An overview of remote sensing applications for agricultural mapping and monitoring in Malaysia

Land Use/Cover Changes, Environment and Emissions in South/Southeast Asia – An International Regional Science Meeting 2019

Helmi Zulhaidi Mohd Shafri and Nur Shafira Nisa Shaharum
Faculty of Engineering, UPM

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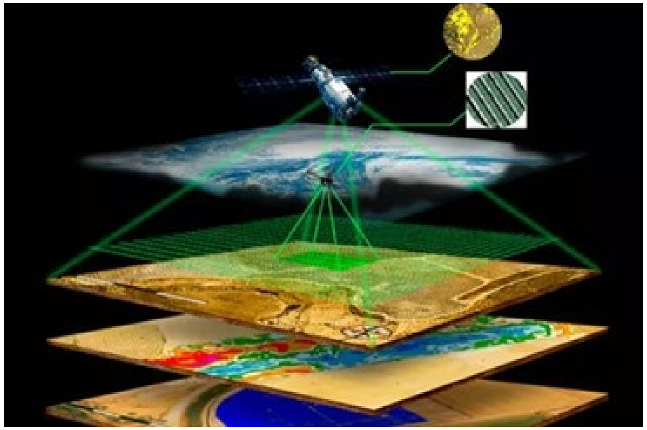


Introduction
Agriculture in Malaysia

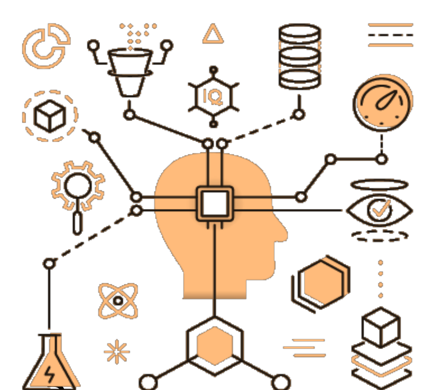
- Agriculture remains an important sector of Malaysia's economy:
  - contributing 12% to the national GDP
  - providing employment for 16% of the population
- Production and food crops
  - Oil palm, rubber, cocoa, paddy etc

Agriculture and Land Cover/Land Use Change

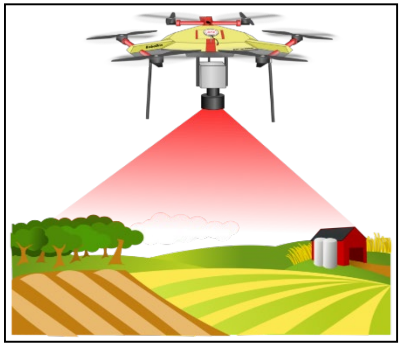
- Converting natural vegetation to agricultural land is likely to change the **radiation balance** of the given unit of area.
- **albedo increases** as land is without vegetation at least part of the year causing more solar energy to reflect back to the space.
- decrease in soil water-holding capacity. As natural vegetation is replaced by agriculture, soil porosity may be reduced by soil compaction, decreasing infiltration capacity and increasing the risks of **soil erosion**.
- Habitat and **biodiversity reduction**.

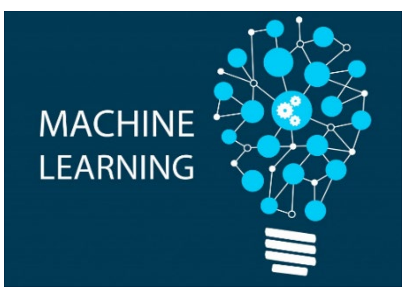
CHALLENGES

- Mapping
- Monitoring
- Pests and diseases
- Sustainability
- Production estimate
- Increase of cost of production requires a new set of strategic direction



Geospatial technology in agriculture





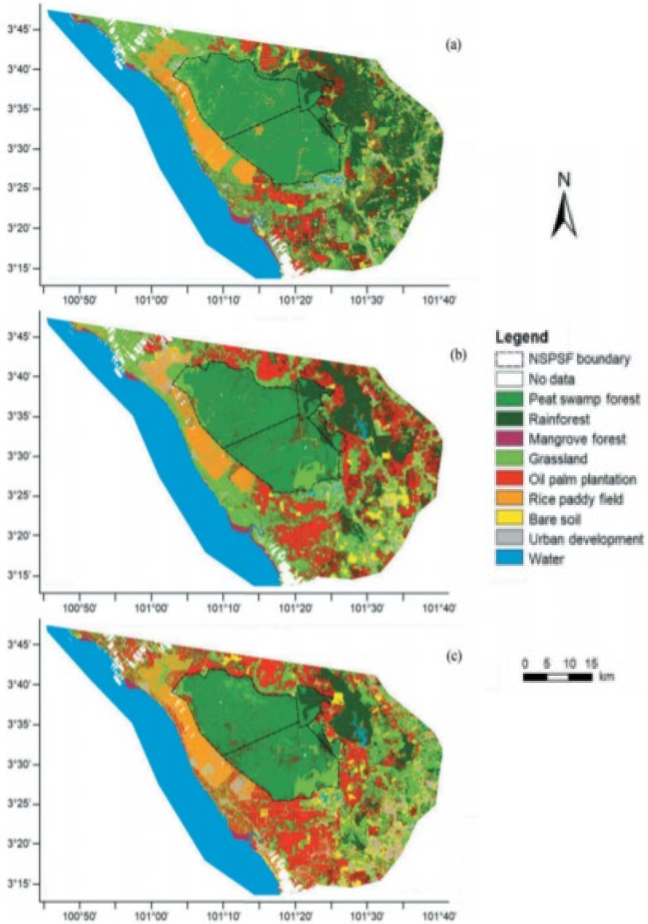
Oil palm

- Malaysia currently accounts for 39% of world palm oil production and 44% of world exports.
- The effects of oil palm plantations on the environment become a matter of concern.
- Oil palms should be managed responsibly and sustainably with a minimum threat to the environment.
- Spatial data provide useful geographical information, which is needed to monitor the oil palms at large area coverage.

