SATELLITE MAPPING OF OIL PALM LAND USE

by: WAHID, B O; NORDIANA, A A and TARMIZI, A M

259

MPOB INFORMATION SERIES • ISSN 1511-7871 • JUNE 2005

MPOB TT No. 255

Satellite remote sensing (RS) technology using optical and radar remote sensing techniques have been used successfully in various applications related to earth resource studies and environmental monitoring. Some advantages of these techniques are cost effectiveness, wide coverage, near real-time data acquisition and frequent revisit capability. RS has significant potential to aid oil palm monitoring and detection efforts. It also provides a cost-effective method to map oil palm and at the same time provides site-specific assessments of management practices and growth performance of the palms. Satellites imaging data of Landsat Thematic Mapper (McMorrow, 1995; Wahid, 1998) and SPOT (Lukman and Poeloengan, 1996) have been successfully used to identify oil palm growing areas and to map differences in palm age at early stages of growth. The remote sensing technique using Landsat Thematic Mapper (TM) image has been employed by MPOB to improve the present methods of updating oil palm land use.

OBJECTIVES

The main objective of this study is to develop a rapid procedure of producing the 1:50 000 scale oil palm land use map by using multi-spectral Landsat 7 ETM images and geographic information system (GIS). The detailed objectives are:

- to test the suitability and accuracy of the multi-spectral Landsat 7 ETM images for oil palm land use mapping;
- to verify and update the existing land use data obtained from registration;
- to obtain more detailed information of the oil palm land use data such as location and stage of growth; and
- to develop an appropriate image processing technique for developing the land use map.

MATERIALS AND METHODS

This study was carried out using 29 scenes of multi-spectral Landsat 7 ETM imagery covering Peninsular Malaysia, Sabah and Sarawak (*Figure 1*). GIS base maps were used for geometric correction and ground truthing. Image processing and analysing was carried out using the image processing programme ERDAS Imagine. Land use maps were created by using the eCognition object oriented classification approach. *Figure 2* shows the methodology used in this study to detect the oil palm growing areas from Landsat ETM data.

Image Processing

Radiometric correction was applied to the images to correct for atmospheric scattering based on the subtractive bias for each spectral band (Jensen, 1996). The images were then geometrically co-registered using image to map registration with an accuracy of $<\sqrt{0.5}$ pixels. A second order polynomial transformation was used for the registration based on more than 12 ground control points (GCP). The images were registered to the Malaysian map

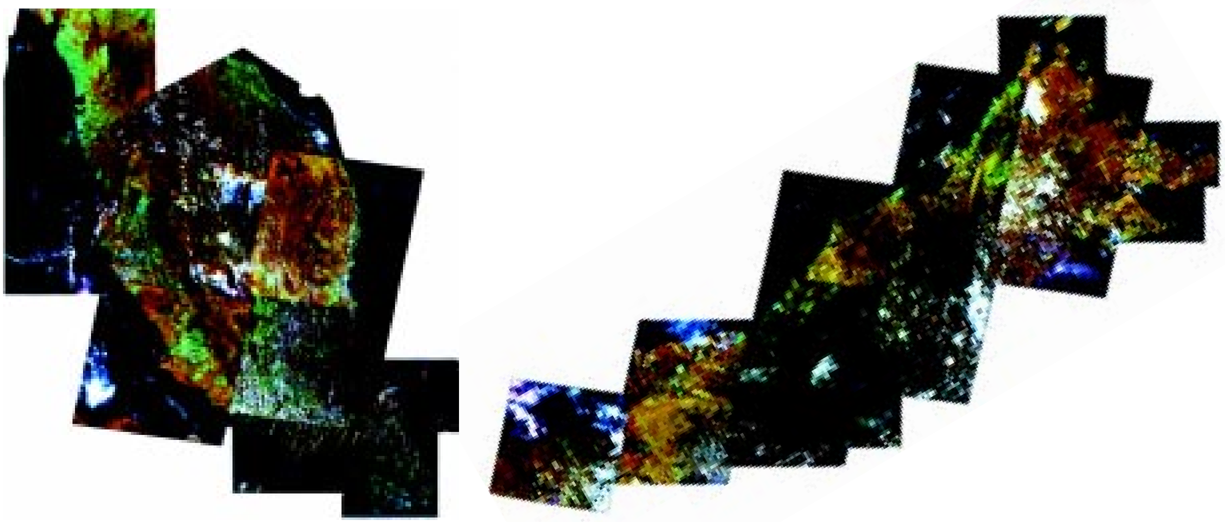

Figure 1. Landsat 7-ETM scenes of Peninsular Malaysia, Sabah and Sarawak (2002).

