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Critical Book Review
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Hyper Spectral Remote Sensing of Tropical and Sub-Tropical Forest (Editors: Margaret Kalacsca & G. Arturo Sances–Publisher: Azofeita CRC Press, Year 2008, 320 pages)

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Introduction

It is estimated that most of the problems in forestry associated with the spatial attributes. From the perspective of forest function that includes production, ecological, and social functions, the spatial aspects has always been a very important part. In Indonesia, the forestry areas is always dealing with very large areas which is mostly inaccessible due to limitation of roads, mountainous with steep slopes, cliffs, hills or wetland such as peat, swamp or marsh. This condition makes it difficult to collect the data in quick manner comprehensively with low cost. Veronique *et al.* (2012) recognized that remote technology may provide objective, practical and cost-effective solution. Currently, one of the most reliable data source that can be repetitively acquired with a unique and consistent traits are those derived from satellite imageries. It had been known that since the 1990s, earth resources remote sensing sensor is progressively developed either with finer spatial resolution, higher spectral resolution, more frequent revisit or wider dynamic range. The advent of high spectral resolution (*e.g.* hyperspectral) is quite challenging and prospectively gives a significant contribution, especially in forest management with higher level of detailed information. Without having adequate spatial information supported by strong scientific arguments, the forestry sector will be persistently pressured by many other sectors.

The advent of hyperspectral data had been provided new insights for both practitioners and scientists working in the field of forest management and the environment. Book on "Hyperspectral Remote Sensing of Tropical and Sub-Tropical Forest" has given a new dimension and the spirit against the use of remote sensing technology for better forest management. This 320-pages of book is composed by about 36 contributors page, quoting around 500 studies, have been conducted in the tropics and sub-tropics. This book became interesting to be read because it was written in modest style that is easy to understand with very clear explanation of their technical aspects.

The main topic of the book

The use of hyperspectral imagery in the sub-tropical forests may have been frequently used, however hyperspectral sensors and data are still novelty in the tropical regions. This book had been focused on the complex and unique set of challenges in using hyperspectral technology to support tropical forest management.

The technical problem to be resolved

This book describes a technical aspect of the application of hyperspectral technology in tropical and sub-tropical forest, mostly dealing with real examples and actual data. The technical aspects of image analysis techniques include the manufacture of various hyperspectral reflectance indices, spectral mixture analysis, pattern classification approach, the selection of the band, partial least square, discriminant analysis, and radiative transfer models.

For analysts of remote sensing, the spatial, spectral, and temporal variation represents opportunity and challenges. In terms of opportunities, hyperspectral imagery has several options to be used for:

1 assessing biological diversity forest vegetation,
2 estimating a stock of carbon in living vegetation and dead wood (necromass),
3 measuring the health of the tree or forest through retrieval of foliar biochemistry, and
4 understanding ecosystem processes

However, the use of optical imagery in the tropics is limited by environmental conditions with relatively permanent cloud cover and haze throughout the year; the persistent human-induced smoke during dry season, sensor limitation with low dynamic range (low radiometric resolution) and low Signal-to-Noise Ratio, atmospheric effect and image artifact. Other limiting factors are the complexity of species diversity, and multi-layer canopy and effect of tree shadows and gaps.

The scope of the book (optic/radar, detail/broad, technical/theory)

This book is consisted of 13 chapters that divided into 3 groups, namely:

1 Overview
   a Tropical tree species discrimination and tropical dry forest phenology
   b Physiology, ecology and spectroscopy in tropical system
   c Carbon dynamic and biodiversity of forest assessment
2 Field spectroscopy
   a Effect of soil type on plant growth, leaf nutrient/chlorophyll concentration and leaf reflectance of tropical tree and grass species
   c Spectral expression on gender
   d Species classification of tropical leaf reflectance and dependence on selection of spectral band

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   e Discrimination of wood-boring pest in pine forest plantations in South Africa
3 Airborne data
   a Hyperspectral remote sensing of exposed wood and deciduous trees in seasonal tropical forests
   b Assessing recovery following selective logging of low land tropical forest
   c A technique for reflectance calibration of airborne hyperspectral data using a broad, multiband radiometer
4 Satellite imagery
   a Assessment of phenology variability in amazon tropical rain forest using hyperspectral Hyperion and MODIS data
5 Future directions
   a Hyperspectral remote sensing of canopy chemistry, physiology, and biodiversity in tropical rainforest
   b Tropical remote sensing: opportunities and challenges