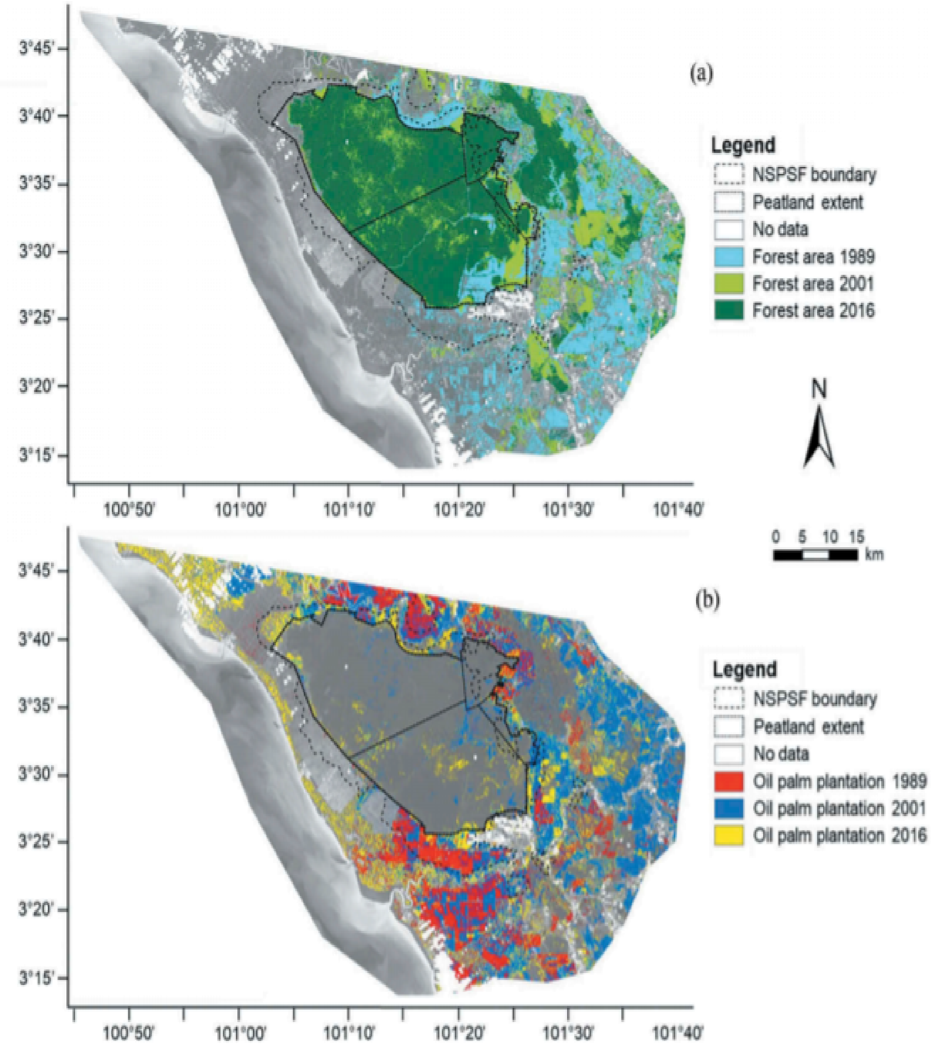
Oil palm – significant/recent works

Author	Focus research	Satellite/ Dataset	Method/Approach/Algorithm	Findings/Outcome
Shafri, H. Z. M., N. Hamdan, and M. I. Saripan. (2011). Semi-automatic Detection and Counting of Oil Palm Trees from High Spatial Resolution Airborne Imagery. International Journal of Remote Sensing 32 (8): 2095–2115.	To suggest a scheme for extracting and counting the palm trees	Airborne Hyperspectral	• Several analysis were conducted (e.g. Spectral analysis, texture analysis, edge enhancement and etc)	Hyperspectral based sensor can detect, count and profile oil palm conditions to a certain extent
Shaharum, N. S. N., Shafri, H. Z. M., Ghani, W. A. W. A. K., Samsatli, S., Prince, H. M., Yusuf, B., & Hamud, A. M. (2019). Mapping the spatial distribution and changes of oil palm land cover using an open source cloud-based mapping platform. International Journal of Remote Sensing, 1-18.	To map and apply change detection on oil palm land cover using cloud computing and machine learning	Landsat	• REMAP cloud computing • Random Forest supervised classification	Cloud computing platform can provide efficient and accurate mapping of oil palm land cover change over Peninsular Malaysia
Mubin, N. A., Nadarajoo, E., Shafri, H. Z. M., & Hamedianfar, A. (2019). Young and mature oil palm tree detection and counting using convolutional neural network deep learning method. International Journal of Remote Sensing, 40(19), 7500-7515.	To implement deep learning for differentiating young and mature oil palms	WorldView3	• CNN deep learning	Use a deep learning approach to predict and count oil palms in satellite imagery with accuracies of 95.11% and 92.96%.
Cheng, Y., Yu, L., Xu, Y., Lu, H., Cracknell, A. P., Kanniah, K., & Gong, P. (2019). Mapping oil palm plantation expansion in Malaysia over the past decade (2007–2016) using ALOS-1/2 PALSAR-1/2 data. International Journal of Remote Sensing, 1-20.	To map oil palm expansion	ALOS PALSAR	• RF, SVM and MLC supervised classifications	Oil palm mapping in Malaysia over the past decade (2007–2016) was conducted with accuracy of 95 %
Hamsa, C. S., Kanniah, K. D., Muharam, F. M., Idris, N. H., Abdullah, Z., & Mohamed, L. (2019). Textural measures for estimating oil palm age. International Journal of Remote Sensing, 40(19), 7516-7537.	To classify the age of the tree	SPOT 5	• Set of textures were used (mean, variance, correlation and etc)	Optimized window size and number of texture measurements for oil palm ages classification with accuracy of 84%

Oil palm



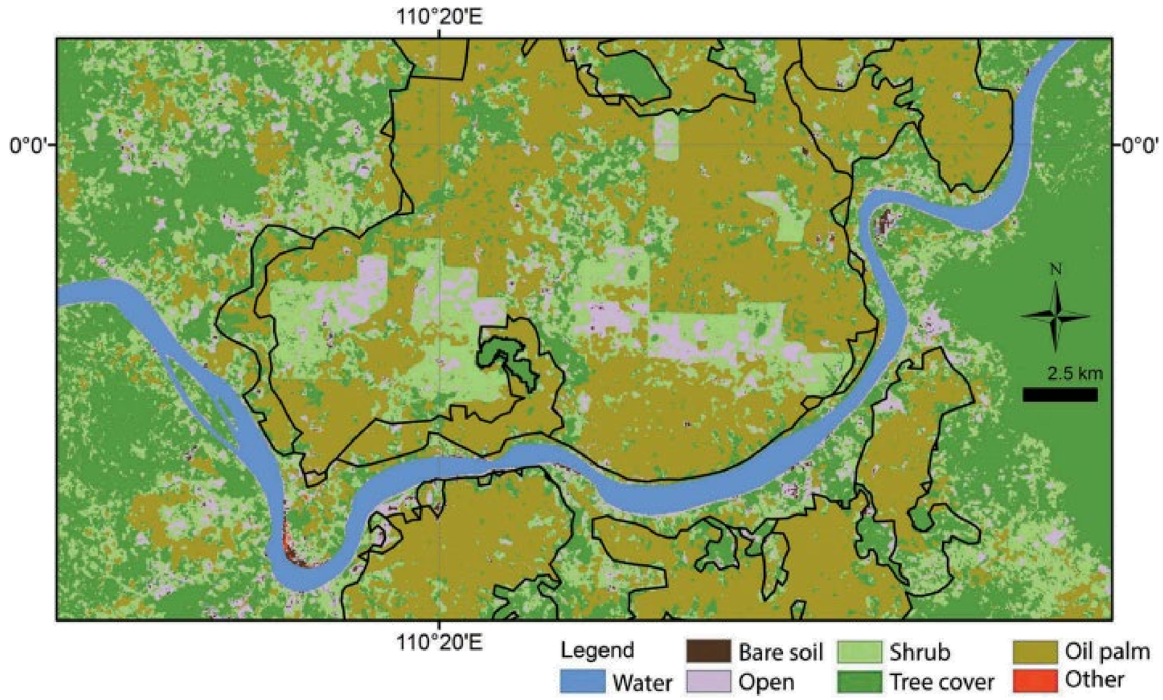
Land cover maps of North Selangor for (a) 1989, (b) 2001 and (c) 2016

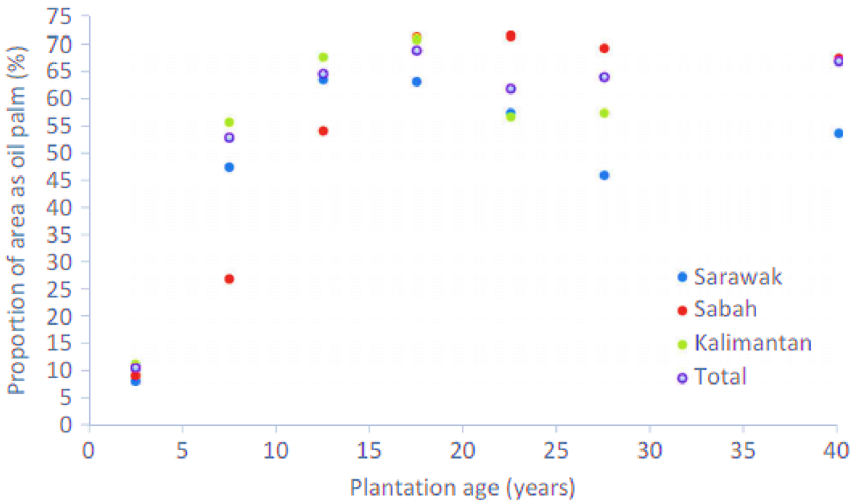


(a) loss of tropical forest and (b) gain of oil palm plantation

Charters, L. J., Aplin, P., Marston, C. G., Padfield, R., Rengasamy, N., Dahalan, M. P., & Evers, S. (2019). Peat swamp forest conservation withstands pervasive land conversion to oil palm plantation in North Selangor, Malaysia. *International Journal of Remote Sensing*, 1-30.

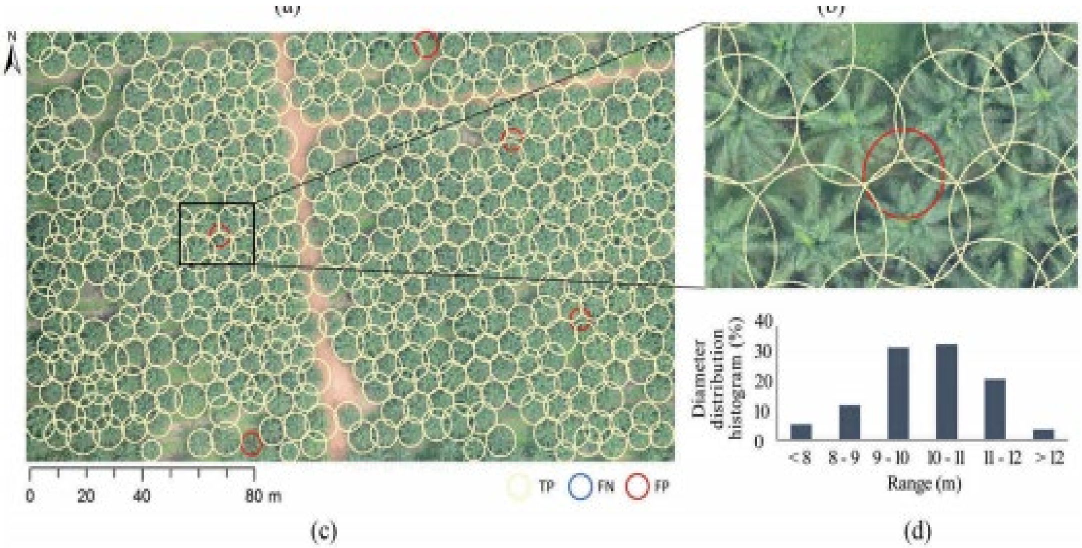
Estimated the proportion of oil palm areas (%) based on the tree age in Borneo



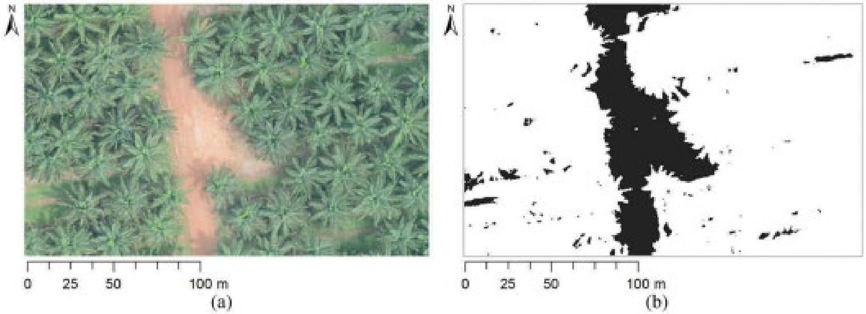


Miettinen, J., Gaveau, D. L., & Liew, S. C. (2019). Comparison of visual and automated oil palm mapping in Borneo. *International Journal of Remote Sensing*, *40*(21), 8174-8185.

