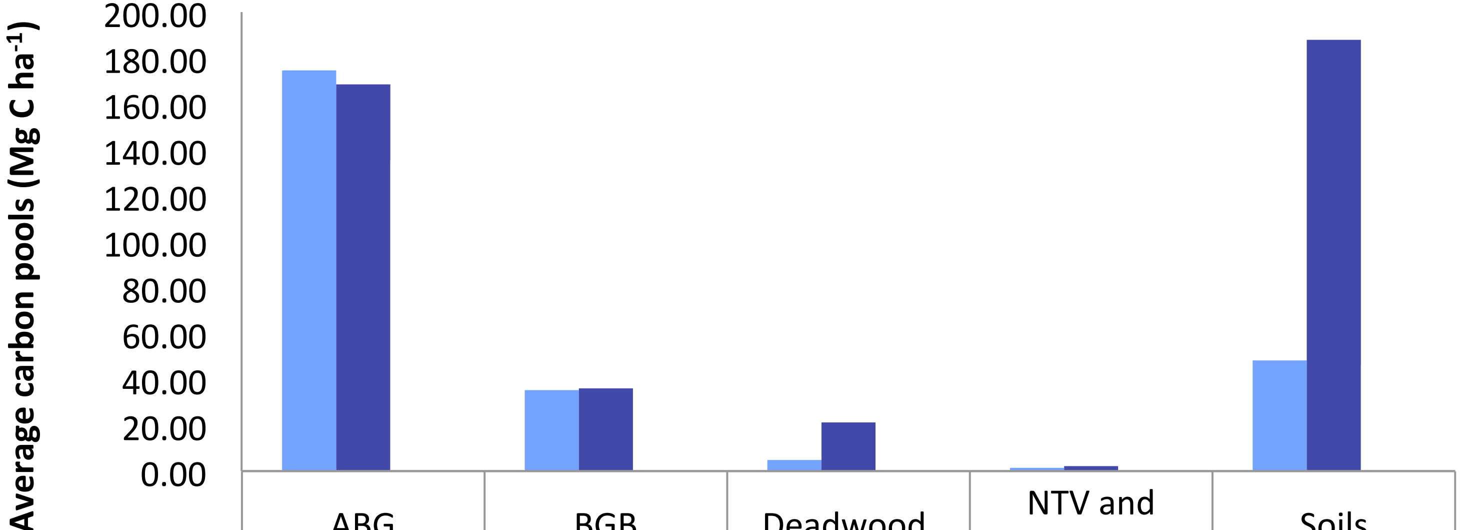
Nest Radius (m)	Size	Tree size, DBH (cm)
2	Sapling	< 10 cm; ≥ 1.3 m
4	Small	≥ 10
12	Medium	≥ 20
20	Large	≥ 40

Stand level AGB estimation

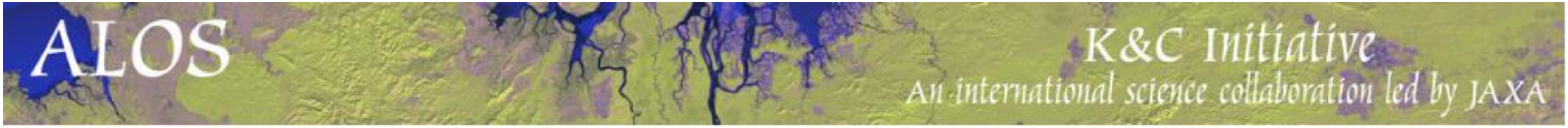
Forest type	Allometric function	Source
Inland forest	$AGB = [\exp(-1.803 - 0.976E + 0.976 \ln(\rho) + 2.673 \ln(D) - 0.0299 [\ln(D)]^2]$	Chave et al. (2014)
Peat swamp forest	$AGB = 0.65 * \exp(-1.239 + 1.98 * \ln(D) + 0.207 * \ln(D)^2 - 0.0281 * \ln(D)^2$	Chave et al. (2005)
Mangrove forest	$AGB = 0.251 \rho D^{2.46}$	Komiyama et al. (2007)



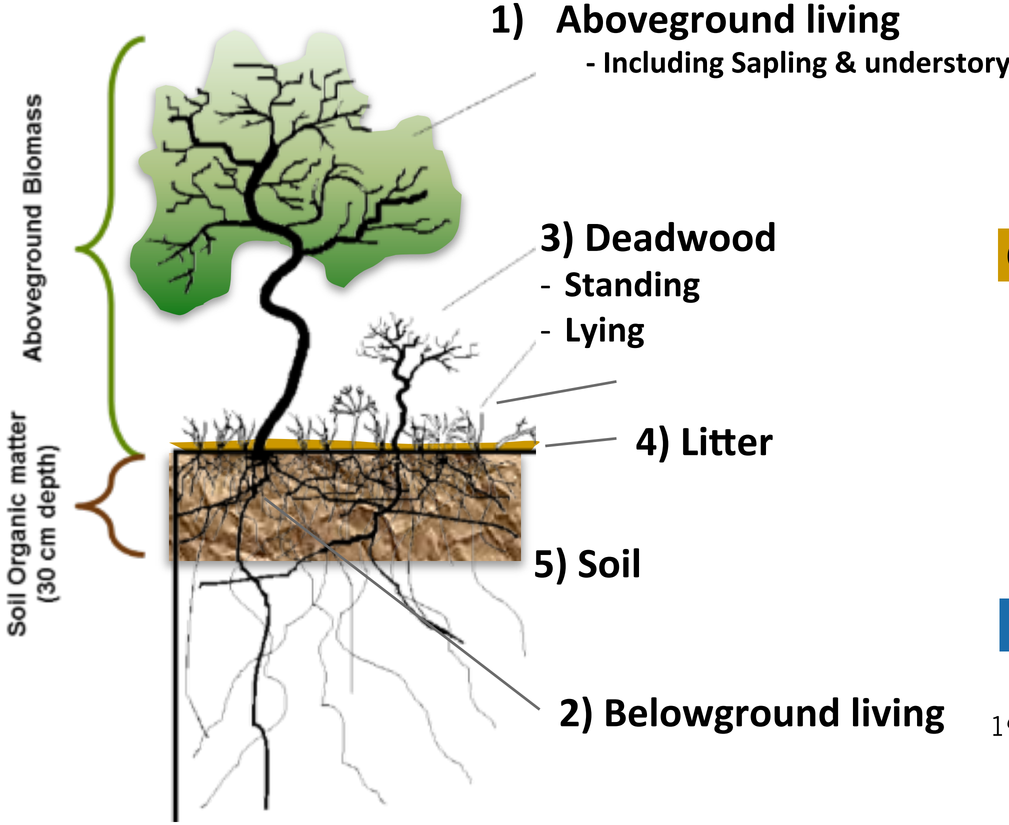
Carbon stock in all carbon pools ($Mg\ C\ ha^{-1}$)



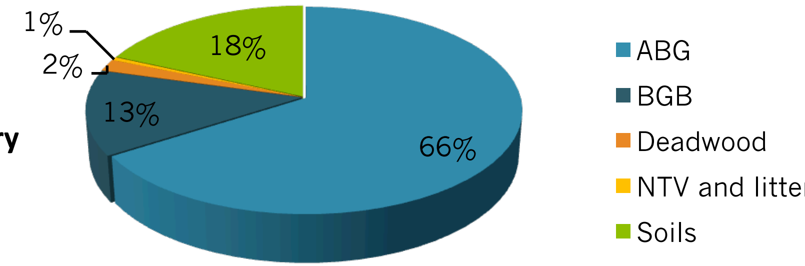
	ABG	BGB	Deadwood	NTV and litter	Soils	TOTAL CARBON
Inland	174.49	35.22	4.92	1.29	48.40	264.32
Peatswamp	168.63	35.95	21.40	2.19	188.1	416.27
Mangrove	135.45	48.57	22.12	3.88	46.02	256.04