ISSN 1511-7871

9 771511 787001

Malaysian Palm Oil Board, Ministry of Plantation Industries and Commodities, Malaysia
P. O. Box 10620, 50720 Kuala Lumpur, Malaysia. Tel: 03-89259155, 89259775, Website: http://mpob.gov.my Telefax: 03-89259446

MPOB

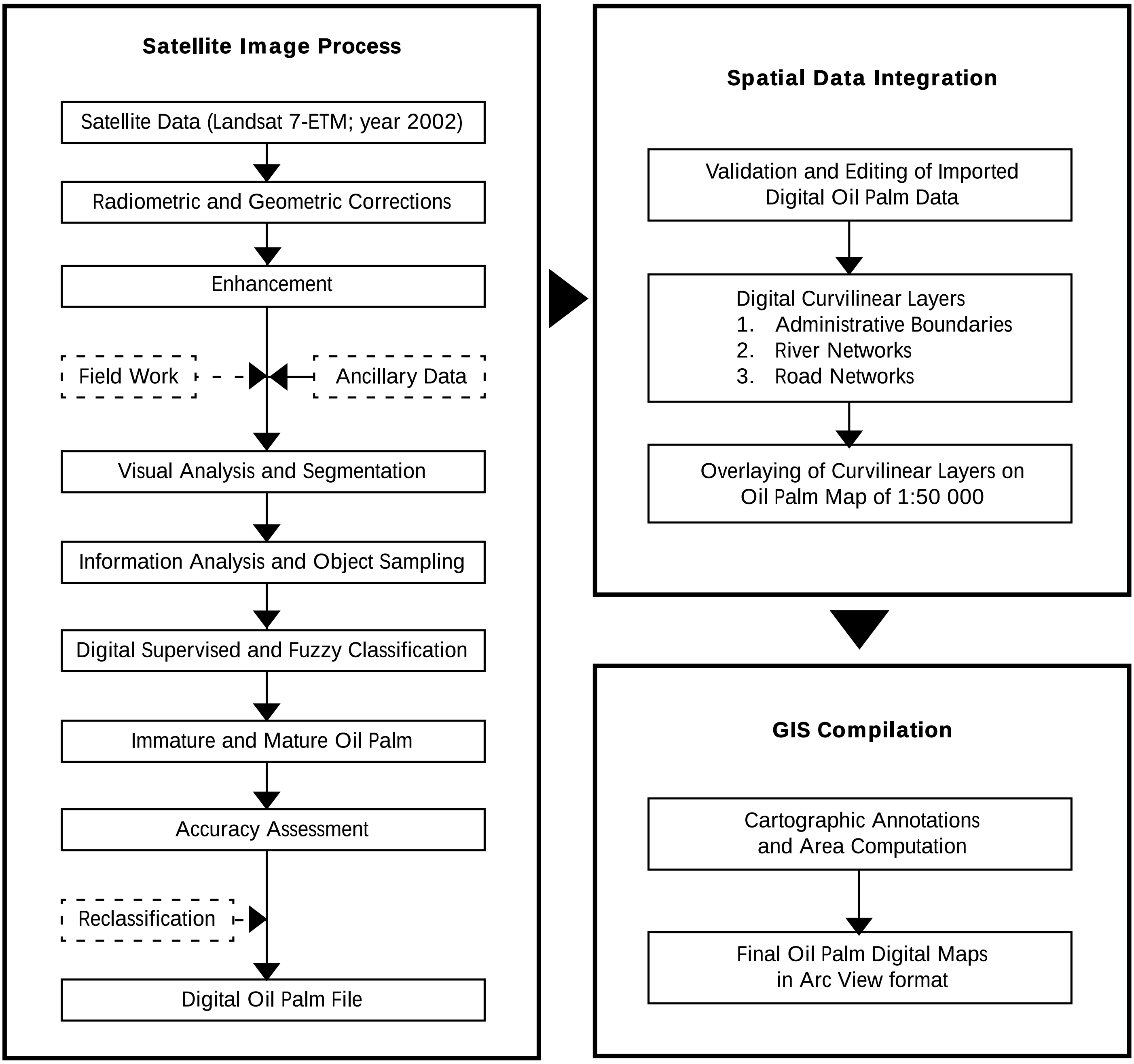

Figure 2. Methodology flow chart of developing oil palm land use map from Landsat ETM Image Classification.

projection, rectified skew orthomorphic (RSO) based on the 1:50 000 topographic map of Malaysia.