- Used UAV data to detect the oil palm trees via SVM in the north of Jeram, Selangor



(c) Palm tree detection results, (d) Histogram of diameter distribution



(a) Original UAV image with RGB bands, (b) Classification result

Wang, Y., Zhu, X., & Wu, B. (2019). Automatic detection of individual oil palm trees from UAV images using HOG features and an SVM classifier. *International Journal of Remote Sensing*, *40*(19), 7356-7370.

Gaps

- Large scale oil palm monitoring from satellites (e.g. Landsat) is well established and successful.
- Main challenges remain for identification of individual disease detection / infection levels for oil palm (precision farming).
- Previous methods used airborne hyperspectral data but practical operation is very costly.
- Current research is trying to develop methods based on UAV-based hyperspectral/multispectral systems to target individual trees.

Rubber

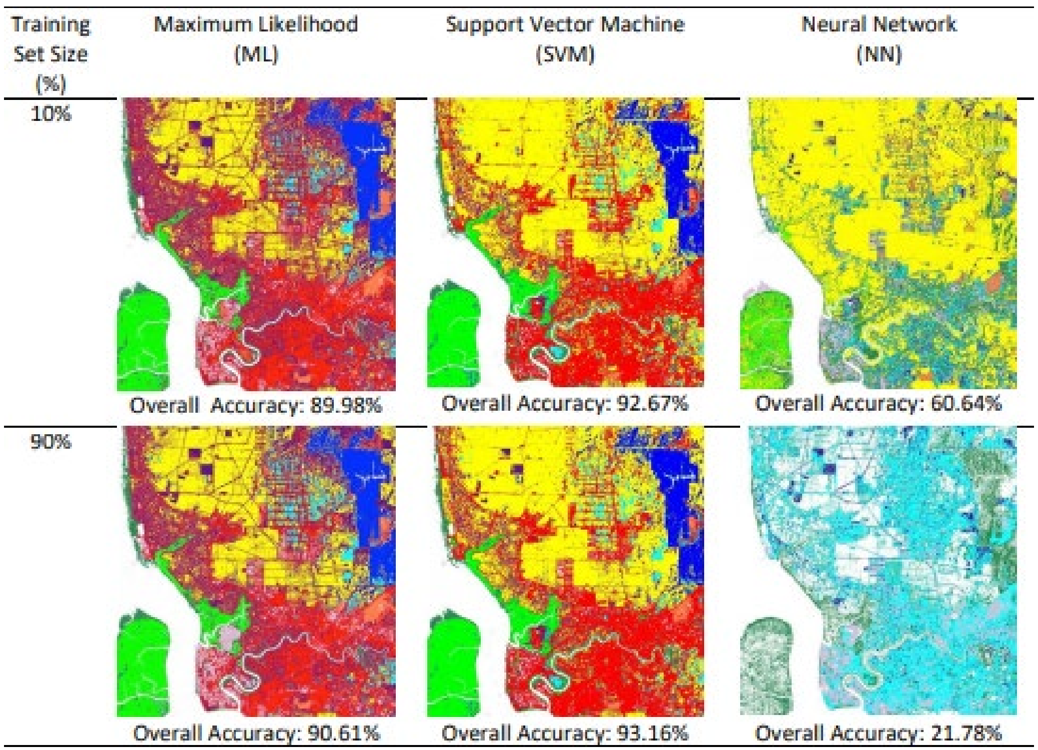
- Production has decreased because most states are switching to a more profitable product, palm oil.
- The rubber industry is targeted to contribute RM52.9 billion to the gross national income (GNI) by 2020.
- Challenges:
  - accurate mapping of rubber plantation area and monitoring of rubber production in this country is necessary so that a proper plan for optimization of land for rubber plantation can be promoted.
  - assess socio-economic and environmental impacts of rubber plantation

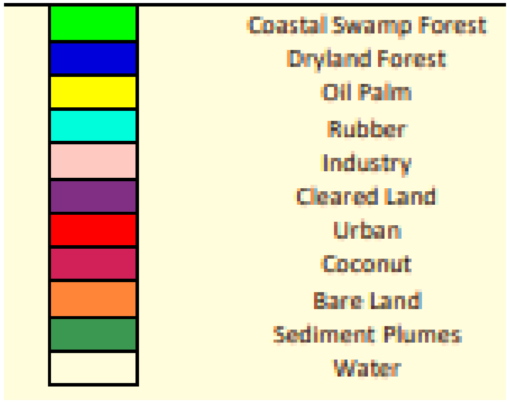
Literature review on rubber crop

Author	Focus research	Satellite/ Dataset	Method/Approach/Algorithm	Findings/Overall accuracy
Shidiq, I. P. A., Ismail, M. H., Ramli, M. F., & Kamarudin, N. (2017). Combination of ALOS PALSAR and Landsat 5 imagery for rubber tree mapping. Malaysian Forester, 80(1), 55–72.	Mapping rubber area (Malaysia)	PALSAR 50m Landsat 5 (TM)	• Decision tree • Vegetation indices (NDVI, GNDVI, EVI, LAI, LSWI and OSAVI)	77.15% (mature rubber tends to saturate with tropical forest causing misinterpretation)
Razak, J. A. A., Shariff, A. R. M., Ahmad, N., & Ibrahim Sameen, M. (2018). Mapping rubber trees based on phenological analysis of Landsat time series data-sets. Geocarto International, 33(6),627–650.	Mapping rubber based on phenology (Malaysia)	Landsat 5 (TM) Landsat 7 (ETM+) Landsat 8 (OLI)	• SVM • Vegetation indices (NDVI, EVI, LAI and RGRI)	91.91% (Defoliation) 90.10% (Foliation) 97.07% (Growing)
Hazir, M. H. M., & Muda, T. M. T. (2018). The viability of remote sensing for extracting rubber smallholding information: A case study in Malaysia. Egyptian Journal of Remote Sensing and Space Science.	Extracting rubber smallholding Information	Landsat 8 (OLI)	• Unsupervised and Supervised Classification • 27 vegetation index • Tasselled cap transformation	Supervised Classification (82%),Vegetation Indices (EVI) (83%) and TCTW (81%)
Dibs, H., Idrees, M. O., & Alsalhin, G. B. A. (2017). Hierarchical classification approach for mapping rubber tree growth using per-pixel and object-oriented classifiers with SPOT-5 imagery. The Egyptian Journal of Remote Sensing and Space Science, 20(1), 21-30.	Evaluate OBIA and PBIA to classify land covers	SPOT 5	• K Nearest Neighbor, Minimum Distance, DT and SVM	Overall accuracies produced: kNN 97.48% MD 96.25% DT 80.80% SVM 96.90%
Yusoff, N.M.; Muharam, F.M. The Use of Multi-Temporal Landsat Imageries in Detecting Seasonal Crop Abandonment. Remote Sens. 2015, 7, 11974-11991.	To identify abandoned crops (rubber and paddy) areas	Landsat TM/OLI	• Crop phenology • OBIA • NDVI	The abandoned areas were identified by producing accuracies: Paddy with 93% Rubber with 83.33%

Rubber

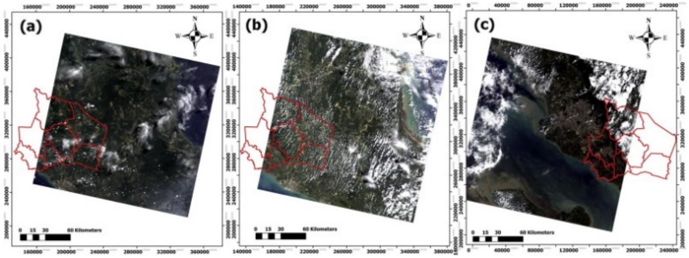
- Classified rubber crops using SVM, MLC and ANN in Klang District, Selangor using Landsat data