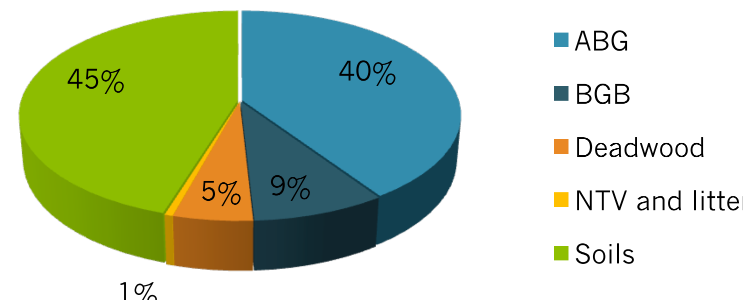
Proportion of carbon pools



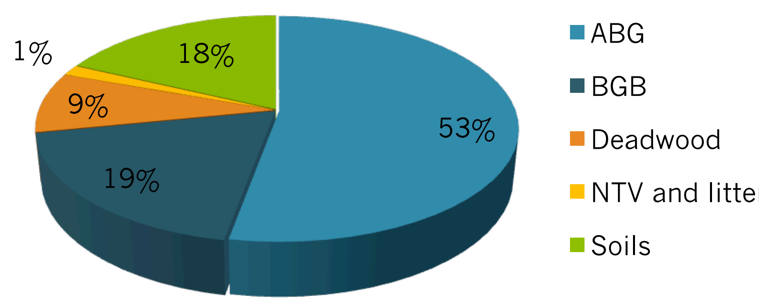
Carbon pools in Inland Forest



Carbon pools in Peatswamp Forest



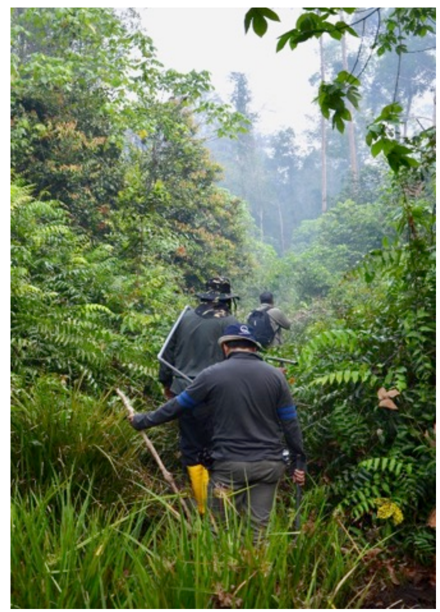
Carbon pools in Mangrove Forest

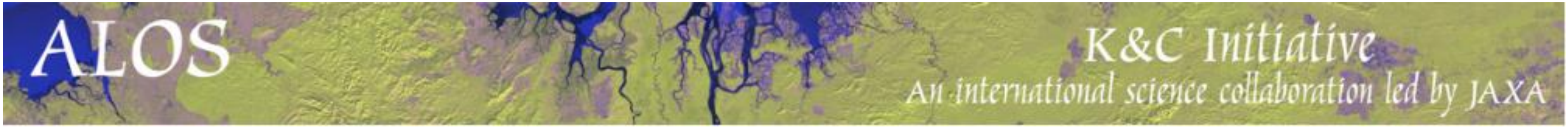


Fieldwork

Lowland Dipterocarp Forest


Fieldwork
Peat Swamp Forest

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Fieldwork
Mangrove Forest


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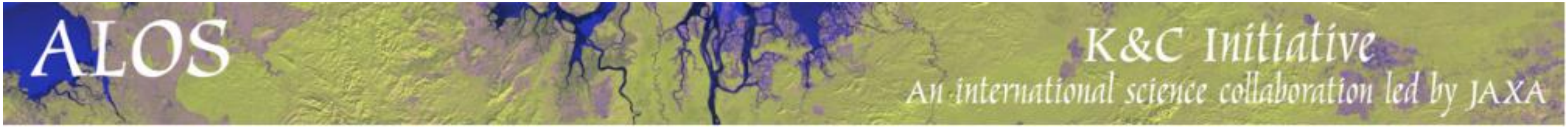
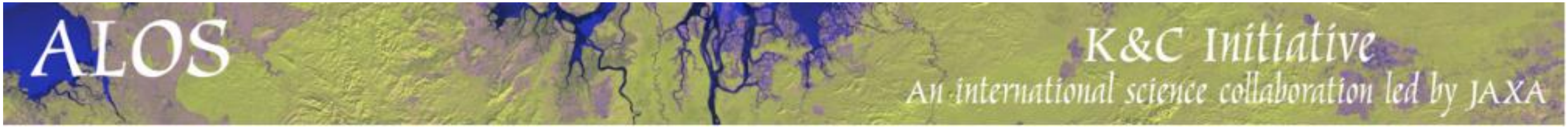


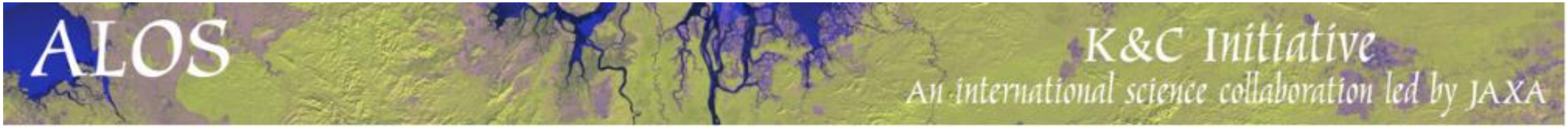
Changes of forest cover and rate of deforestation between years 2007 and 2015

Forest type *Jenis hutan*	Year *Tahun*			Deforestation *Kehilangan hutan* (ha)	Rate of deforestation *Kadar kehilangan hutan*	
	2007 (ha)	2010 (ha)	2015 (ha)		(ha yr^{-1})	(% yr^{-1})
Inland *Darat*	5,720,317	5,690,816	5,525,034	195,284	24,410	0.43
Peat swamp *Paya gambut*	298,763	290,038	264,578	34,185	4,273	1.43
Mangrove *Paya laut*	118,636	115,181	106,198	12,438	1,555	1.31
TOTAL ***JUMLAH***	**6,137,716**	**6,096,035**	**5,895,810**	**241,906**	**30,238**	**0.49**



Categories of land uses that have been converted from the forested areas from 2007 to 2015

Land use category *Kategori guna tanah*	Area *Keluasan* (ha)	Percentage area *Peratusan keluasan* (%)
Water body *Badan air*	8,745	3.6
Oil palm plantation *Ladang kelapa sawit*	142,790	59.0
Rubber plantation *Ladang getah*	34,936	14.4
Agricultural land *Kawasan pertanian*	22,095	9.1
Urban areas *Kawasan bandar*	14,858	6.1
Others *Lain-lain*	18,481	7.6
TOTAL ***JUMLAH***	**241,907**	**100**



Summary of carbon loss and emission of CO_2 resulting from deforestation from 2007 to 2015

Land use category *Kategori guna tanah*	Carbon loss *Kehilangan karbon* (Mg C)	CO_2 emission *Pelepasan CO_2* (Mg CO_2)	Percentage *Peratusan* (%)	Rate of emission *Kadar pelepasan* (Mg CO_2 yr^{-1})
Water body *Badan air*	230,454	844,998	3.6	105,625
Oil palm plantation *Ladang kelapa sawit*	3,097,950	11,359,150	48.6	1,419,894
Rubber plantation *Ladang getah*	883,840	3,240,747	13.9	405,093
Agricultural land *Kawasan pertanian*	537,900	1,972,300	8.4	246,538
Urban areas *Kawasan bandar*	509,255	1,867,268	8.0	233,409
Others *Lain-lain*	1,109,490	4,068,130	17.4	508,516
TOTAL ***JUMLAH***	**6,368,889**	**23,352,593**	**100.0**	**2,919,074**

Calculation of net emission

$$Ct = \sum (AD \times EF)$$

Ct = carbon loss in time t (Mg C)
AD = area undergoing a specific type of land use change (ha)
EF = emission factor, (Mg C ha^{-1})

Carbon emission (Mg CO_2) = Carbon Loss (Mg C) * (44/12)

Emission Factor (EF)

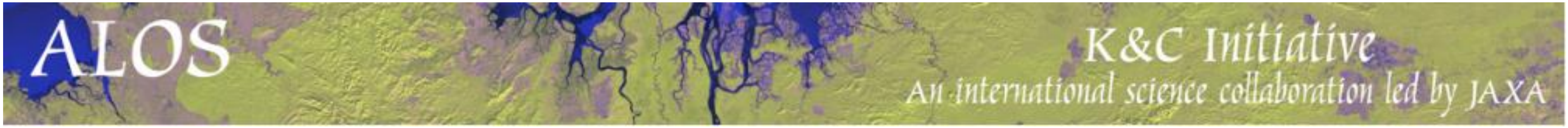
Land use classes	Carbon stock ($Mg\ C\ ha^{-1}$)	Conversion of forest to	Emission factor ($Mg\ C\ ha^{-1}$)
Forest	**186**	Forest	0
Oil palm	36	Oil palm	150
Rubber	58	Rubber	128
Urban area	7	Urban area	179
Agriculture	54	Agriculture	132
Water body	0	Water body	186
Mine and quarry	0	Mine and quarry	186
Grassland	3	Grassland	183
Animal Husbandry	3	Animal Husbandry	183
Cleared land	0	Cleared land	186

Source: Agus, F., Henson, E. I., Sahardjo, H. B., Harris, N., Noordwijk, V.M., Killeen, J. T. (2014). Review of emission factors for assessment of CO2 emission from land use change to oil palm in Southeast Asia. Report from the technical panels of the 2nd Greenhouse Gas Working Group of the Roundtable on Sustainable Palm Oil (RSPO)

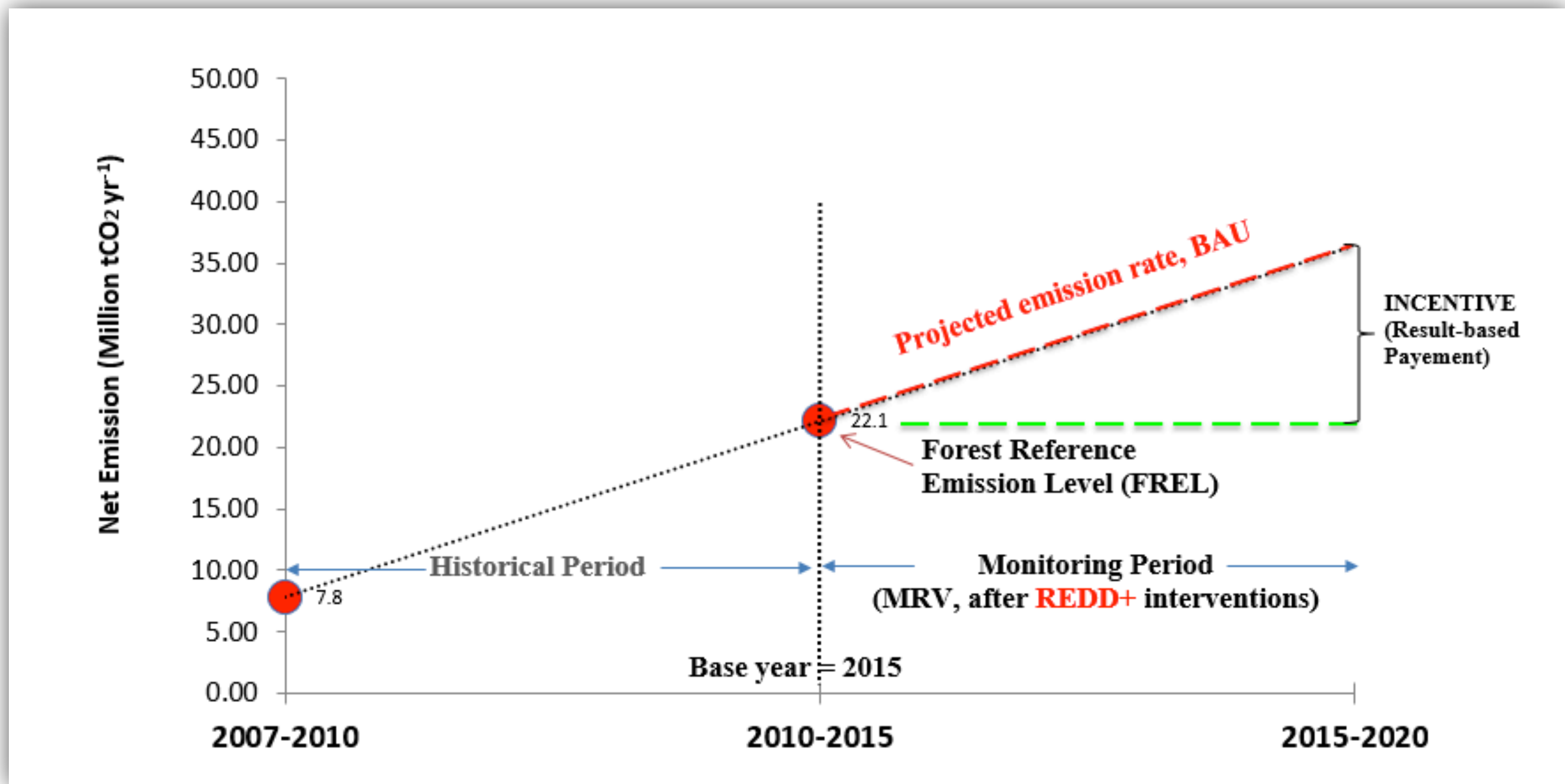
Carbon loss and emission of CO_2 resulted from deforestation in years 2007, 2010 and 2015