Break point histogram matching was used to maximize the enhancement of image visualization among the land use types. Visual analyses of the enhanced images were carried out with the assistance of field and ancillary data such as existing land use and topographic maps.

For classification, the enhanced images were segmented into polygons with built-in topology through an Object Oriented Multiresolution Segmentation tool classification approach by using the eCognition programme. The oil palm land use was discriminated by supervised classifications using Nearest Neighbour (NNB). The NNB algorithm was used to search for the closely related image polygons in feature space while the fuzzy operator generated multi-dimensional membership functions with values ranging from 0 to 1. The polygons were then assigned to different classes of land use.

GIS Integration

After the classification had been made, the polygons were exported to the GIS environment for spatial integration and analysis. This process comprises of (i) validating polygon attribute data, feature coding, and land use nomenclature and (ii) polygon editing to correct for node error, dangle, pseudo polygon, gap, overlapping and non-matching arcs. Upon completion of the validation and editing process the digital vector files were merged and sectored into maps according to state boundaries at 1:50 000 scale.

Overlaying of Topographical Base Data

The vector files of river networks, road networks and administrative boundaries for Peninsular Malaysia, Sabah and Sarawak were obtained from the Department of National Mapping and Survey. The vector files were superimposed on the geocoded satellite imagery to update road, river and boundary features through screen digitization. The updated vector files were then overlaid on the individual state digital oil palm land use map and sectored to the size of the state boundary.

RESULTS AND DISCUSSION

Data Processing, Analysing and Map Development

Figures 3a to *d* show the sequence of image processing to create the oil palm land use map for the state of Selangor. The composite of TM bands 4, 5 and 3 gave the best discrimination of oil palm from other land cover types (*Figure 3a*). Radiometric and geometric corrections were used to reduce image atmospheric attenuation and conform the image to Malaysian map projection respectively. Image enhancement was adopted to generate a clear image for visual analysis (*Figure 3b*). The enhanced images were then segmented into polygons by using the eCognition programme for oil palm land use classification (*Figure 3c*). Finally, the polygons were exported to the GIS environment for spatial integration and analysis to create the oil palm land use map (*Figure 3d*).

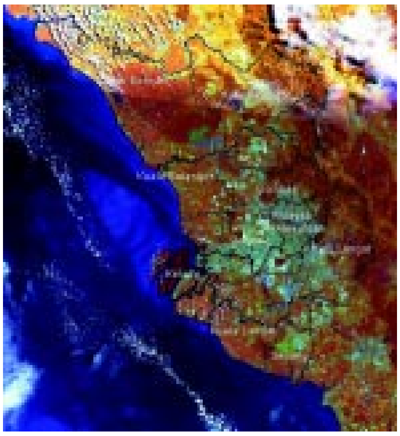

Figure 3a. Landsat image of Selangor with 4, 5 and 3 false colour composites.

Figure 3b. Enhanced image of Landsat.

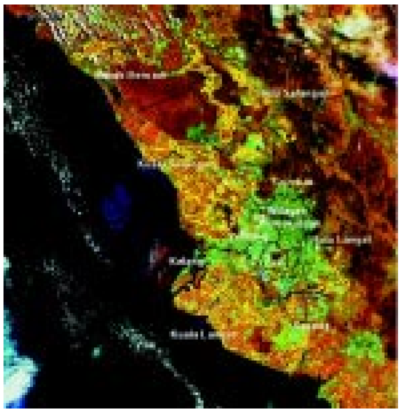

Figure 3c. eCognition classification.