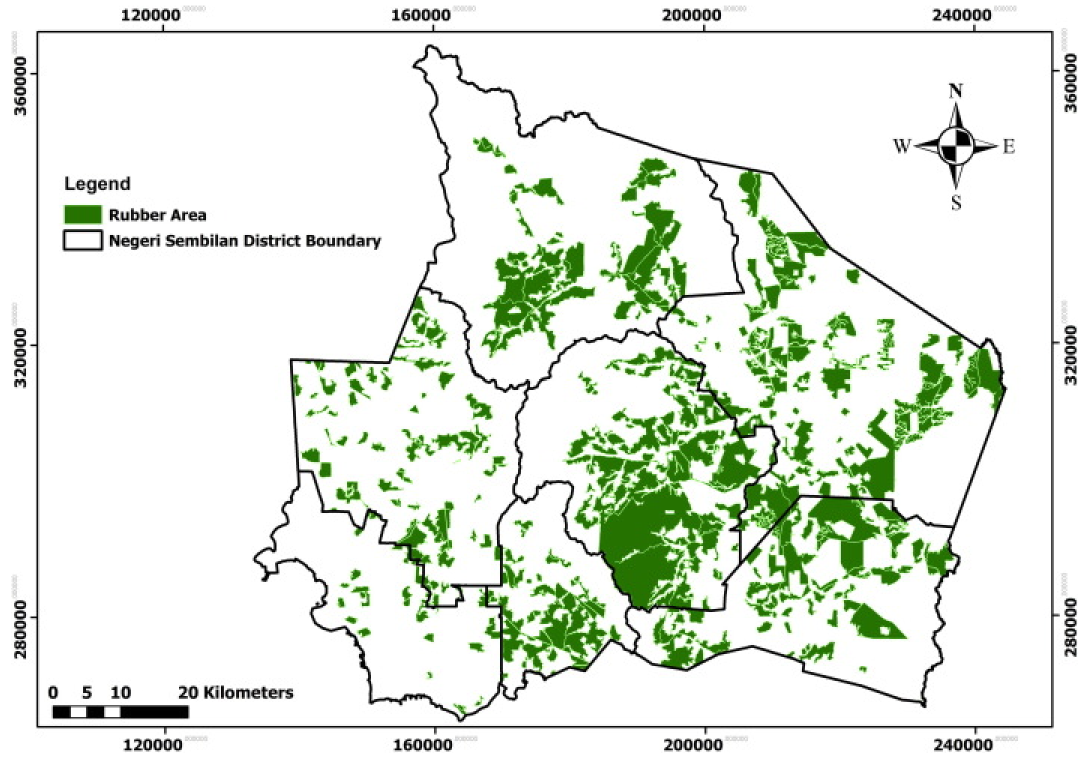




Ahmad, A., Hashim, U. K. M., Mohd, O., Abdullah, M. M., Sakidin, H., Rasib, A. W., & Sufahani, S. F. (2018). Comparative analysis of support vector machine, maximum likelihood and neural network classification on multispectral remote sensing data. *International Journal of Advanced Computer Science and Applications*, *9*(9), 529-537.

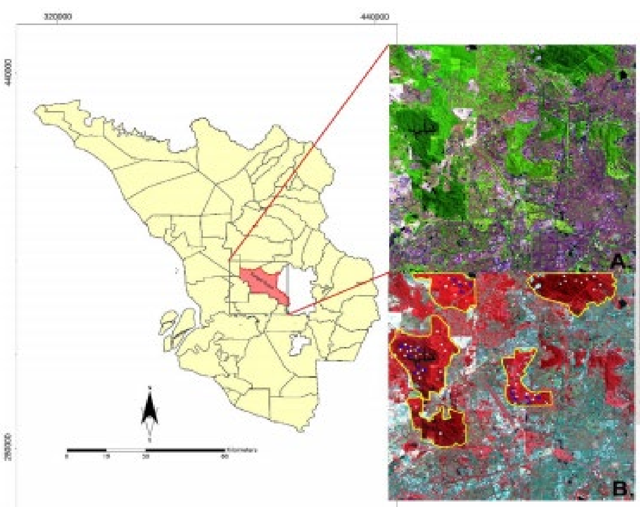
- Extraction of rubber crops in Negeri Sembilan using Landsat data



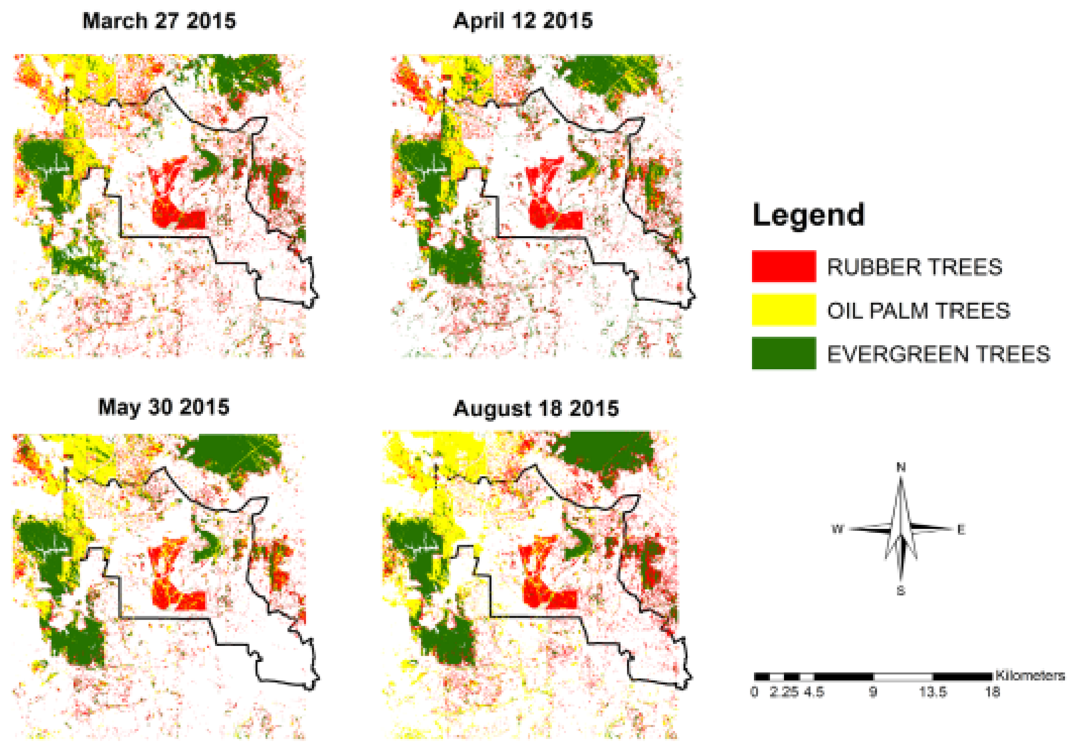


Hazir, M. H. M., & Muda, T. M. T. (2018). The viability of remote sensing for extracting rubber smallholding information: A case study in Malaysia. *The Egyptian Journal of Remote Sensing and Space Science*.

- Rubber classification was carried out based on the phenological state via Landsat data