Landuse Category	Changes 2007-2010 (ha)	Carbon loss 2007-2010 (Mg C)	CO_2 emission 2007-2010 (Mg CO_2)
WATER BODY	1,239	230,454	844,998
OIL PALM	20,653	3,097,950	11,359,150
RUBBER	6,905	883,840	3,240,747
AGRICULTURE	4,075	537,900	1,972,300
URBAN	2,845	509,255	1,867,268
OTHERS	5,965	1,109,490	4,068,130
Total	41,682	6,368,889	23,352,593
		Total (Mg CO_2)	**23,352,593**
		Rate of emission (MgCO_2 yr^{-1})	**7,784,198**

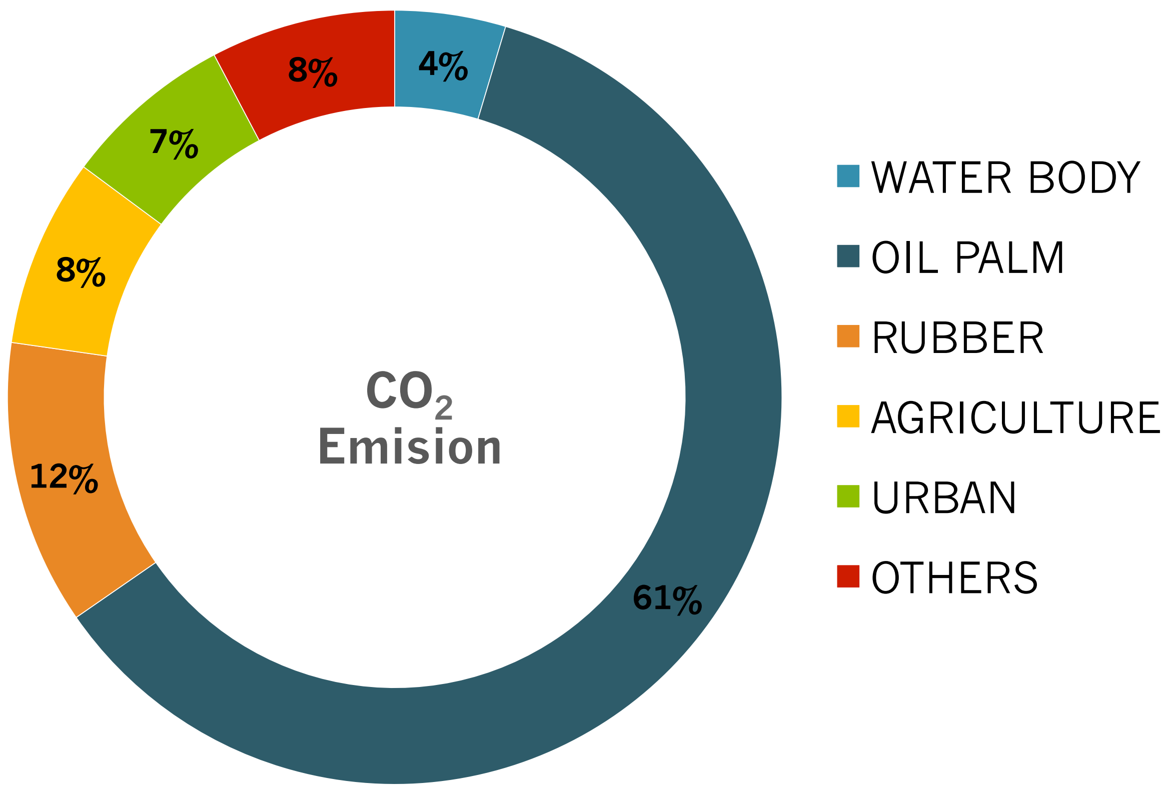
Landuse Category	Changes 2010-2015 (ha)	Carbon loss 2010-2015 (Mg C)	CO_2 emission 2010-2015 (Mg CO_2)
WATER BODY	7,506	1,396,116	5,119,092
OIL PALM	122,137	18,320,555	67,175,367
RUBBER	28,031	3,588,026	13,156,094
AGRICULTURE	18,020	2,378,669	8,721,785
URBAN	12,013	2,150,413	7,884,846
OTHERS	12,516	2,328,062	8,536,228
Total	200,225	30,161,840	110,593,412
		Total (Mg CO_2)	**110,593,412**
		Rate of emission (MgCO_2 yr^{-1})	**22,118,682**

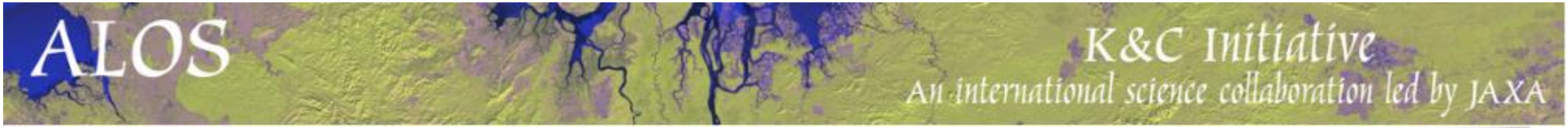


Forest Reference Emission Level (FREL) in Peninsular Malaysia



Emission of CO_2 resulted from deforestation between 2010 and 2015





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ORIGINAL ARTICLE

QUANTIFYING RATE OF DEFORESTATION AND CO_2 EMISSION IN PENINSULAR MALAYSIA USING PALSAR IMAGERIES

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ABSTRACT

Increasing human population and the rapid growth of Malaysia's economy are often associated with various environmental disturbances, which have been contributing to depletion of natural resources and climate change. The need for more spaces for numerous land development activities has made the existing forests suffer from deforestation. This study was carried out in Peninsular Malaysia, which currently has about 5.9 mil. ha of forests. Phased array type L-band SAR (PALSAR) and PALSAR-2 images over the years 2010 and 2015 respectively were used to identify forest cover and deforestation occurrences resulting from various conversions of forests to other land uses. Forests have been identified from horizontal-vertical (HV) polarization and then classified into three major categories, which are inland, peat swamp and mangrove. The pixel subtraction technique was used to determine areas that have been changing from forests to other land uses. Forest areas were found to have declined from about 6.1 mil. ha in 2010 to some 5.9 mil. ha in 2015 due to conversion of forests to other land uses. Causes of deforestation have been identified and the amount of carbon dioxide (CO_2) that has been emitted due to deforestation activity has been determined in this study. Oil palm and rubber plantations expansion has been found to be the most prominent factor that caused deforestation in Peninsular Malaysia, especially in the states of Pahang, Terengganu, Johor and Kelantan. The rate of deforestation in the period was at 0.66% yr^{-1}, which amounted a total of about 200,225 ha over the five years. Carbon loss was estimated at about 30.2 mil. Mg C, which resulted in CO_2 emission accounted at about 110.6 million Mg CO_2. The rate of CO_2 emission that has resulted from deforestation was estimated at 22.1 million Mg CO_2 yr^{-1}. This study found that the use of a series of PALSAR and PALSAR-2 images are the most appropriate sensors to be used for monitoring of deforestation over the Peninsular Malaysia region.

Keywords: *Deforestation; carbon loss; agricultural crops; climate change.*

1. INTRODUCTION

In Malaysia, forest is defined as land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 30%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010). Major forest types in Malaysia are lowland dipterocarp, hill dipterocarp, upper hill dipterocarp, montane, ericaceous, peat swamp and mangrove forests. In addition, there also smaller areas of freshwater swamp forest, heath forest, forest on limestone and forest on quartz ridges. Currently there are about 5.89 mil. ha of forest occur in Peninsular Malaysia, which covers about 44.7% of its land area. Out of this, 4.92 mil. ha falls under Permanent Reserved Forest (PRF), 0.58 mil. ha is Totally Protected Area (TPA) and the remaining 0.39 mil. ha belongs to state/alienated land (FDPM, 2015).

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Abstract No: A-177

COMBINATION OF PALSAR-2 AND SPOT-6 IMAGES FOR ESTIMATING ABOVEGROUND BIOMASS OF PEAT SWAMP ECOSYSTEM IN MALAYSIA

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SUMMARY

Aboveground biomass (AGB) is one of the key parameters important for carbon accounting in a forest ecosystem. However, estimating this parameter by using remote sensing approach has been challenging as it is constrained by various limitations, especially in tropical region. Spaceborne optical and radar systems have the potential in obtaining AGB reliable estimates but several issues such as cloud cover, dense and complex stand structure, and saturation of signals at certain biomass level still remain unanswered. Peat swamp forest, one of the forest types in Malaysia, is centric as it known to store a large amount of biomass carbon and plays a significant role in balancing terrestrial carbon cycle. A study was conducted to investigate the possibility of combining both optical and radar to improve accuracy of AGB estimation in the peat swamp forest. Optical Satellite Pour l'Observation de la Terre (SPOT-6) and Phased Array type L-band Synthetic Aperture Radar (PALSAR-2) data that have been acquired in year 2015 were used in this study. Peat swamp forest in Pekan, Pahang which is the biggest patch of peat swamp forest in Peninsular Malaysia was selected as the study area. It covers 107,203 ha comprised entirely of peat swamp forest. A number of sample plots were established on the ground and the AGB was measured. Regression models were produced correlating the measured AGB and several variables derived from both satellites data. The study found that the best performing regression model was from the combined modified vegetation-water index (MVWI) with horizontal-vertical (HV) polarized backscatter. The combination of optical and radar systems data has countered limitations of each other and improved the estimate. This approach was therefore suggested to obtain better accuracy in estimating AGB in a large area of peat swamp forest.

Keywords*: Peat ecosystem, aboveground biomass, remote sensing*

INTRODUCTION

Peat swamp forest and its ecosystem play a significant role in the climate change because they serve as sinks of carbon and store carbon more compared to other forests. Due to the rising climate change issue, the information on peat swamp forest is become vital. There are also interest and rapidly increasing need on carbon stocks (and CO_2) information at a national level in line with international initiatives such as Kyoto Protocol (1997), Reducing Emissions from Deforestation and Forest Degradation and forest conservation (REDD+) (2007), host by United Nations Framework Convention on Climate Change (UNFCCC) and national policies related to climate change (National Forestry Policy (1978), National Energy Policy (1979), National Policy on Biodiversity (1998), National Policy on Environment (2002). Among others, REDD+ program is now is attracting most attentions from the governments including Malaysia.

However, the question of how to measure carbon stock in the forests as well as carbon emissions resulted from the deforestation are crucial and should be answered before the REDD+ can be implemented. There is a tradeoff between the cost and the accuracy of the methods. In some countries, the need for a high level of precision requires the use of fine-resolution remote sensing imagery (e.g. to detect forest degradation or small-scale deforestation), imagery repeated over time (e.g. to overcome cloud cover limitations) or imagery that requires significant expertise to process (e.g. analyzing radar images), all of which come at a cost. Similarly, ground measurements, crucial to verify and measure carbon stocks, are time consuming and relatively expensive at a large scale, such as a national inventory (Gibbs *et al.* 2007).This project is therefore proposed as an initial idea to examine the use of remote sensing technology in providing carbon stock information with optimized cost and accuracy.