The favorite chapters

Within 13 chapters available in this book, the most favorite chapters are Chapter 3 and Chapter 9. Chapter 3 is dealing with the use of hyperspectral image for assessing carbon dynamic and biodiversity of forest, while Chapter 9 describes the use of hyperspectral data for assessing the recovery following selective logging of low land tropical forest. Chapter 3 provides an overview of the use of hyperspectral data in tropical and sub-tropical forest and focused mainly on forest types that prevalent in the region, such as rain forest (evergreen and semi-ever green), mangrove and wooded savannas. This chapter conveys feature of spectral data that allow different levels of information, as well as demonstrates the use of hyperspectral data for assessing forest biodiversity, carbon dynamics and health. Finally, this chapter concludes the perspective of the use of hyperspectral remote sensing for tropical and sub-tropical forest particularly in providing information for conservation, restoration and sustainable utilization of forest. The conclusion of Chapter 3 is in line with the research of Lambin *et al.* (2003) and Jaya (2002b; 2003) on the use of Compact Airborne Spectograph Imager (CASI) for discrimination trees species and biomass. It was found that CASI (hyperspectral) image may provide better accuracy than IKONOS. Foody *et al*. (2001) also found the relationship between biomass and remotely sensed data.

Examination of hyperspectral data for detecting the succession stage of tropical forest after selective logging had been neatly presented in Chapter 9. This chapter is focused on monitoring natural forest changes particularly due to selective logging in tropical forest. This chapter is very much in line with the tropical forest harvesting techniques widely applied in Indonesia. As we know that since the 1970s, almost all forest concessions in Indonesia apply Indonesian selective cutting system. Monitoring the rate of forest succession after logging is a very important task to predict the ability of recovery from natural forests. The on-going major limitation for assessing the forest recovery rate is the lack of information representing a chronological sequence of the harvesting, thus precluding solid forecasting of regeneration trajectory. This chapter describes the successful of hyperspectral imagery to be used to detect age class after selective cutting, accurately with an error lower than 5%, both in the spatial resolution of 16 or 30 m. By understanding the impact of logging on the landscape scale, it is necessary to improve conservation practices outside the protected area. This is also in line with the study results reported by Susilawati and Jaya (2003). The content of this chapter is also coincide with the previous study of Jaya (2000, 2002a) and Jaya *et al*. (2000) in using the medium-resolution optical imageries for detecting deforestation and forest degradation.

The use of hyperspectral may be one reliable tool to measure the success or failure of reforestation for incentives or disincentive award. It is also possible to measure the rate of deforestation and forest degradation.

The most practicable use of hyperspectral for measurement, reporting and verification of tropical forest

For practical purposes, the presence of hyperspectral imagery will significantly contribute the implementation of monitoring, reporting and verifying (MRV) system. In this MRV, the use of hyperspectral remote sensing is becoming very relevant, because the principle measurement of MRV basically use:
1 The remote sensing and terrestrial approaches. The emission factor calculations are based on data derived from land-use and land cover change using remote sensing data and data measurement of detailed carbon through national forest inventory (NFI).
2 Using appropriate land use categories that in line with the IPCC Guidelines published in 2006.

The MRV principle is applied to collect carbon content for each forest type and forest cover, which is usually diverse among forest types. For MRV activities, the analytical tool suggested by the IPCC are (1) monitoring forest cover change via satellite imageries, and (2) implementation of national forest inventory to determine the carbon content in each type of forest. Hyperspectral imageries are potential to provide information such as activity data for calculating emissions levels of green-house-gases (GHG). The collection of activity data can be obtained from a variety of satellite imagery (e.g. hyperspectral data), and calculation of GHG emission or absorption that occurred in 5 carbon pools according to their tiers.

Hyperspectral data are potential to be used to provide detailed information on the implementation of MRV with the following principles (Jaya & Saleh 2011):
1 Consistent: since the hyperspectral can be analyzed with consistent method, then it would provide consistent MRV system.
2 Transparent: remotely-based MRV system is open to the public and can be verified by an independent agency.
3 Complete: hyperspectral may provide major portion of information required.
4 Accurate: hyperspectral may provide a certain level of accuracy.
5 Comparable: the result derived from satellite imagery can be comparable with the information derived from other countries.

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Conclusion

Hyperspectral remote sensing offers to revolutionize studies of tropical forest biochemistry, physiology and biodiversity that could bear conservation, management, and policy development effort.

Lesson learned

The methods and sensors play a major role in determining what can be done today and might be possible in the future. No single wavelength or region uniquely sensitive to a particular biochemical. At the crown or canopy level, hyperspectral reflectance properties are driven by leaf properties, but are mediate by canopy structural and architectural characteristics. However, the general applicability and scability of the biochemical-diversity approach remains unknown.

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