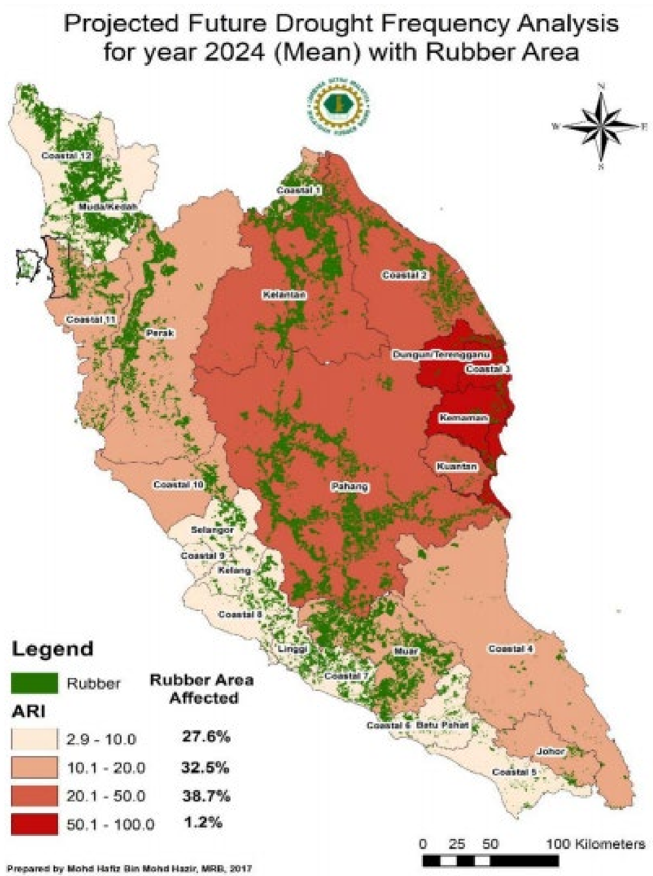


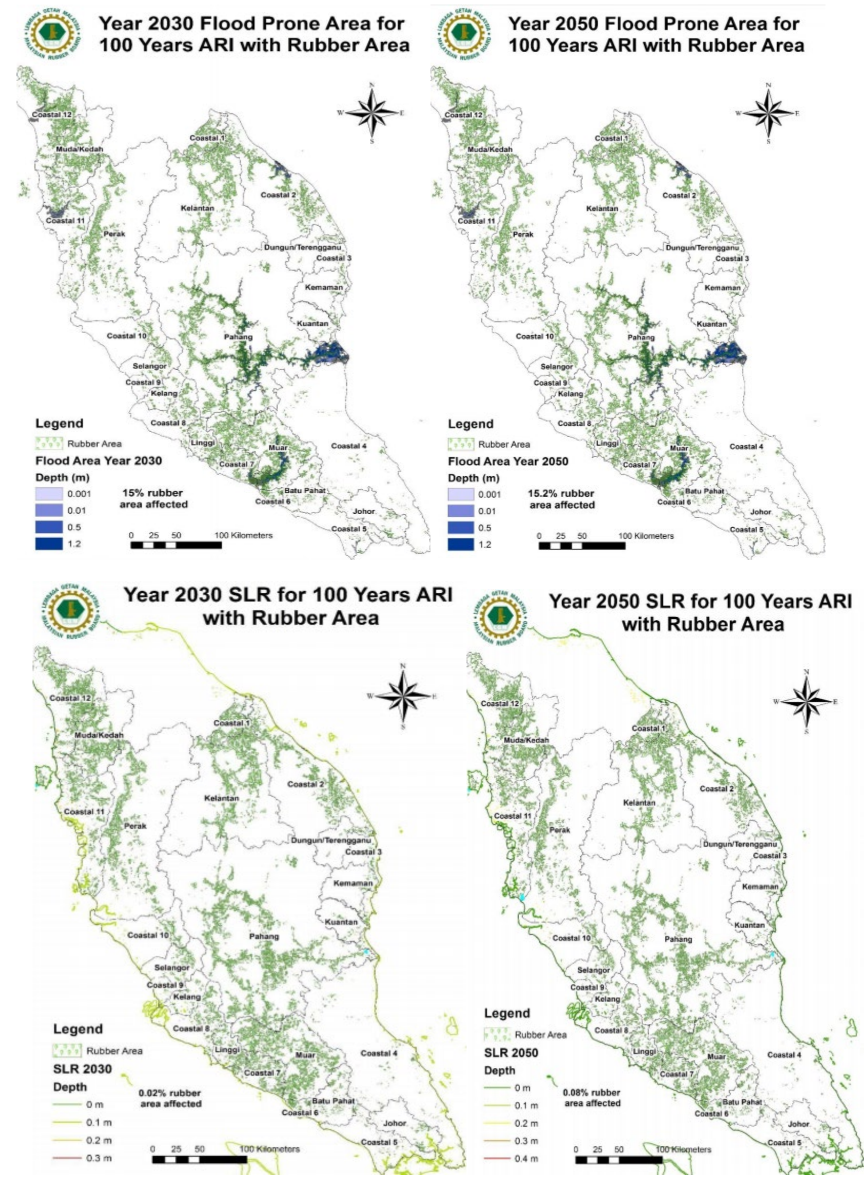
Landsat 8 OLI colour composite image (a). The image in (b) display the location of training (white) and ground truth ROIs (blue)



Razak, J. A. B. A., Shariff, A. R. B. M., Ahmad, N. B., & Ibrahim Sameen, M. (2018). Mapping rubber trees based on phenological analysis of Landsat time series data-sets. *Geocarto international*, *33*(6), 627-650.

- Projected the affected rubber areas based on the Average Recurrence Interval (ARI) and Sea Level Rise (SLR)





Hazir, M. H. M., Kadir, R. A., & Karim, Y. A. (2018). Projections on future impact and vulnerability of climate change towards rubber areas in Peninsular Malaysia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 169, No. 1, p. 012053). IOP Publishing.

Gaps

- Still lack of study on rubber using RS in Malaysia compared to oil palm.
- Difficulty to differentiate rubber and other green trees.
- There is even less use of Sentinel-2 data in mapping and detecting rubber. Further studies are needed to determine the performance of this satellite in detecting young and mature rubber

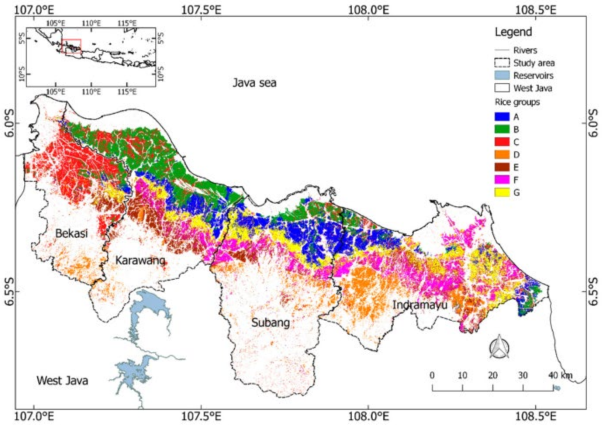
Paddy

- Rice is a crucial part of everyday Malaysian diet.
- As the population grows, rice productions have become important to provide sufficient needs.
- RSGIS can be used to monitor and evaluate agricultural systems to determine where and when rice is grown.
- where crops are performing well or where they are not.
- sustainable crop management.

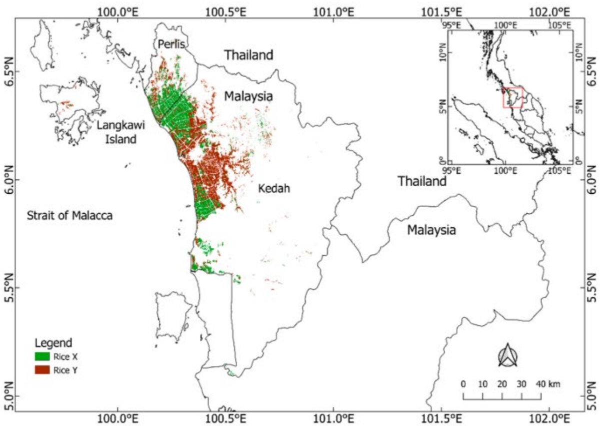
Studies on paddy

Author	Focus research	Satellite/ Dataset	Method/Approach/ Algorithm	Findings/Overall accuracy
Rudiyanto; Minasny, B.; Shah, R.M.; Che Soh, N.; Arif, C.; Indra Setiawan, B. Automated Near-Real-Time Mapping and Monitoring of Rice Extent, Cropping Patterns, and Growth Stages in Southeast Asia Using Sentinel-1 Time Series on a Google Earth Engine Platform. Remote Sens. 2019, 11, 1666.	Mapping of paddy via GEE for parts of Malaysia and Indonesia.	Sentinel 1 radar	• Support vector machine (SVM), artificial neural networks (ANN), random forests, and C5.0 classification models	Overall rice extent with an accuracy of 96.5%.
Ghobadifar, F., Aimrun, W., & Jebur, M. N. (2016). Development of an early warning system for brown planthopper (BPH)(Nilaparvata lugens) in rice farming using multispectral remote sensing. Precision agriculture, 17(4), 377-391.	To establish an early warning technique for pests in rice farming	SPOT 5 Landsat	• NDVI threshold • Probability analysis	- Maps of BPH attacked region were produced. - BPH in the field can be detected using remote sensing data.
Yusoff, N. M., Muharam, F. M., Takeuchi, W., Darmawan, S., & Abd Razak, M. H. (2017). Phenology and classification of abandoned agricultural land based on ALOS-1 and 2 PALSAR multi-temporal measurements. International journal of digital earth, 10(2), 155-174.	To develop crop phenology of abandoned and non-abandoned lands for paddy and other type of crops	ALOS PALSAR 1 and 2	• Segmentation and object-oriented classification were implemented to extract paddy	Overall accuracies for paddy and abandoned paddy were 93% and 96% respectively.
Manjunath, K. R., More, R. S., Jain, N. K., Panigrahy, S., & Parihar, J. S. (2015). Mapping of rice-cropping pattern and cultural type using remote-sensing and ancillary data: a case study for South and Southeast Asian countries. International Journal of Remote Sensing, 36(24), 6008-6030.	To demonstrate the application of high-temporal resolution SPOT VGT NDVI data in building a geospatial database for rice crops	SPOT 4	• NDVI • Unsupervised ISODATA	The total rice area mapped in Malaysia is 552 × 103 ha. Wet irrigated rice accounts for 77.69%, dry season 21.44%, followed by upland 0. 24% and deep-water 0.62%.
Sameen, M. I., Nahhas, F. H., Buraihi, F. H., Pradhan, B., & Shariff, A. R. B. M. (2016). A refined classification approach by integrating Landsat Operational Land Imager (OLI) and RADARSAT-2 imagery for land-use and land-cover mapping in a tropical area. International Journal of Remote Sensing, 37(10), 2358-2375.	To investigate the integration of Landsat OLI with the RADARSAT-2 sensor for LULC mapping	Landsat RADARSAT	• Vegetation indices (NDVI, NDRS) • Image fusion • Pixel-based and object-based • SVM and SAM	OBIA is better than PBIA for classifying LULC. SVM produces better results than SAM