In many parts of the world, especially in tropical region, the frequent cloud conditions often restrain the acquisition of high-quality remotely sensed data by optical sensors. The acquisition of cloud-free, wall-to-wall optical satellite images in tropical countries is almost impossible (Hamdan *et al.* 2014a). Thus, synthetic aperture radar (SAR) data become the only feasible way of acquiring remotely sensed data within a given timeframe because the SAR systems are independent of cloud coverage, weather and light conditions. Due to this unique feature

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Quantifying rate of deforestation and CO_2 emission in Peninsular Malaysia using Palsar imageries

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Abstract. Increasing human population and the rapid grows of Malaysia's economy are often associated with various environmental disturbances which have been contributing to depletion of natural resources and climate change. The need for more spaces for numerous land development activities has made the existing forests suffer deforestation. The study was carried out in Peninsular Malaysia, which currently has about 5.9 million ha of forests. Phased array type L-band SAR (Palsar) and Palsar-2 images over the years 2010 and 2015, respectively were used to identify forest cover and deforestation occurrences resulted from various conversion of forests to other land uses. Forests have been identified from horizontal-vertical (HV) polarization and then classified into three major categories, which are inland, peat swamp and mangrove. Pixel subtraction technique was used to determine areas that have been changing from forests to other land uses. Forest areas have been found declined from about 6.1 million ha in year 2010 to some 5.9 million ha in 2015 due to conversion of forests to other land uses. Causes of deforestation have been identified and the amount of carbon dioxide (CO_2) that has been emitted due to deforestation activity has been determined in this study. Oil palm and rubber plantations expansion has been found the most prominent factor that caused deforestation in Peninsular Malaysia, especially in the states of Pahang, Terengganu, Johor and Kelantan. The rate of deforestation in the period was at 0.66 % yr^{-1}, which amounted a total of about 200,225 ha over the five years. Carbon loss was estimated at about 30.2 million Mg C, which has resulted in CO_2 emission accounted at about 110.6 million Mg CO_2. The rate of CO_2 emission that has resulted from deforestation was estimated at 22.1 million Mg CO_2 yr^{-1}. The study found that the use of a series of Palsar and Palsar-2 images are the most appropriate sensors to be used for monitoring of deforestation over the Peninsular Malaysia region.

1. Introduction

In Malaysia, forest is defined as land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 30 %, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use [1]. Major forest types in Malaysia are lowland dipterocarp, hill dipterocarp, upper hill dipterocarp, montane, ericaceous, peat swamp and mangrove forests. In addition, there also smaller areas of freshwater swamp forest, heath forest, forest on limestone and forest on quartz ridges. Currently there are about 5.89 million ha of forest occur in Peninsular Malaysia, which covers about 44.7% of its land area. Out of this, 4.92 million ha falls under Permanent Reserved Forest (PRF), 0.58 million ha is Totally Protected Area (TPA) and the remaining 0.39 million ha belongs to state/alienated land [2].

Forests play an important role as a substantial coastal carbon sink. It is interesting to note that plant biomass in the ocean and coastal areas comprise of only 0.05% of the total plant biomass on land, get it cycles a comparable amount of carbon each year. Forests account for a large percentage of carbon fixing of about 80% of plant biomass carbon and 40% of the soil carbon [3]. Carbon sequestration results from

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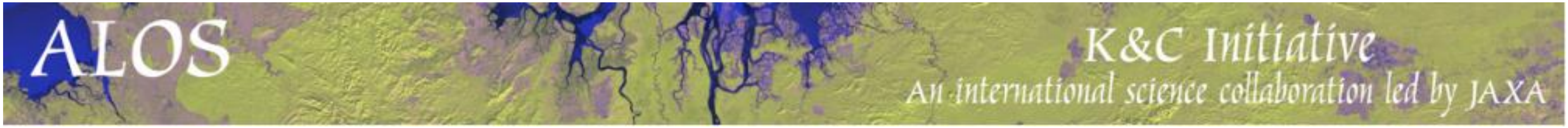

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MediaTitle	Harian Metro		
Date	14 Jun 2016	Color	Full Color
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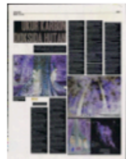
Page No	7	Readership	3,812,000
Language	Malay	ArticleSize	694 cm²
Journalist	Nor Hanisah Kamaruzaman	AdValue	RM 27,235
Frequency	Daily	PR Value	RM 81,705



UKUR KARBON DIOKSIDA HUTAN

Kajian kumpulan penyelidik FRIM hasilkan 11 penerbitan, menang 6 anugerah

Nor Hanisah Kamaruzaman
rencana@hmetro.com.my

Hutan tropika yang dimiliki Malaysia menyimpan sejumlah besar stok karbon berbanding hutan jenis lain di dunia.

Terkini, Malaysia mempunyai 18.056 juta hektar hutan, iaitu 5.831 juta hektar di Semenanjung, 4.430 juta hektar di Sabah dan jumlah terbesar 7.795 juta hektar di Sarawak.

Majoriti hutan kita daripada tiga jenis iaitu Hutan Dipterokarpa, Hutan Paya Laut dan Hutan Paya Gambut.

Stok karbon adalah perkara utama membabitkan isu perubahan iklim dan dikenal pasti sebagai 'Essential Climate Variable' (ECV) oleh Pertubuhan Bangsa-Bangsa Bersatu Mengenai Konvensyen Kerangka dan Perubahan Cuaca (UNFCCC) yang perlu dikur dan dinilai.

Ini kerana hutan menyumbang dan membantu menyimpan pelepasan karbon dioksida (CO2) yang terhasil daripada penebangan hutan dan penghapusan tapak hutan untuk tujuan pembangunan yang menjadi punca pemanasan global dan menjurus kepada perubahan iklim.

Mengambil inisiatif itu, kumpulan penyelidik daripada Bahagian Perhutanan dan Alam Sekitar, Institut Penyelidikan Perhutanan Malaysia (FRIM) diketuai Dr Hamdan Omar mula menjalankan penyelidikan mengukur jumlah karbon dioksida.

Dr Hamdan berkata, penyelidikan yang bermula pada 2012 itu menggunakan dua jenis pengumpulan data iaitu data satelit dan lapangan.

"Data satelit kami peroleh dengan kerjasama Japan Aerospace iaitu organisasi satelit dari Jepun menggunakan satelit aktif yang dikuasakan radioaktif dan sistem radar yang mampu menembusi awan," katanya.

Menurutnya, pengumpulan data lapangan dilakukan di hutan menggunakan pengiraan yang dirumuskan sendiri dan kiraan karbon diokisida diukur dengan berat perhektar.

"Penyelidikan kami bermula dari kawasan hutan FRIM di Kepong dengan keluasan sekitar 540 hektar.

"Apabila pengumpulan data satelit dan pengiraan data lapangan stabil, kami luaskan pengiraan ke seluruh Semenanjung dan kini kandungan karbon dioksida di hampir semua hutannya sudah dicatatkan," katanya.

Katanya, kadar yang baik ialah 200 tan karbon dioksida perhektar hutan dan hasil kajian di Semenanjung mendapati secara purata hutan di Malaysia mempunyai kira-kira 190 tan karbon dioksida perhektar.

Hutan di FRIM antara terbaik dengan menyimpan sekitar 300 tan karbon dioksida perhektar setanding dengan hutan simpan lain di Semenanjung.

Dr Hamdan berkata, jumlah karbon dioksida yang tinggi menunjukkan hutan berkenaan menyimpan banyak pokok besar dan berusia lama.

"Kita dapat lihat jumlah karbon dioksida tinggi terutama pada kawasan hutan yang menyimpan pokok lama dan besar manakala jumlah rendah dari hutan yang 'diusik' atau hutan yang ditebang," katanya.

Hasil kajian kumpulan Dr Hamdan sudah menghasilkan 11 penerbitan dalam beberapa jurnal dan memenangi enam anugerah.

Katanya, penyelidikan bakal diteruskan di Sabah dan Sarawak bermula Julai ini dan dijangka mengambil masa dua tahun.

"Kita mulakan pengumpulan data dan mengukur jumlah karbon dioksida di Sarawak pada Julai ini.

"Kami bakal meneroka hutan jenis lain seperti Hutan Gunung dan Hutan Gelam namun ia bakal mengambil masa kerana setiap hutan ada komposisi berbeza dan pengiraan juga berbeza," katanya.

ANUGERAH DITERIMA:

1. Best Scientific Achievement, Kyoto & Carbon Initiative, Japan Aerospace Exploration Agency, Jepun. 2015.

2. Pingat Perak, Pameran Rekacipta, Penyelidikan dan Inovasi 2014 (PRPi, 2014), UPM Serdang. Tajuk Kajian: L-Band Alos Palsar for Biomass Estimation of Forests in Malaysia.

3. Anugerah Penerbitan: Kategori Teknikal FRIM 2014. Tajuk artikel: Mangrove Carbon Stock assessment by Optical Satellite Imagery.

4. Anugerah Penerbitan: Kategori Teknikal FRIM 2012. Tajuk artikel: Remotely sensed L-Band SAR Data for Tropical Forest Biomass Estimation.

5. Best Research Award, FRIM, Malaysia. 2013. Tajuk Projek: Updating Forest Cover and Assessing Aboveground Biomass in Various Tropical Forest Ecosystems from Palsar-2 Polarizations.

6. 8-Bands Research Challenge Award, DigitalGlobe Æ Inc. USA. 2012.