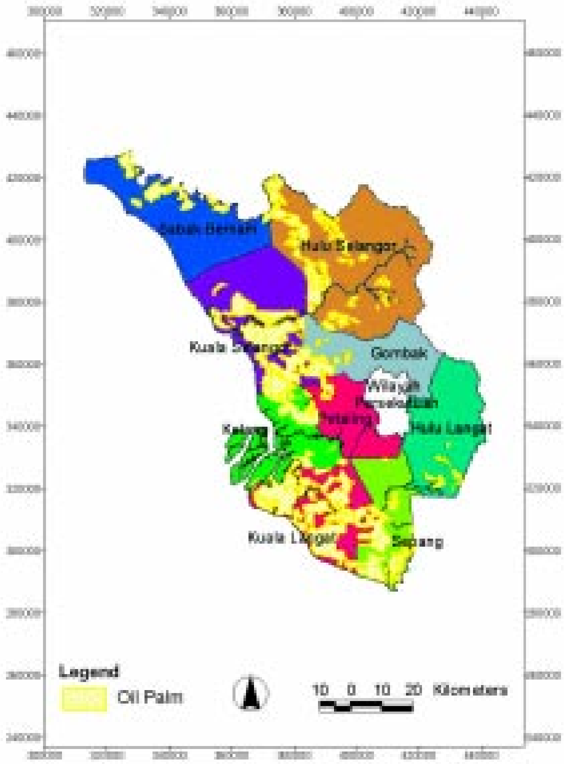

Figure 3d. Oil palm land use map of Selangor.

Accuracy of the Land Use Classification

Table 1 shows the result of the land use validation using a 4x4 confusion matrix. The result showed that the user's accuracy for the oil palm land use classes (mature and immature) were 100%. The overall land use classification accuracy (Kappa coefficient) was 98%.

Oil Palm Growing Area

The result showed that RS detected 142 176 ha (3.87%) more planted area compared to MPOB registration (Anon, 2002). Most of the extra areas detected by RS were unregistered immature oil palm. Other problems that can cause error in the result are the image's shadow and atmospheric noise. However, these problems can be reduced by using shadow-free images, carry out more ground truthing and using the right image processing techniques.

TABLE 1. CONFUSION MATRIX FOR THE ACCURACY ASSESSMENT

Predicted land use classification	Ground truth						
	3OM	3OY	3RM	3RN	Row total	User's accuracy (%)	Commission error (%)
3OM	51	0	0	0	51	100	0
3OY	0	14	0	0	14	100	0
3RM	1	0	18	0	19	95	5
3RN	0	0	0	8	8	100	0
Column total	52	14	18	8	92	-	-
Producer's accuracy (%)	98	100	100	100	-	-	-
Omission error (%)	2	0	0	0	-	-	-
Overall accuracy	Observed correct 91				Total observed 92		
	% of observed correct (51+14+18+8)/92 *100 = 98.91%						
Kappa coefficient K_{hat}	= $[(92(91) - 3254)/(92^2 - 3254)]*100$ = 98 %						

Note: 3OM = mature oil palm; 3OY = immature oil palm; 3RM = manage rubber and 3RN = unmanage rubber.

CONCLUSION

Results of this study showed that the RS technique can be used to identify oil palm growing areas. Some advantages of the technique are its cost effectiveness, wide coverage, near real-time data acquisition and frequent revisit capability. Results of RS techniques are very much influenced by the quality of the image and the image processing technique used, and ancillary data gathered during ground truthing. The eCognition programme used in this study has improved the image classification for developing oil palm land use. The integration of RS and GIS has allowed a more accurate assessment of oil palm land use.

REFERENCES

ANON (2002). *Malaysian Palm Oil Statistics 2002*. 22nd edition. 139 pp.

JENSEN, J R (1996). *Introductory Digital Image Processing – a Remote Sensing Prospective*. Prentice Hall, Upper Saddle River, New Jersey 07458. p. 107-135.

LUKMAN, F M and Z POELOENGAN (1996). Application of remote sensing technique for oil palm plantation management. *Proc. of the 1997 PORIM International Palm Oil Congress -"Competitiveness for the 21st Century"*. p. 460-467.

McMORROW, J M (1995). Relation of oil palm spectral response to stand age. *Int. J. Remote Sensing, 16*: 3203-3209.

WAHID, B O (1998). Discrimination of oil palm from other land cover types using remote sensing technique. *Proc. of the PORIM-Industry Forum*. December 1998. 16 pp.

For more information kindly contact:

Director-General
MPOB
P. O. Box 10620
50720 Kuala Lumpur, Malaysia.
Tel: 03-89259155, 89259775
Website: http://mpob.gov.my
Telefax: 03-89259446