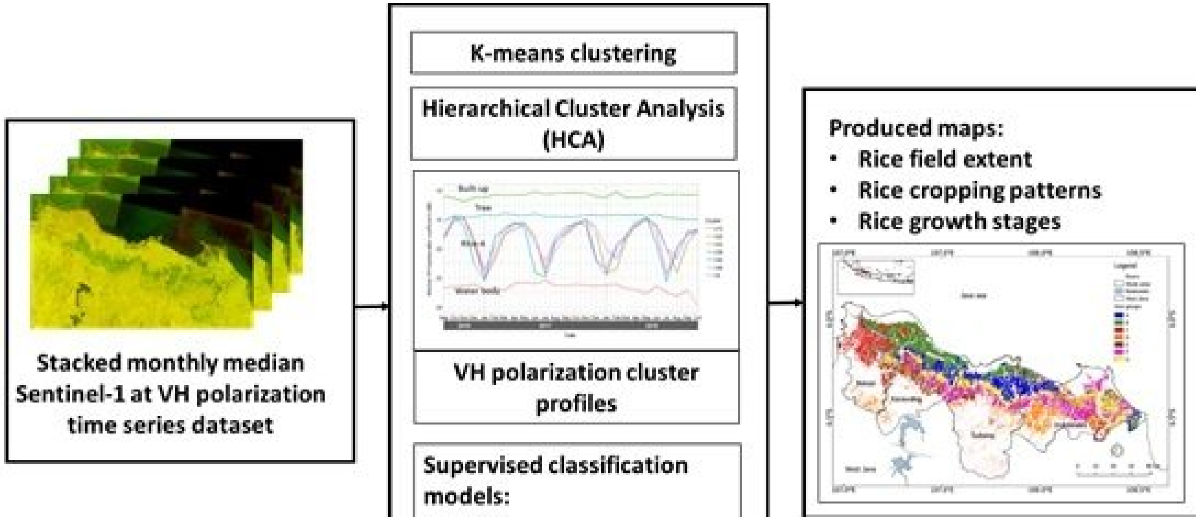
Paddy



(a)

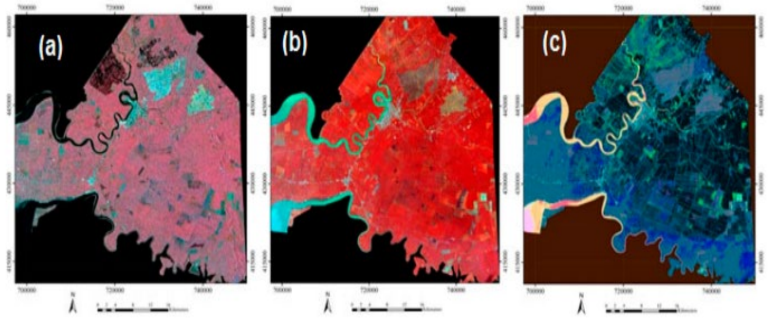


(b)

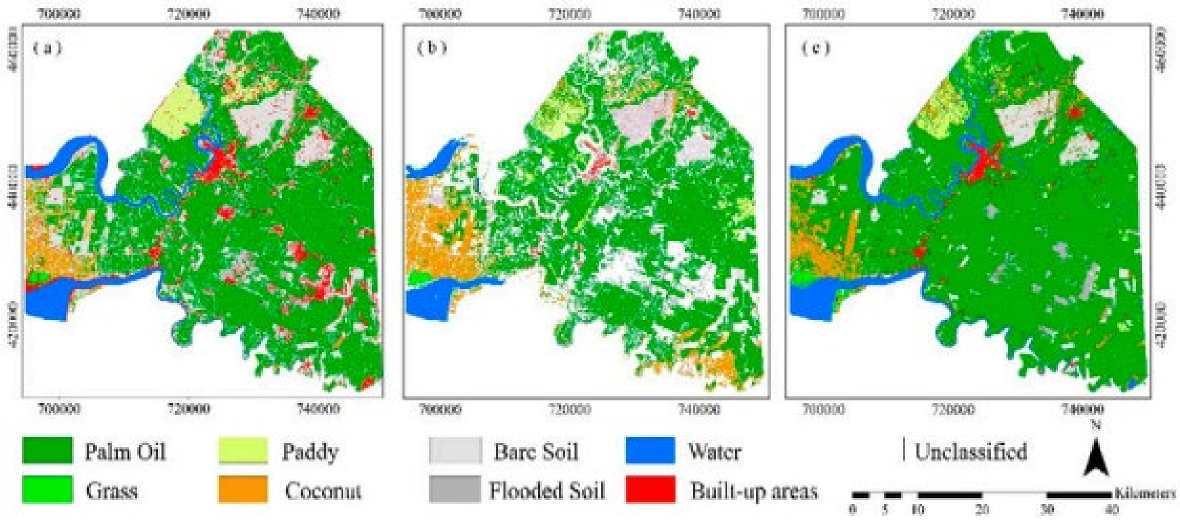


Rudiyanto; Minasny, B.; Shah, R.M.; Che Soh, N.; Arif, C.; Indra Setiawan, B. Automated Near-Real-Time Mapping and Monitoring of Rice Extent, Cropping Patterns, and Growth Stages in Southeast Asia Using Sentinel-1 Time Series on a Google Earth Engine Platform. Remote Sens. 2019, 11, 1666.

- Fusion between Radarsat-2 and Landsat 8.
- To classify crops located at administrative district of Perak, Malaysia.



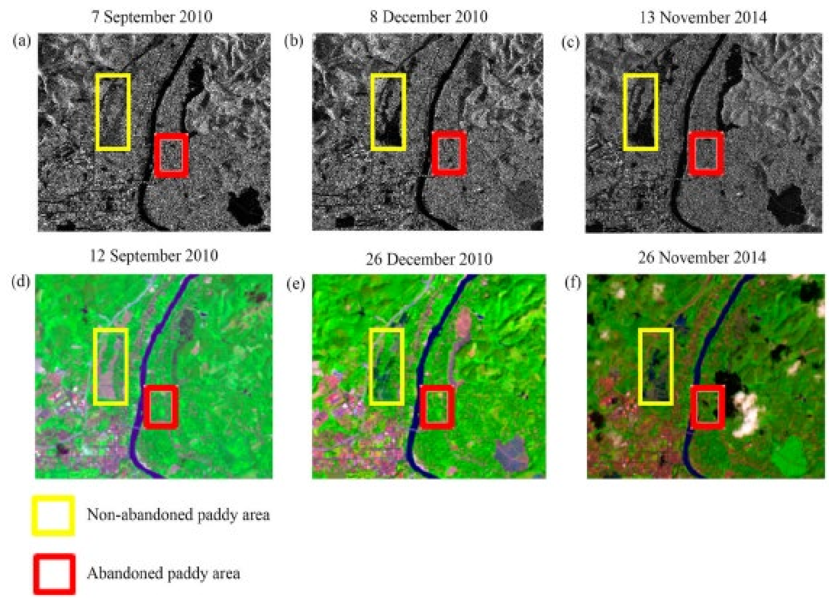
(a) Brovey transform, (b) Wavelet transform, and (c) Ehlers fusion



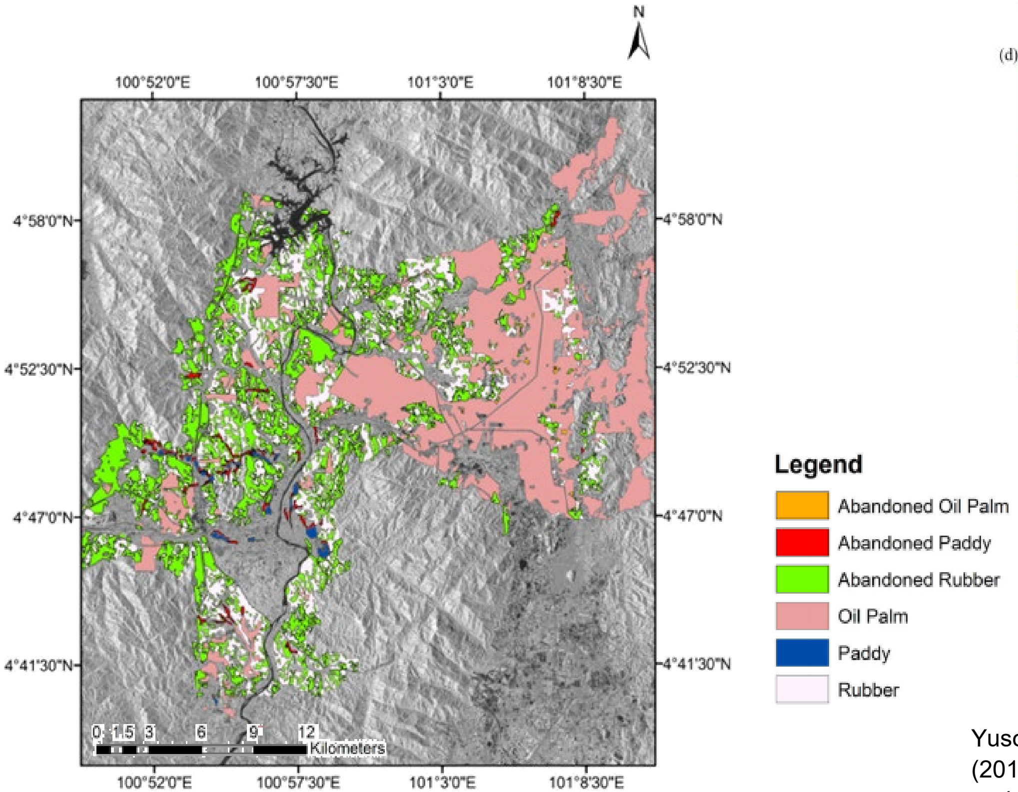
(a) maximum likelihood classification, (b) Spectral Angle Mapper, (c) Support Vector Machine.

Gibril, M. B. A., Bakar, S. A., Yao, K., Idrees, M. O., & Pradhan, B. (2017). Fusion of RADARSAT-2 and multispectral optical remote sensing data for LULC extraction in a tropical agricultural area. *Geocarto international*, *32*(7), 735-748.