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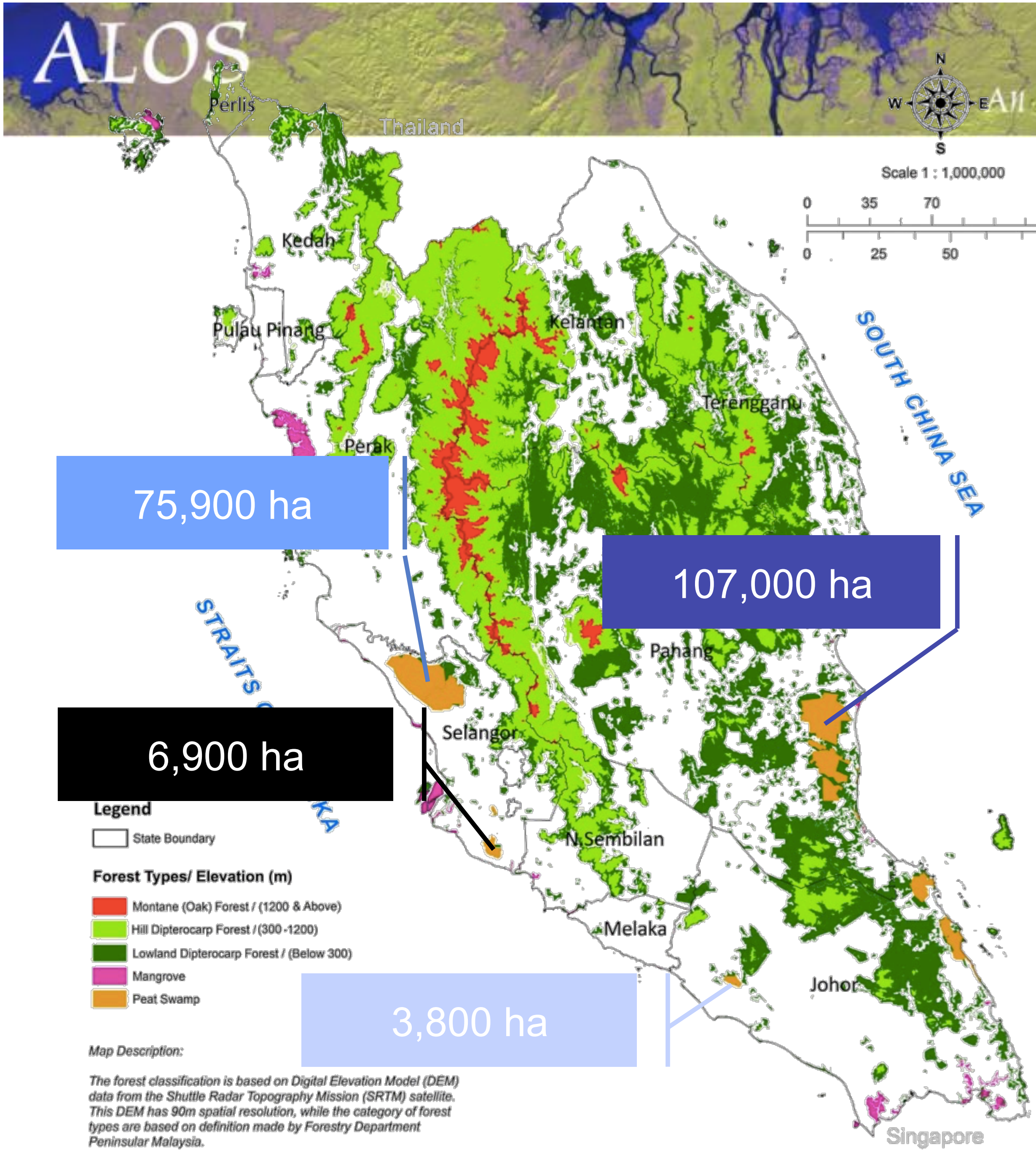
Palsar-2 + Optical SPOT-6 for biomass estimation on Peat Swamp Forest

- Peat swamp forest and its ecosystem play a significant role in the climate change because they serve as sinks of carbon and store carbon more compared to other forests.
- Malaysia has about 1.3 million ha of peat swamp forest and is keep depleting over years.
- Rapidly increasing need on carbon stocks (and CO_2) information at a national level in line with international initiatives – e.g. REDD+.
- However, the question of HOW? to measure and produce reliable information on carbon stock in this forest as well as carbon emissions resulted from the deforestation are crucial and should be answered before the REDD+ can be implemented.



Peat Swamp Forest in Malaysia

16%

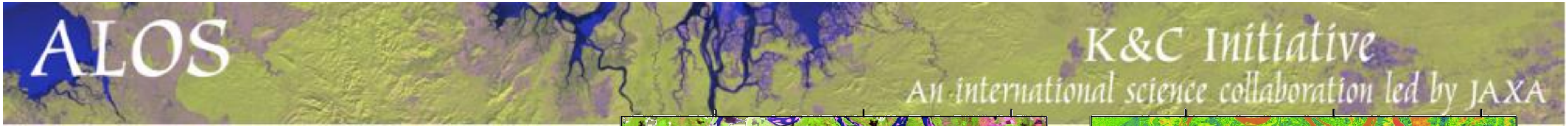
PENINSULAR MALAYSIA

About **300,000** ha
Mainly in Pahang, Selangor and Johor

84%

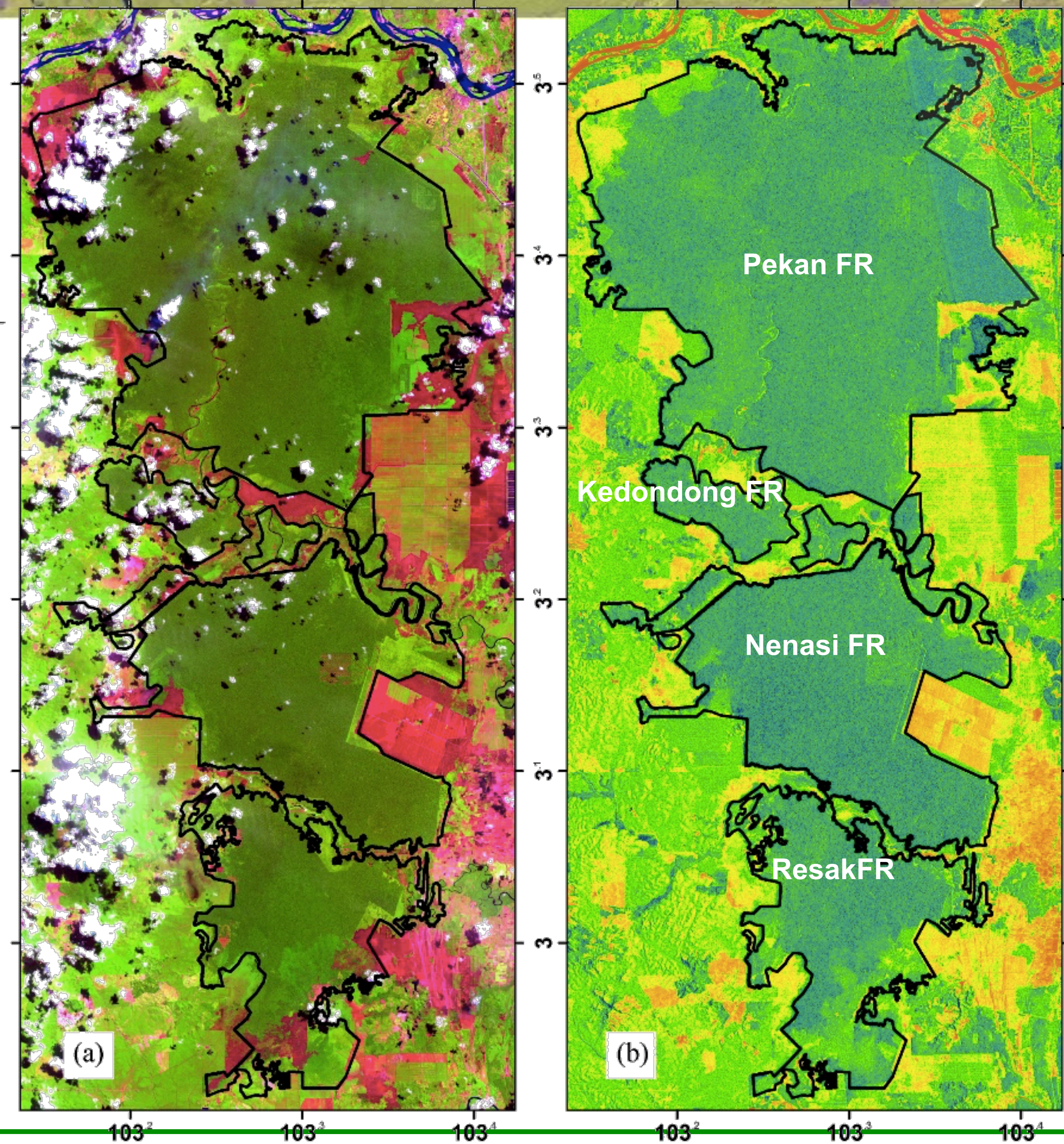
MALAY BORNEO

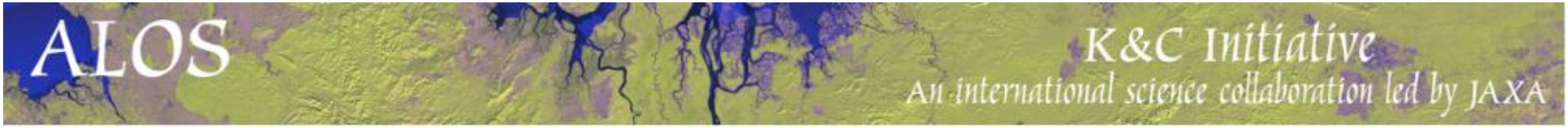
About **1.06 million** ha
Mainly in Sarawak



