

Workshop on Land-Cover Land-Use Change in Southeast Asia

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LCLUC workshop participants.

Introduction

The annual international Land-Cover Land-Use Change (LCLUC) Science Team Meeting and Training Workshops were held jointly with the Monsoon Asia Integrated Regional Study (MAIRS) and the Global Observations of Forests Cover and Land Cover Dynamics (GOF-C-GOLD) programs in Hanoi, Vietnam, from November 5-11, 2011. The Center for Research and Ecological Studies of Hanoi University of Agriculture hosted the meeting, with contributions from the Global Change System for Analysis Research and Training (START) program; Vietnam Forestry University (VFU); University of Maryland, College Park (UMCP); Michigan State University (MSU); the East-West Center (EWC); and NASA. More than 100 participants representing eight countries attended the Southeast Asia (SEA) regional meeting. The goals of the meeting were to review LCLUC research conducted throughout Southeast Asia (SEA) by regional and international scientists, and to discuss the availability of satellite datasets and new research methodologies relevant to regional analysis.

This meeting was a follow-on to the Khon Kaen meeting held in Thailand in January 2009¹, and provided an opportunity for scientists to present and discuss research related to remote sensing measurement and

¹ The Khon Kaen meeting was described in the March-April 2009 issue of *The Earth Observer*, [Volume 21, Issue 2, pp. 22-24].

monitoring tools, and analysis related to land-cover and land-use change in the SEA subtropical and tropical regions. In particular, there have been several recent advances in remote-sensing methods that have been fueled by open access to Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat data archives, including NASA research contributions to near-real-time monitoring, systematic long-term monitoring, ground-based global positioning system (GPS)-photo sharing, unmanned aerial vehicles, forest age measurement capabilities, and forest rotation analysis.

These new methodological techniques and data are applicable to the study of land-use changes in the SEA region. Current LCLUC-funded projects that focus on this region raise awareness about available NASA assets; they also strengthen relationships with local scientists and regional networks to address emerging issues associated with rapid land-use/land-cover change. In addition, satellite programs in Thailand, China, Japan, India, and Vietnam also offer opportunities for national baseline development and monitoring of land-use change. Improving access to these national and regional datasets and land-cover products would benefit local and international research projects, alike.

Opening Presentations

The first three presentations provided context for the focus on scientific activities that followed.

Chris Justice [UMCP—LCLUC Program Scientist] explained that one of the international remote sensing community's priorities is to encourage data collectors and providers beyond those already involved—including national governments and private industry—to allow open access to datasets for research to foster the continued long-term availability of data and to support improved access to data through enhanced information networks and access to databases.

Garik Gutman [NASA Headquarters—LCLUC Program Manager] described the LCLUC Program and its relationship to the MAIRS program. MAIRS is an international research program in SEA that aims to enhance understanding of human–natural systems and the complex interactions within and between them, in the local and global context of sustainable development. MAIRS also coordinates integrated studies among institutions and stakeholders and builds capacity for observations, analysis, and modeling in the region. The LCLUC Program is one of several that provide support to regional science projects as a contribution to the MAIRS program. Several of these projects quantify land-cover land-use change in the SEA region using remote sensing techniques or methodologies, and include an evaluation of the socioeconomic and political drivers associated with the physical land changes observed.

Alikun [MAIRS—International Project Office] provided an overview of recent MAIRS initiatives in SEA, including a description of some of the currently funded regional studies. The MAIRS Megacity project is evaluating the potential health risks and hazards associated with increases in urban land area, urban populations, pollution, temperatures, and extreme weather events. This project uses comprehensive observational networks to establish relationships between climate change and urbanization, while modeling the impact of urbanization on regional and global climate. Another MAIRS project involves exploring environmental changes occurring in dryland Asia, focusing on the impact of global warming on water resources, the water cycle, and ecosystem services; the vulnerability of human–environmental systems from climate change; and the feasibility of resilient adaptation strategies for the region. Alikun explained that the goal of the MAIRS program is to improve land surface and terrestrial ecosystem models for the region through offline model intercomparisons.