- Identifying the abandoned areas for crops at Mukim Sungai Siput and Kuala Kangsar in the Kuala Kangsar district, Perak, Malaysia



(a-c) multi-temporal of ALOS PALSAR and (d–f) Landsat imageries



Yusoff, N. M., Muharam, F. M., Takeuchi, W., Darmawan, S., & Abd Razak, M. H. (2017). Phenology and classification of abandoned agricultural land based on ALOS-1 and 2 PALSAR multi-temporal measurements. International journal of digital earth, 10(2), 155-174.

Gaps for paddy remote sensing

- Studies on paddy in Malaysia using remote sensing are still lacking – e.g. SAR complexity
- Challenges to detect disease/pest

(i) optical and free remote sensing imagery had relatively low spatial resolution led to inaccurate estimation of rice areas

(ii) radar imagery would suffer from speckles, which potentially would degrade the quality of the images

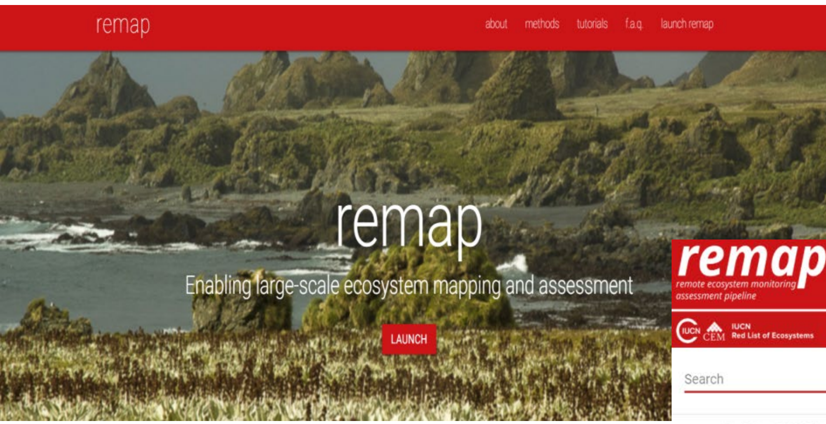
Current projects

- Remote Ecosystem Monitoring Assessment Pipeline (REMAP) and Google Earth Engine (GEE) for oil palm – measuring the impact of plantation on sustainability in Peninsular Malaysia

- Using the integration of cloud computing and machine learning to perform image classification and change detection

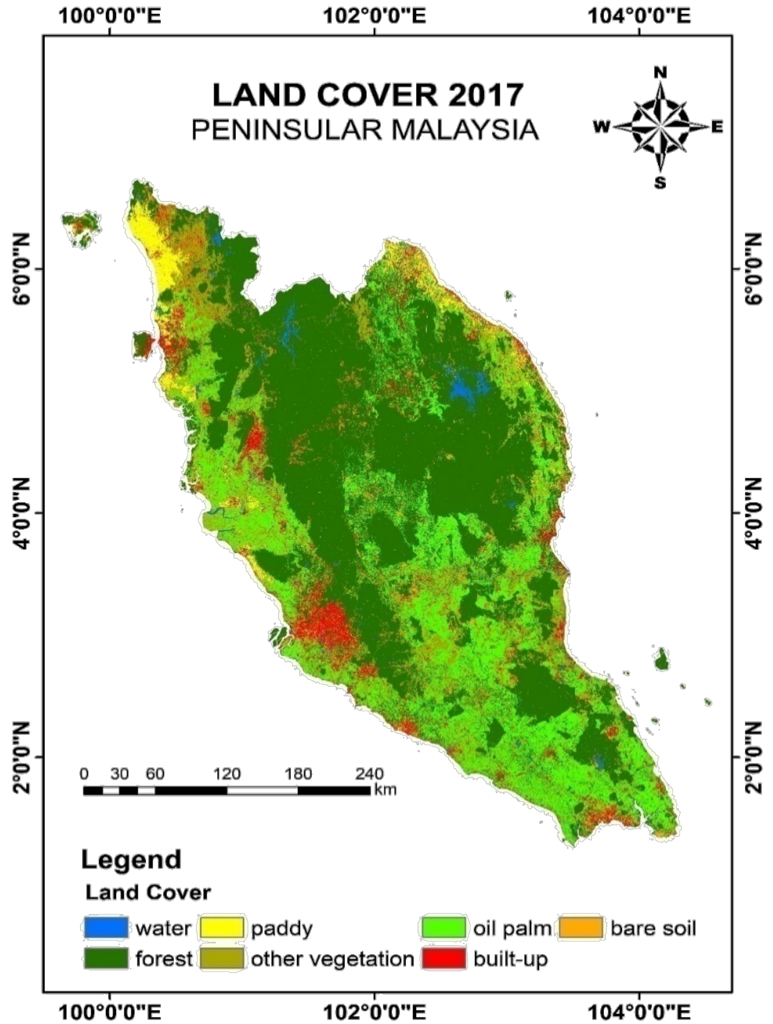
REMAP

- Open access cloud-based platform
- Image classification using machine learning
- Change detection



REMAP

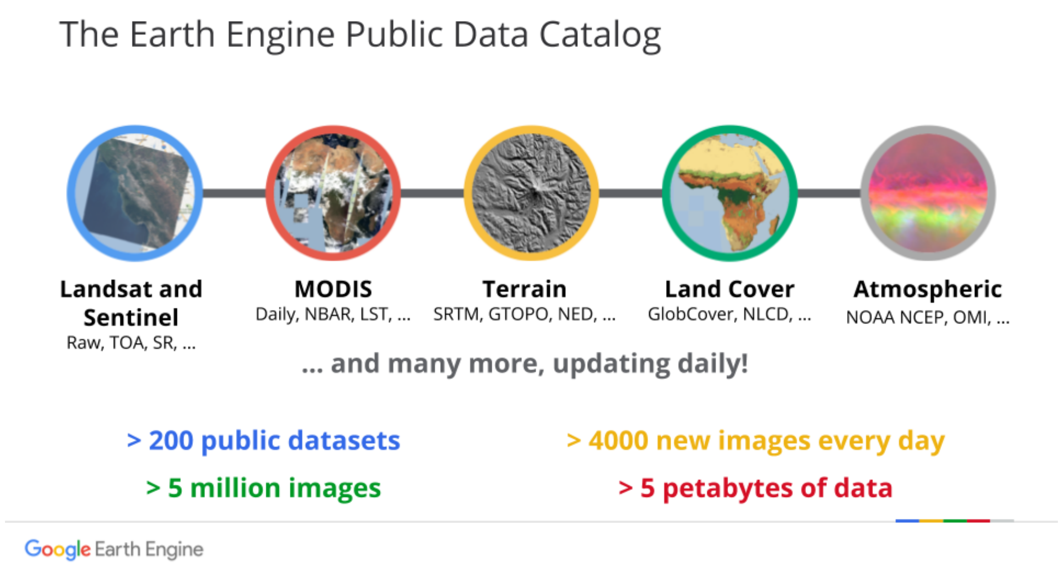
- ➢ Cloud-based analysis
- ➢ Image classification
- ➢ Peninsular Malaysia