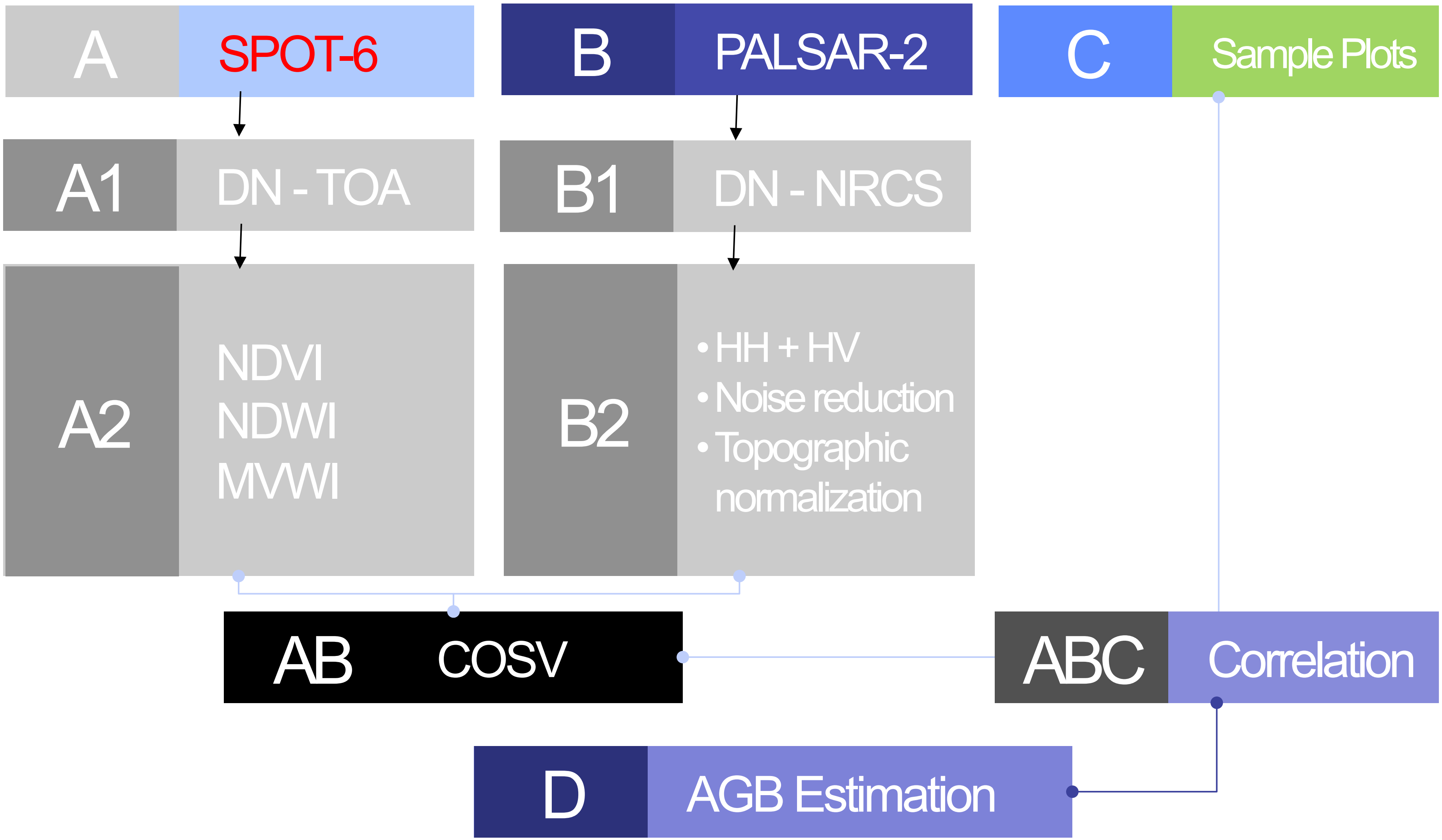
The study area

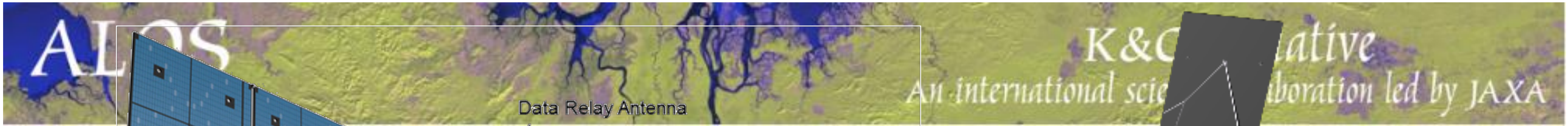
- The south-east Pahang peat swamp forest (SEPPSF), located at Pahang state is the largest peat swamp forest complex in Peninsular Malaysia
- It covers an area of 107,203 ha and comprises four Forest Reserves, namely Pekan, Kedondong, Nenasi and Resak.
- It harbors unique flora and fauna, provides benefits and services of national interest and supports the livelihood of the aborigines (Orang Asli) communities.

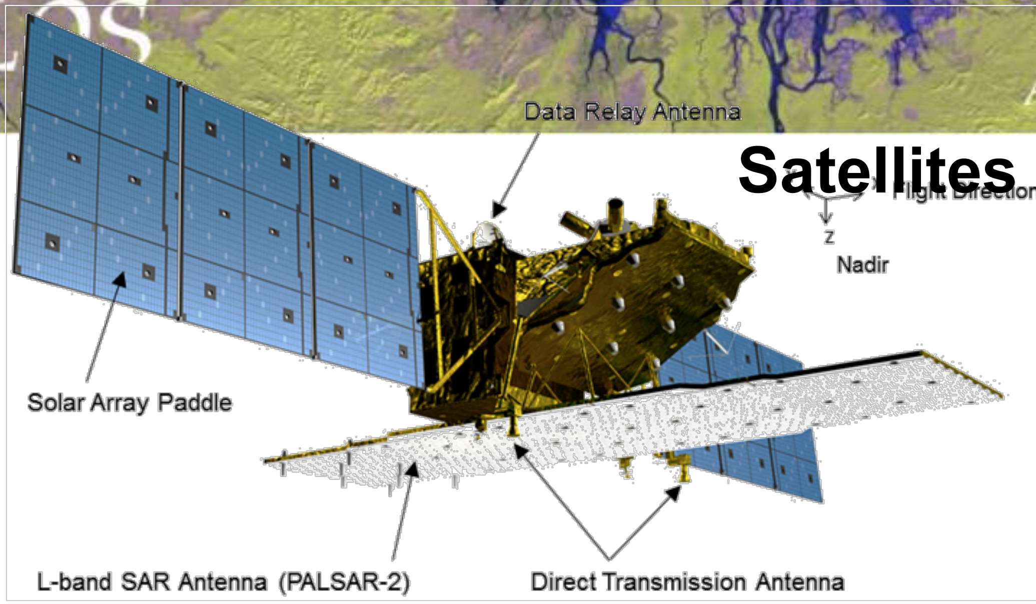




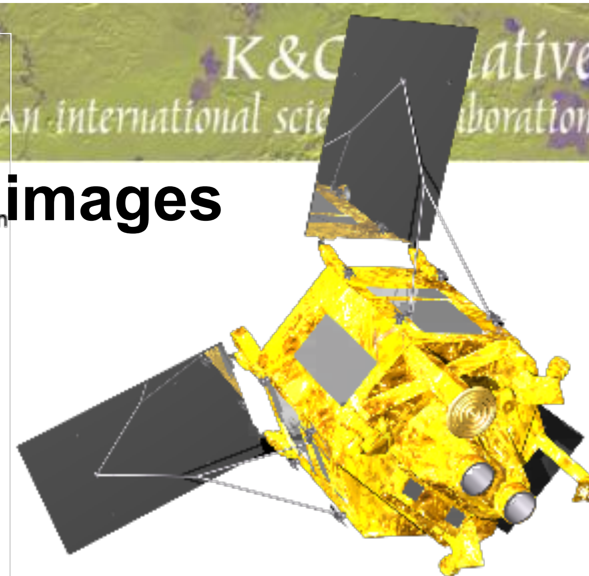
Methodology







Satellites images



SAR Data	
Satellite	Advance Land Observing Satellite (ALOS-2)
Sensor	Phased Array type L-band Synthetic Aperture Radar (PALSAR-2)
Wavelength	23.62 cm (1270 MHz)
Image Res.	6 m
Date of acq.	16 Oct 2015

Optical Data	
Satellite	SPOT-6
Sensor	High Resolution Geometric (HRG)
Band	Band 1; 0.50 – 0.59 µm, G Band 2; 0.61 – 0.68 µm, R Band 3; 0.79 – 0.89 µm, NIR Band 4; 1.58 – 1.75 µm, SWIR
Image Res.	5 m
Date of acq.	10 June 2015

Summary of image variables used in the AGB predictions

Image Variables	Formula	Description	Source
NDVI	$NIR-R/NIR+R$	Normalized Difference Vegetation Index. Related to changes in amount of green biomass, pigment content and concentration and leaf water stress etc.	Huete (1988)
NDWI	$NIR-SWIR/NIR+SWIR$	Normalized Difference Water Index is a remote sensing based indicator sensitive to the change in the water content of leaves.	Gao (1996)
HV	PALSAR-2 HV	HV backscatter of PALSAR-2 sensor in sigma-naught values (dB).	-
MVWI	NDVI × NDWI	Enhancement of normalized vegetation and water indices to extract plant component of peat swamp forest.	This study
COSV	$e^{(HV*MVWI)}$	Combination of indices derived from optical data with PALSAR-2 HV polarization to enhance forest height and biomass of peat swamp forest.	This study

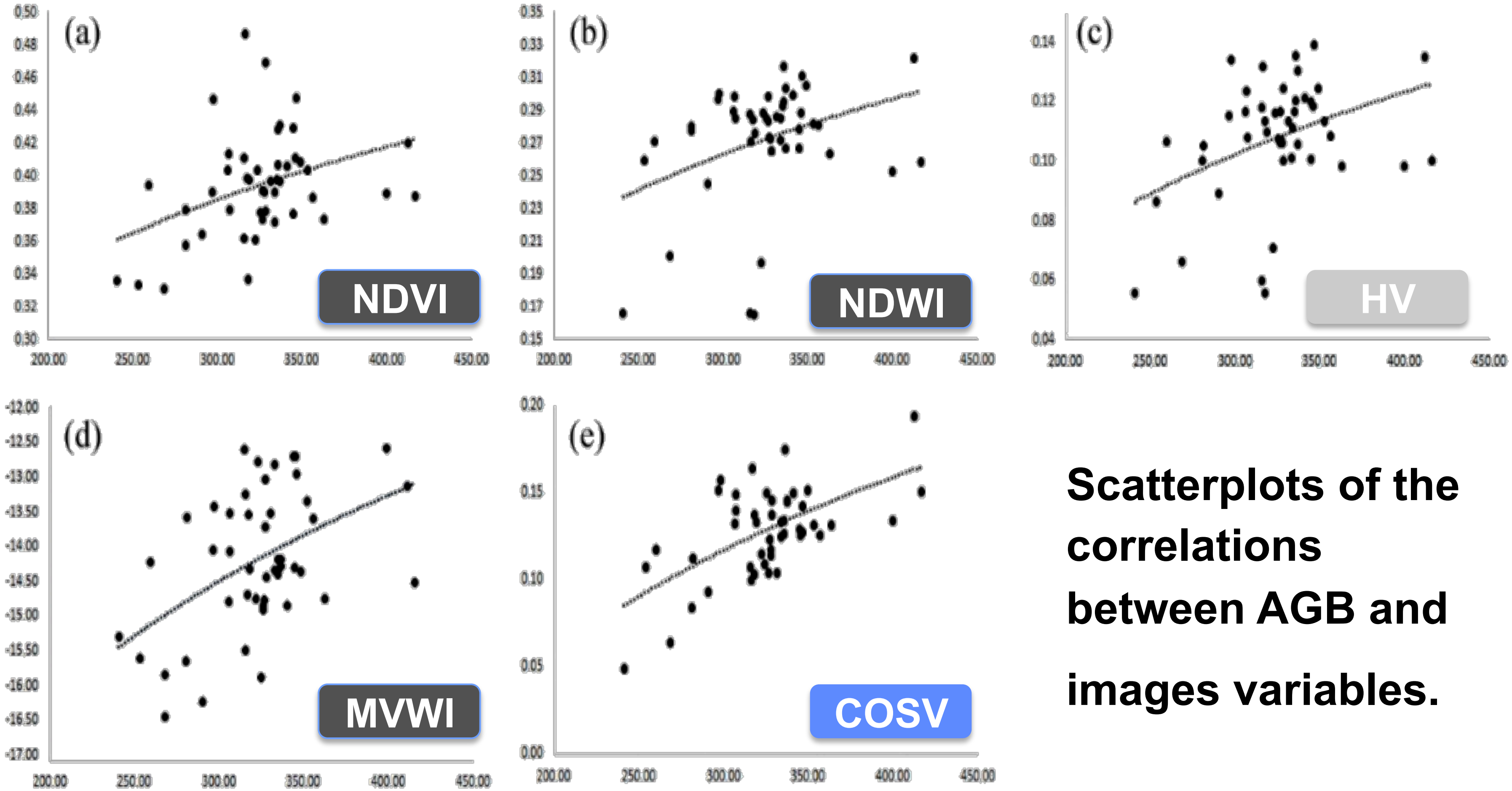
The model was generally written in logarithmic form as

$$y = a \times ln(x) + b$$

where y = AGB (Mg ha^{-1})
x = image variables

Image variables	Model coefficient		R^2	RMSE (Mg ha^{-1})
	a	b		
NDVI	0.11211	- 0.2536	0.1429	98.76
NDWI	0.11811	- 0.4123	0.1233	93.21
MVWI	0.07261	- 0.3117	0.1552	71.42
HV	4.29740	- 39.015	0.2257	62.70
COSV	0.14561	- 0.7136	0.3653	51.94