Science Presentations

After these introductory remarks, the remainder of the meeting consisted of invited scientific presentations. The full meeting agenda, presentations, and posters are available at the LCLUC website at lcluc.umd.edu/meetings.php?mid=21. A few selected highlights follow.

Xiaoming Xiao [University of Oklahoma] provided a description of a methodology to fuse optical and microwave sensor data for land-cover mapping of the region using Phased-Array type L-band Synthetic Aperture Ra-



Local and regional scientists at the Science Team Meeting poster session in Hanoi, Vietnam.

dar (PALSAR), Landsat Enhanced Thematic Mapper Plus (ETM+), and MODIS 250-m datasets. Xiao also described methods used to measure cropping intensity in the region, providing an overview of the current LCLUC-funded project titled *Quantifying changes in agricultural intensification and expansion in monsoon Asia during 2000–2010*. The algorithm employed to describe cropping intensity calculates the number of crops per year using the Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), and Land Surface Water Index (LSWI). These field-scale data are then complemented with a recently developed community- and citizen-science data portal (www.eomf.ou.edu/photos) that archives georeferenced field photos of croplands in the region. The photos and field measurements are used to calibrate the model and to validate the algorithm. This approach will be used to map agricultural intensity around the world.

Nguyen Dinh Duong [Institute of Geography—Hanoi, Vietnam] presented a methodology used to develop a 14-category land-cover map for Vietnam for 2001–2003. This multitemporal, multispectral classification, using MODIS cloud-free composites, was based on fea-

tures of the spectral reflectance curve shape and total reflectance from different spectral bands. In this project, GPS photos were also used to provide more than 6000 ground samples of land cover. The classification, when compared to 100 random points, demonstrated greater than 85% accuracy. The resulting national statistical yearbook and the land-cover map for 2002 match well with one another.

Matt Hansen [UMCP] provided an overview of the use of MODIS and Landsat regional products to monitor forest cover. His presentation focused on mapping forest extent and recent changes in Indonesia. A national-scale forest-type map should be completed by the end of 2012; the map will include classification of primary/intact, primary/degraded, wetland, peatland, timber, and palm forest-cover types, with a description of the rates of change within and between categories. These forest themes can be characterized in a hierarchical manner to quantify change dynamics for use in national, policy-driven monitoring objectives. Hansen also mentioned the importance of automated preprocessing of large volumes of imagery for most humid tropical areas—needed because a considerable amount of imagery contains cloud cover that can interfere with analyses.

REDD+ Carbon Sequestration Initiatives

Many of the presentations at this year's international LCLUC meeting described the United Nations Collaborative Initiative on Reducing Emissions from Deforestation and forest Degradation (UN REDD+) program and related initiatives that build local capacity for measuring and monitoring carbon. Numerous *afforestation* programs have been initiated because of increasing incentives for forest conservation from the international community. According to the United Nations Food and Agriculture Organization, from 1990–2005 Vietnam and China afforested 1–5% of the countries' land area, while Cambodia experienced deforestation at the same rate, and Thailand, Laos, and Myanmar lost an average of 0–1% of forest land area. Recently established UN REDD+ programs will provide incentives for afforestation projects and reduce, or at least counterbalance, deforestation that is occurring in the region. **Chris Justice** explained that efforts need to focus on making linkages between conventional forest inventory and remote sensing methods. He also noted that recently developed practical methods for monitoring, reporting, and verification—all in the context of REDD+—could benefit national efforts.

Dave Skole [MSU] described the relationships between carbon, forests, and livelihoods, noting the importance of agroforestry and carbon sequestration carbon credits for the region's forest conservation initiatives. He provided examples of various marketable forest ecosystem

services, including the use of the subcanopy shrub plants from the *Indigofera* family for the production and sale of natural indigo dye, or the collection of edible mushrooms for sale at the local markets. These products can be included in mixed agroforest systems as secondary products to provide income and to ensure protection of carbon sequestering landscapes. Skole continued with a description of MSU's recently developed Carbon Benefits Project—funded by the United Nations Environment Programme—that models, measures, and monitors forest-cover change for carbon markets using high-resolution remote sensing data to enhance capacity at the national, state, and local levels for carbon-market participants. Thailand's Inpang Network uses the resources of the MSU *Carbon2Markets* project to evaluate the development of the pilot Tree Bank project.