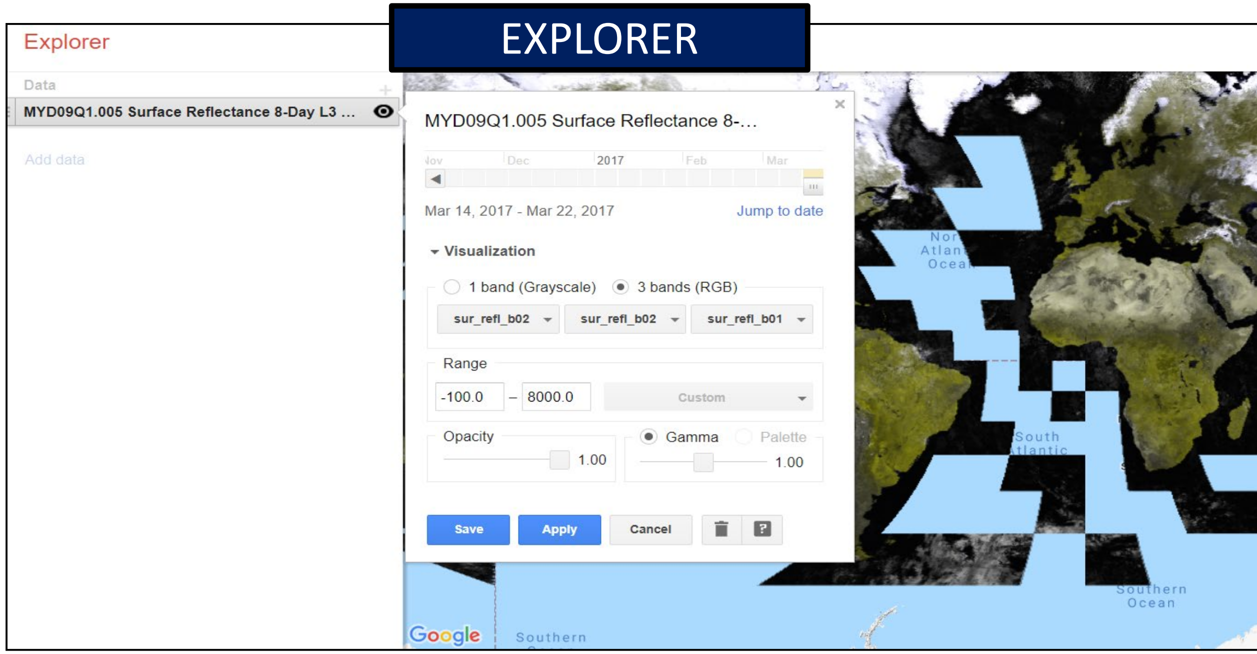
Overall accuracy produced is 80.00%

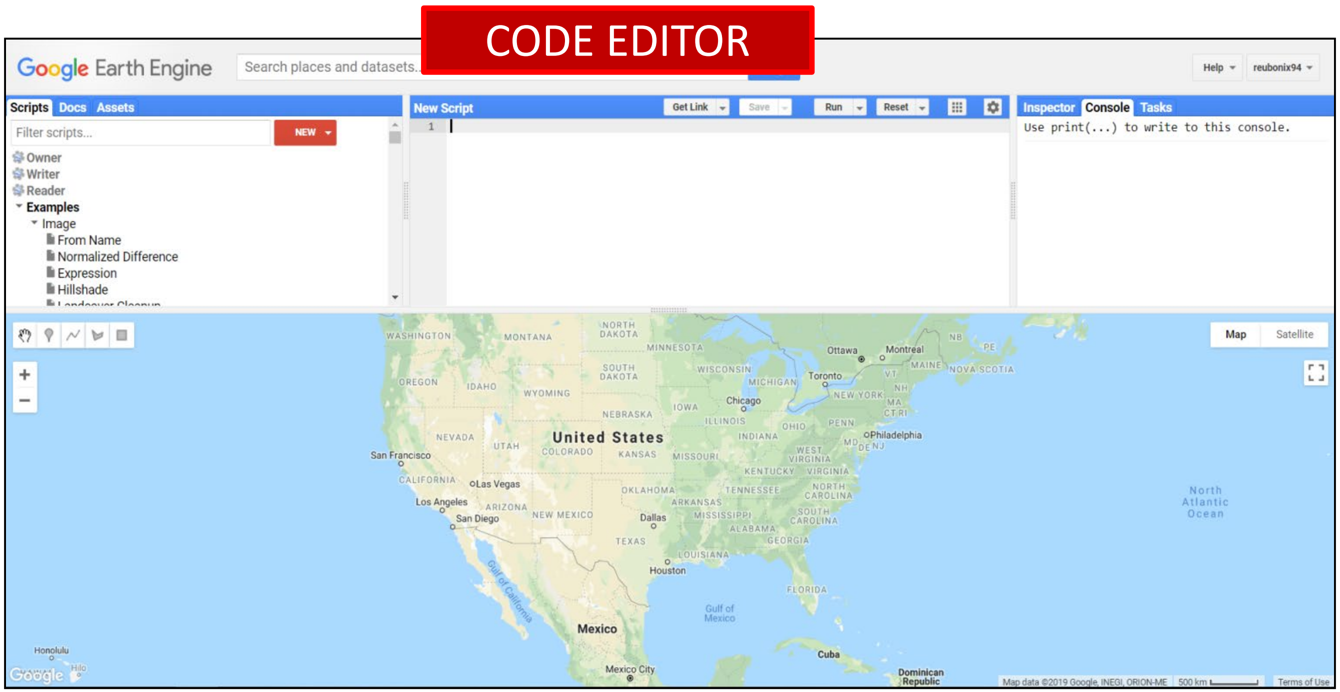
Google Earth Engine

- Open access cloud-based platform
- Image analysis and pre-processing
- Various remote sensing data provided
- Can be used either using Explorer or Code Editor



- ➢ Easily used
- ➢ Direct analysis
- ➢ Requires no programming



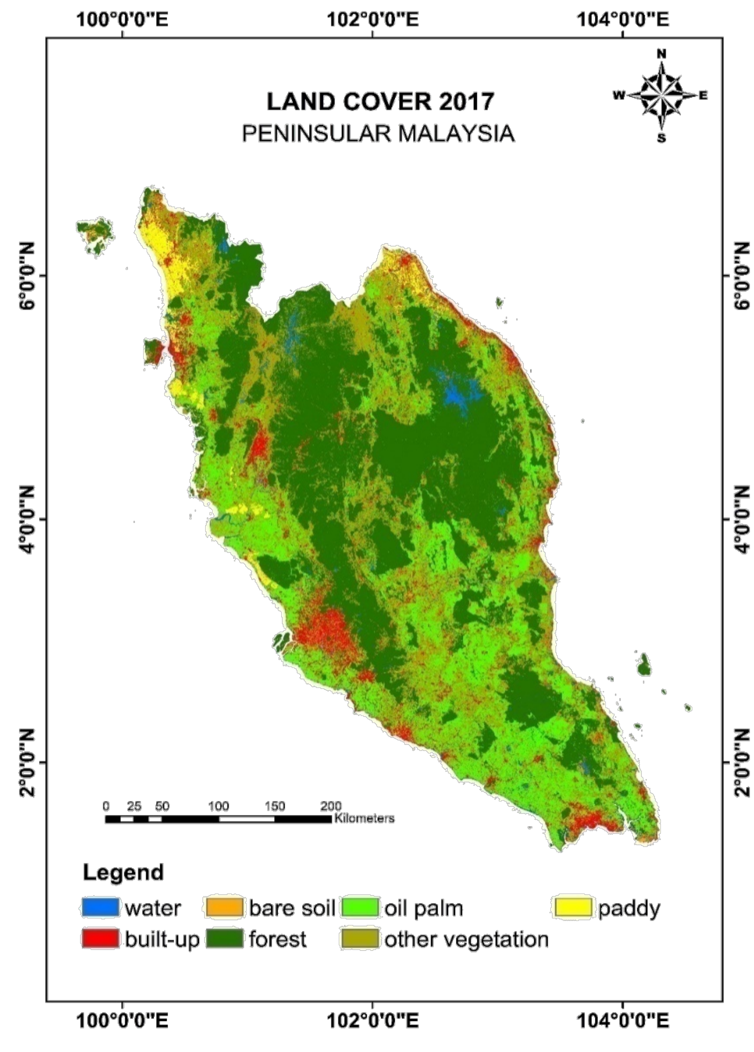


- ➢ More flexible
- ➢ Data control
- ➢ Can be programmed

Google Earth Engine

Google Earth Engine

- ➢ Cloud-based analysis
- ➢ Image Classification
- ➢ Peninsular Malaysia



Overall accuracy is 79.77%

Findings/ Discussion

- Large scale crop mapping can be done effectively through cloud computing such as REMAP and GEE.

- The use of machine learning has helped to improve the efficiency and accuracy of crop mapping over large area.

- Status of oil palm plantation in Peninsular Malaysia is sustainable.

Other crops

- Pineapple

  - ➢ Balasundram, S. , Kassim, F. , Vadamalai, G. and Hanif, A. (2013) Estimation of red tip disease severity in pineapple using a non-contact sensor-approach. Agricultural Sciences, 4, 206-208. doi: 10.4236/as.2013.44029.

- Coconut

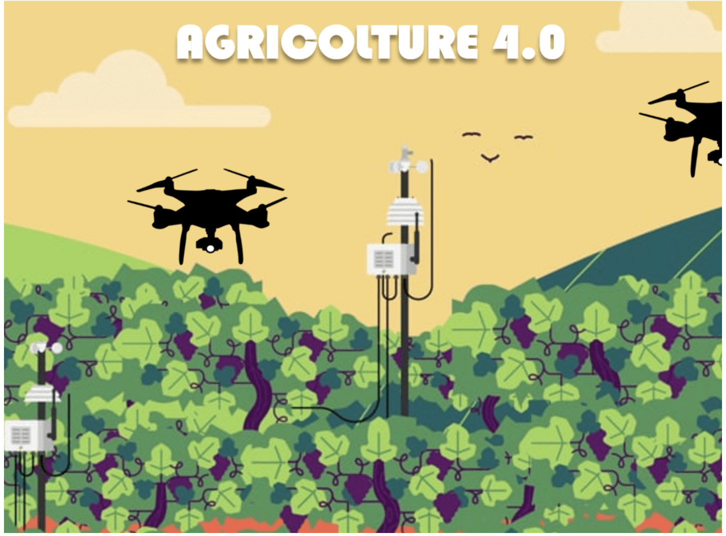
  - ➢ Ruzinoor et al (2019) Exploring the potential of web based 3d visualization of GIS data in coconut plantation management (2019) International Journal of Innovative Technology and Exploring Engineering, 8 (5s), pp. 147-153. (15)

- Cocoa

  - ➢ Bakar S A, Adnan N A, Redzuwan U (2019). Temporal Geospatial Assessment Of Cocoa Pollinator, FORCIPOMYIA In Cocoa Plantation Area. Serangga. Jun 25;24(1).

Directions

- Agriculture 4.0
- Free data – Sentinel systems
- Open source software
- Cloud computing
- Artificial intelligence
- UAV
- Fusion (Active and passive)
- Spaceborne hyperspectral



Conclusions

- Geospatial technology is crucial for Malaysian agriculture.
- Oil palm, rubber and paddy have benefited from the use of geospatial tech (e.g. remote sensing).
- Other crops should also take advantage of geospatial technology.
- Way forward is to make use of the new paradigms in geospatial data utilization to maintain/increase competitiveness.

TERIMA KASIH / *THANK YOU*