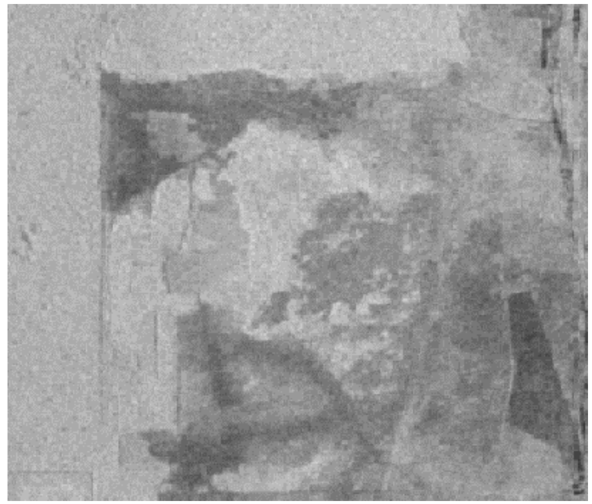
Correlation Analysis



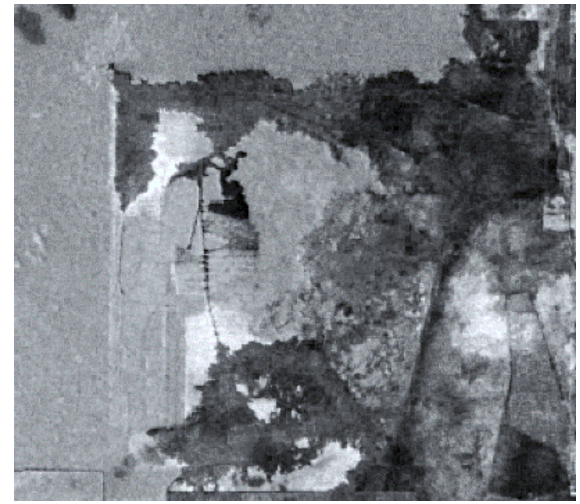
Scatterplots of the correlations between AGB and images variables.

Image variables that were used for AGB prediction

01 MVWI



02 HV Pol



03 COSV

The enhancement technique has produced an image with more pixel variations that were able to explain various conditions of vegetation composition on the ground

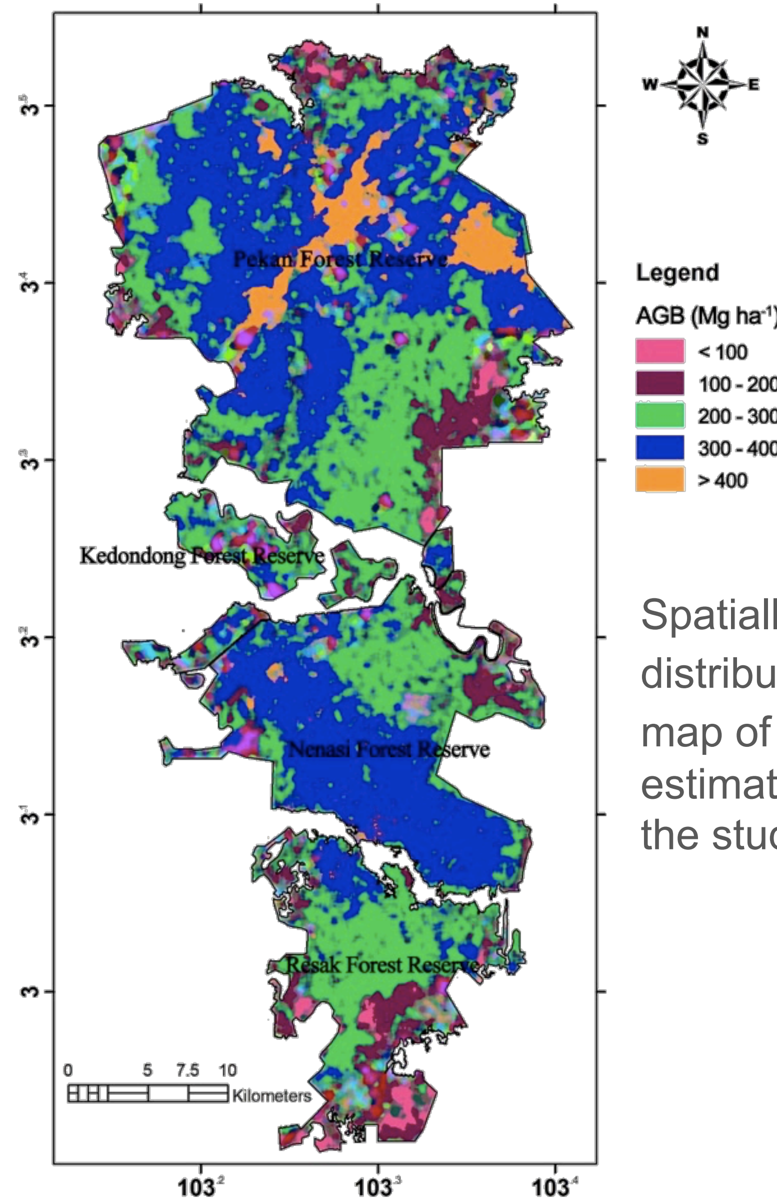
Spatially distributed map of AGB

68 to 583 Mg ha^{-1}

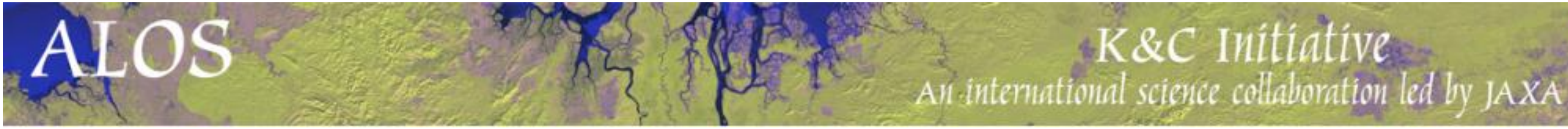
It was found that the AGB in the study area ranged from 68 to 583 Mg ha^{-1} with an average of 352.47±51.94 Mg ha^{-1}.

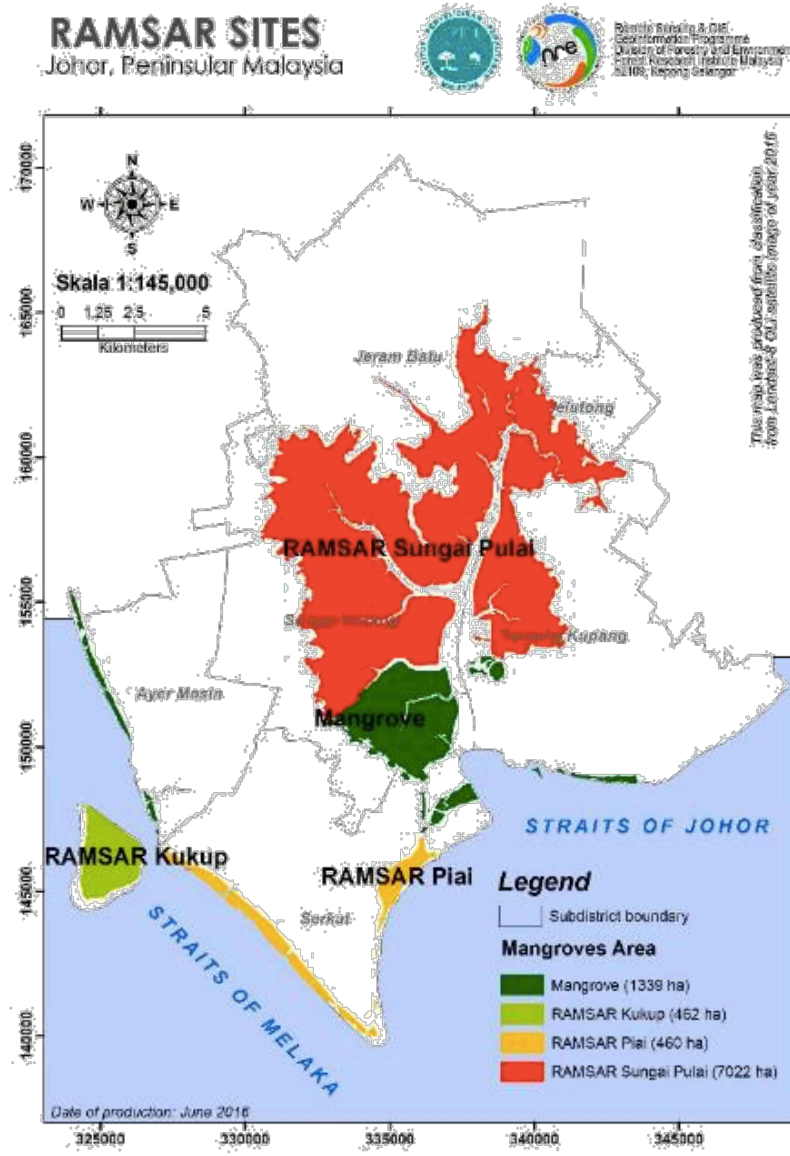
$352.47^{\pm 51.94}$ Mg ha^{-1}

From these figures, it was estimated that the total AGB stored in the study area was about **37,785,841 Mg**.