Usa Klinhom [Maharakham University] described Tree Bank's pilot program, which has been established in one of the poorest areas of Thailand. The project assisted 4000 households in 890 villages from five provinces, raising the area's average annual income from \$1228 to \$3077—U.S. Dollars (USD)—by making the transition from monocropping products (like cassava and sugarcane) to teak plantations. The next step will be to expand the carbon credit from teak plantations to agroforestry, incorporating multiple-crop agroforestry and orchard areas of dipterocarp, longan, tamarind, and mango. To complete the project, as well as the measurement and monitoring strategies, the results of this pilot program will be assessed by submitting the results to the U.N. as a community-scale pilot program for REDD+.

Do Xuan Lan [Department of Science Technology and Environment, Ministry of Agriculture and Rural Development—Vietnam] described REDD+ measurement, reporting, and verification initiatives for Vietnam that have taken place since the approval of \$4.4 million (USD) from UN-REDD+. The U.N. funding has been used for REDD+ pilot program implementation at the district, province, and national levels to improve the institutional and technological capacity for nationally coordinated management of REDD+ activities. These activities include developing a payment scheme with equitable and transparent benefits for ecological services at the provincial and district levels, while incorporating a participatory carbon-stock (C-stock) monitoring system, and improving information networks to address the different approaches for reducing regional displacement of carbon emissions and regulation, and enforcement to combat the cross-border flow of illegal timber.

LCLUC Panel Discussion

After these presentations, a panel session took place, allowing regional representatives the opportunity to pres-

ent their views on their respective national priorities for LCLUC research. Scientists representing Vietnam, Thailand, Myanmar, Laos, China, and Indonesia participated in the discussion.

- **Nguyen Dinh Duong** [Institute of Geography—Hanoi, Vietnam] argued that incentives for remote sensing of LCLUC could be established for government investments if the research projects were associated with measuring or monitoring policy.
- **Thiha** [Walai Rukhavej Botanical Research Institute, Myanmar] explained that scientists must find a way to work within the government framework. He stated that there is no opportunity to conduct this research—either formally or informally—or to successfully implement sustainable management practices without the cooperation of government agencies.
- **Heqing Huang** [Chinese Academy of Sciences] described the value of models, particularly the utility of agent-based models, in understanding human vulnerability, resilience, and adaptation to Earth system changes and extreme weather events.
- **Wardoyo** [Ministry of Forestry—Indonesia] established that there is a regional need for high-resolution satellite data to quantify LCLUC, particularly for peatland forests and carbon monitoring.
- **Saphangthong Thatheva** [National University of Laos] expressed a need to share platforms to organize and distribute information about data availability and to whom requests should be made for further information on data from within and outside of Laos.

The panelists agreed on many other national and regional LCLUC priorities. These include long-term data archives; continued and increased support for data-sharing initiatives; photographic and field measurement data collection projects; commencement of within-nation negotiations for the release of data to the community; standardization of scale for the region; and increased emphasis on training and access to information and technology.

Suggestions for enhancing the regional network included restructuring the Southeast Asia Regional Research and Information Network (SEARRIN) to increase communication and coordination between the SEARRIN secretariat and other regional programs, organizations, and institutions like SEA-START, and to produce tangible opportunities for funding, linkages, education, and capacity building. Investments should be made to develop a synthesis of the results of prior research in the region and

research and development projects that meet the needs of emerging climate and carbon policy, forest investment policy, and agricultural and development policy, all while strengthening research that investigates the human dimension of and political influences on land-use change.