Spatially distributed map of AGB estimated in the study area

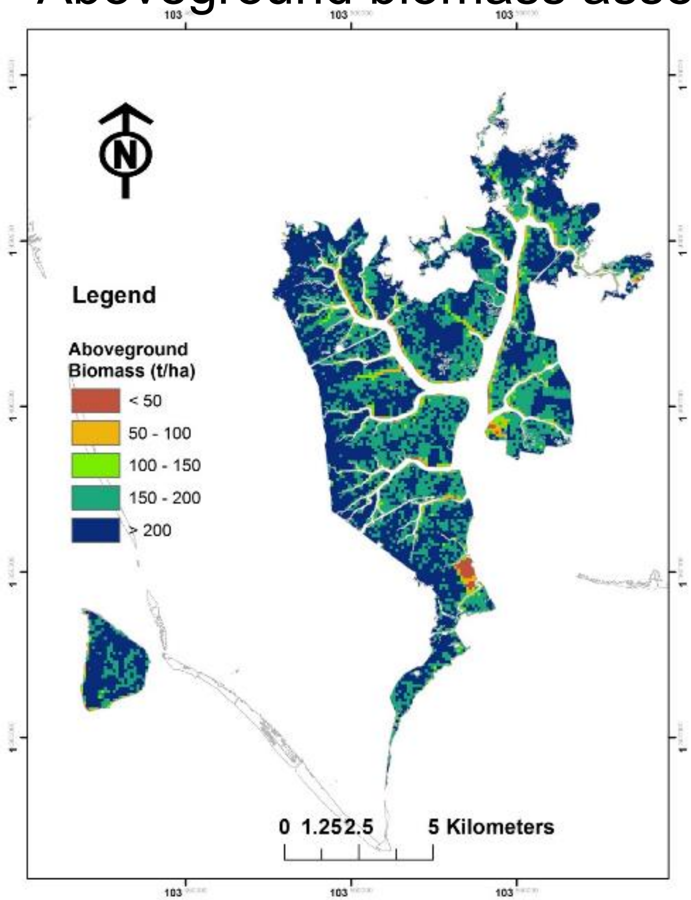

ALOS
K&C Initiative
An international science collaboration led by JAXA

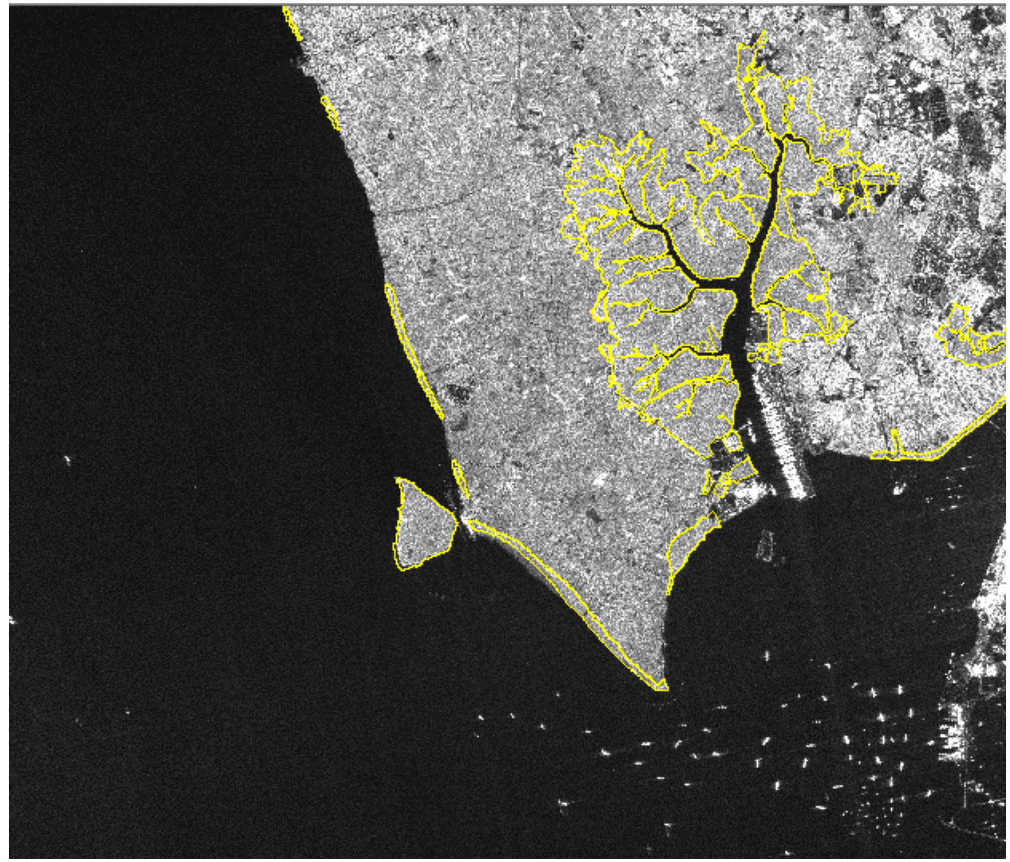

RAMSAR SITES
Johor, Peninsular Malaysia
Geoinformation Programme
Division of Forestry and Environment
Forest Research Institute Malaysia
52109, Kepong Selangor
N
W
E
S
Skala 1:145,000
0 1.25 2.5 5
Kilometers
This map was produced from classification from Landsat-8 OLI satellite image of year 2016
Jeram Batu
RAMSAR Sungai Pulai
Ayer Masin
Mangrove
RAMSAR Kukup
RAMSAR Piai
Serkat
STRAITS OF JOHOR
STRAITS OF MELAKA
Legend
Subdistrict boundary
Mangroves Area
Mangrove (1339 ha)
RAMSAR Kukup (462 ha)
RAMSAR Piai (460 ha)
RAMSAR Sungai Pulai (7022 ha)
Date of production: June 2016
170000
165000
160000
155000
150000
145000
140000
325000
330000
335000
340000
345000

Impact of erosion:

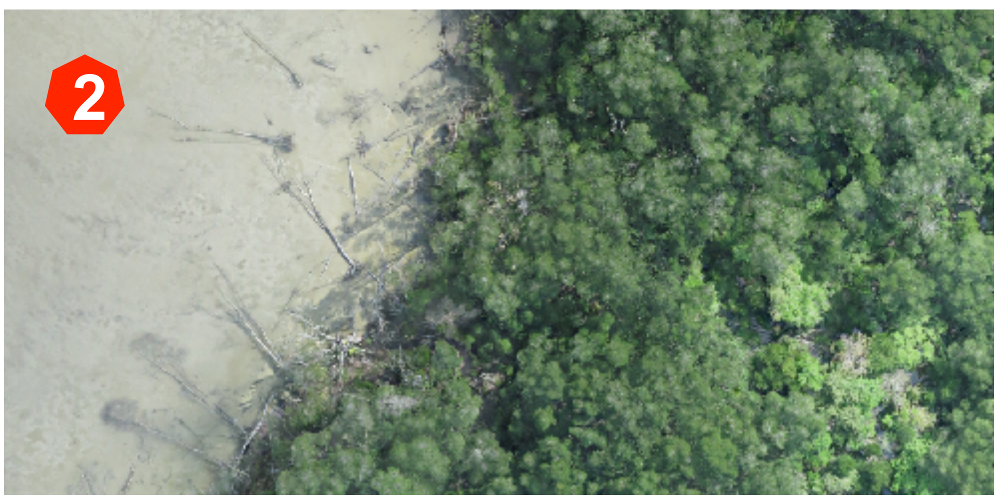
Replacement of SEA Tip monument

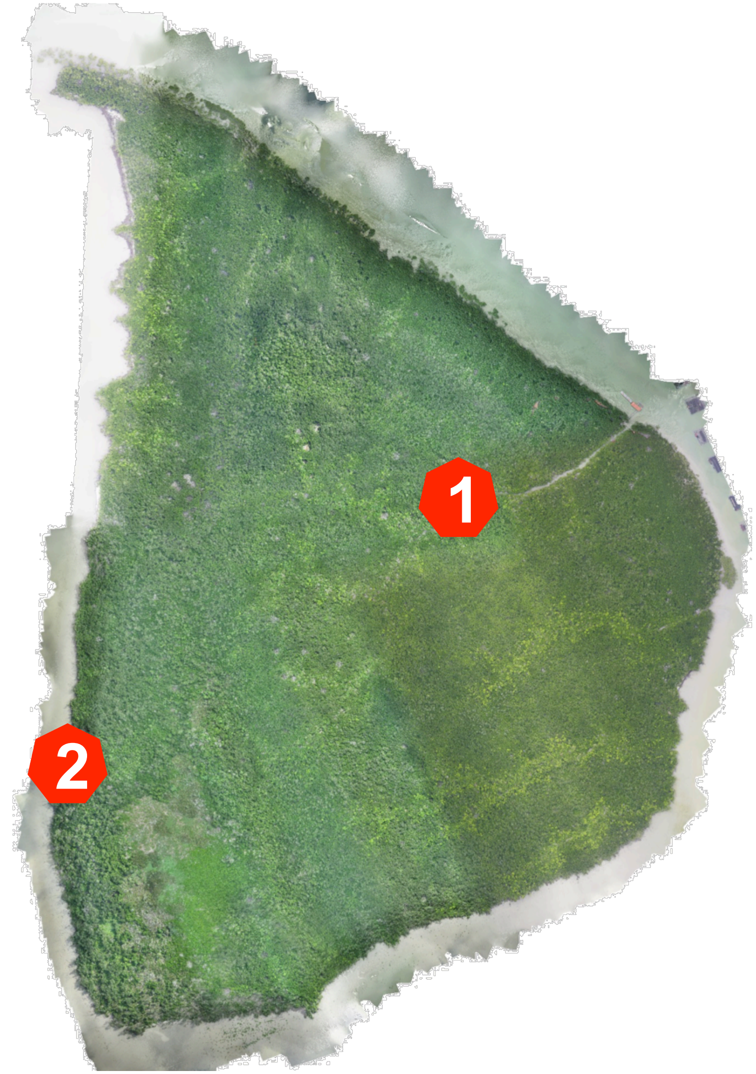
Aboveground biomass assessment using Palsar-2





Mangrove area	Extent (ha)	Biomass (Mg ha^{-1})			Total (Mg)
		Minimum	Maximum	Average	
Sg. Pulai & Kukup Island, Johor	8,636	28.48	484.17	39.29	1,792,032.90



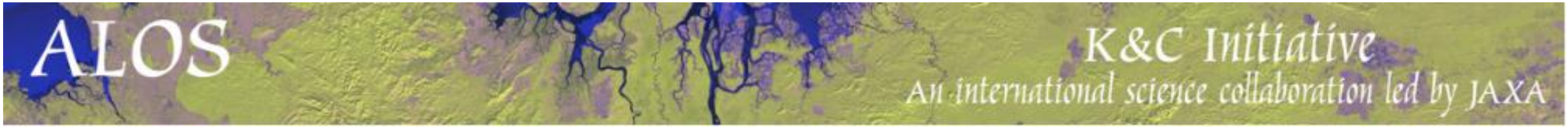


Data Acquisition using UAV

What's Next?

- **Validation of Biomass in the project sites by using Palsar-2 FBD (6m) and Ultrafine (3m) – 2015-2016**
- **Updating forest cover 2017 – Waiting for Mosaic product**
- **Integration of Palsar-2 with Sentinel-1A, Optical images & Lidar**
- **Publications***

*Journal of Applied Science: Special Issues on SAR Polarization, deadline 30 April 2017



Thank you

Terima kasih

ありがとうございます