To conclude, **Chris Justice** provided a synthesis of the workshop, highlighting the LCLUC issues in the region that arose during the meeting. Regional issues include rapid expansion and landscape modification, loss and degradation of agricultural land, the lack of adequate public services (like water supply and sanitation), human health and livelihood issues, and increasing land values. There is some assessment of environmental impact, but little progress towards systematic monitoring and reporting of LCLUC impacts in the region. Justice explained that the changing face of agriculture resulting in increased field size, biofeed stocks, year-round agroforestry, and livestock, will continue to grow, and the associated ecological impacts of land-use change could benefit from more attention. Regional landscape fragmentation resulting from various economic development initiatives, government policies, land management, and effectiveness of policy enforcement could be helped by regional agreements to deter transboundary leakage and invite international investment. Resource disparities within and between provinces exist and are exacerbated by competition between the local peoples, private industry, and government institutions. Such conditions often result in an inability to manage LCLUC and to address the economic imbalance within nations and throughout the region.

LCLUC Workshop Training

Directly after the meeting, from November 9-11, 2011, two concurrent workshops, organized in collaboration with local universities, were held to train participants in LCLUC analysis, with emphasis on combining remote sensing, ground, and census data to describe afforestation, deforestation, and urban sprawl—all of which are major land-cover changes occurring in the area.

The first workshop, cohosted by the VFU and the Vietnamese Ministry of Agriculture and Rural Development (MARD), addressed remote-sensing and field-based estimation of C-stocks in tropical forests. More than twenty scientists from Vietnam, Indonesia, China, Thailand, Laos, Russia, and the U.S. participated in the training. This two-day gathering included both training in field-based data collection and computer laboratory work on remote sensing analytical techniques to quantify carbon in forest and agroforestry systems. On the first day of the workshop, participants collected field data in Bac Giang province, approximately 100 km (~62 mi) northeast of Hanoi; this area offers a complex, mosaic landscape of annual dryland

crops such as cassava and soybean, litchi orchards, wetland rice, and forested areas consisting of both production and protection forests. Land devoted to litchi production in Bac Giang has increased significantly since the mid-1980s. Reforestation for both production and protection forests has also increased over the past ten years. These landscape transitions over the past 20–30 years have resulted in higher landscape C-stocks, as long-lived woody perennials replace annual crops and degraded shrub land.

For the field component of the training, participants established biomass data collection plots in a litchi orchard and an acacia plantation. They also recorded GPS locations; examined canopy openness with a digital camera's fish-eye lens; and recorded tree biometric data with 30-m (~98-ft) tapes (to measure crown diameters), diameter breast height measurement tapes, and laser hypsometers. These data were used to cross-calibrate the measurement approaches and to validate the automated tree-crown area and forest fractional-cover products derived from remotely sensed satellite data, as well as to calculate biomass and carbon by using the tree biometry data. The laboratory training, held at the VFU on the second day of the workshop, included hands-on processing of Landsat ETM+ data for vegetation fractional cover as well as geographic information systems (GIS)

transformation of the tree-crown area output data (from high-resolution data) to polygon shapefiles; associated Carbon stock values were derived from a tree-crown-to-biomass allometric equation. This allometric equation was recently developed by MSU's Department of Forestry, VFU, and MARD. **David Skole** and **Jay Samek** [MSU] led the workshop with support from **Phung Van Khoa** [VFU] and **Do Xuan Lan** [MARD].

The second workshop session was led by **Jeff Fox** [EWC], and focused on training the eleven participants in mapping peri-urbanization with remote sensing and census data. The goal of this training was to teach two methods for mapping peri-urbanization. The training included lectures, discussions, hands-on computer exercises, and map-validating ground measurements. On the first day, participants learned methods for exploratory data analysis and visualization of census data. On the second day, participants learned methods for satellite image classification and change detection using the geospatial imagery processing and analysis application, ENVI. To complete the analysis, the participants traveled to three nearby communes that represented rural (Phu Dong), urban (Phuc Loi), and peri-urban (Co Bi) landscapes for ground measurements of the map classifications. ■



Carbon training workshop participants beginning field measurements in the Bac Giang province.