Regional Drought Information System

Rishiraj Dutta, Senaka Basnayake, Susantha Jayasinghe, Asian Disaster Preparedness Center (ADPC)
Chusit Apirumanekul, Stockholm Environment Institute (SEI)
Peter Cutter, Spatial Informatics Group (SIG)
John Bolton, NASA Goddard Space Flight Center

Why this project?
- Droughts in the Lower Mekong Region negatively impact ecosystem services, food and water security, and biodiversity. These impacts are exacerbated by climate change, further highlighting the need for improved governance and decision making in virtually all sectors.

Objectives
- Develop an integrated information system to be used by local decision makers for drought monitoring, analysis and forecasting and planning to respond to droughts.
- Provide policy-makers and growers with drought indices and forecast drought indices to facilitate better decision making at the single growing season resolution.
- Provide ecological and financial forecasting information to inform seasonal cropping decisions. Subsequent functionality may include additional information relevant to decisions at sub-seasonal or multi-year temporal scales.

Approach/Project Activities
- **Evaluation of drought indices** using a comparative evaluation method to identify the most suitable approach for drought monitoring. Examples include: Standard Precipitation Index (SPI), Standard Precipitation Evaporation Index (SPEI), Palmer Drought Severity Index (PDSI), and Vegetation Health Index (VHI).
- Forecast drought with seasonal weather forecasting products and a multi-model ensemble technique for climate prediction / projection on seasonal to inter-annual time scales.
- Customize and calibrate drought products at a regional scale to allow stakeholders to plan their activities in the event of a drought and allow decision makers to make and review the effectiveness of their decisions.
- Operationalize the system and make the products available through a web-based platform.

Sample Results

**Return Period of Droughts in Cambodia**

![Moderate Drought (Annual)](image)
![Severe Drought (Annual)](image)

**Observed Drought Susceptibility (Probability of Drought Occurrence) for Cambodia and Lao PDR**

(Source: ADPC)

**Drought in the Mekong impacting farmers**

Outcomes/Anticipated Impacts
- Improve the operational, technological and institutional capabilities to prepare for and respond to droughts in the Lower Mekong Region;
- Assist local governments and the agricultural sector with seasonal drought forecasting;
- Assist local governments and the agricultural sector implement short and long-term mitigation measures during and in advance of droughts;
- Assist local governments and the agricultural sector with drought preparedness, projection/monitoring systems, mitigation strategies and planning;
- Characterize droughts by identifying accurate, reliable, and timely estimates of severity and impacts of droughts;
- Assess the economic, social and environmental impacts of drought on vulnerable people and water-related resource systems;
- Develop critical regional and local thresholds, reflecting increasing levels of risk and vulnerability to drought, as agreed by stakeholders. These thresholds could be used for drought monitoring, forecasting and projection.

Focus Area
- Lower Mekong Region including Cambodia, Lao PDR, Myanmar, Thailand and Vietnam (with adjustments the tool can easily be used elsewhere.)

Project Partners
- [SERVIR MEKONG](https://www.servirmekong.org)
- [AdPC](https://adpc.or.th)
- [SEI](https://www.sei.se)
- [Monthly](https://www.monthly.com)

Earth Observations & Other Inputs
- Vegetation Health Index (VHI)
- Normalized Difference Vegetation Index (NDVI)
- Standard Precipitation Index (SPI)
- Standard Precipitation Evaporation Index (SPEI)
- Palmer Drought Severity Index (PDSI)
Regional Land Cover Monitoring System

Why this project?
• Monitoring land cover and land use change is important for land resource planning, understanding ecosystem services including resilience to climate change, biodiversity conservation, and other issues. However, updates are infrequent and classification systems do not always serve key user groups. At the regional level, the only maps currently available are the products of global land cover maps that lack some of the typological resolution needed for many regional applications and decision-making contexts.

Objectives
• To develop a unified regional (satellite-based) land cover monitoring system.
• Produce annual land cover (LC) maps of the Lower Mekong Countries: Thailand, Cambodia, Myanmar, Lao PDR and Vietnam for each of the years 2000 to 2015.
• Provide an analysis tool that can easily be used for different time-series.

Approach/Project Activities
• Catalogue existing typologies and use cases
• Recommend a unified regional typology that will be used as a basis to design the land cover monitoring system.
• Select disaggregated specific classification algorithms (i.e., algorithms for mapping mangroves, urban areas, forested areas, agricultural production, etc.)
• Integrate algorithms into the land cover tool to derive regional LC maps. The tool consists of two components:
  1. a Google Earth Engine (GEE) application that performs image analysis
  2. a user-friendly site/app using Google’s appsspot.com that exposes the application to the users.
• Collect control points from multiple sources using a random stratified sampling approach consistent with the regional LC classification typology.
• Employ a validation method that quantifies a confusion matrix for each LC product. Improvements will be made to the system and uncertainties quantified.
• Perform initial testing (tool ver-1) using a 15-year archive of Landsat data for 2000-2015.

Focus Area
5-country SERVIR-Mekong region (Myanmar, Lao PDR, Vietnam, Cambodia, and Thailand)

Anticipated Impacts
• The project will develop a system that will use a common set of input data sources coupled with custom classification “ontologies” to generate unified high-quality land cover maps reflecting the needs of countries and agencies on a regular (at least annual) basis.
• Improved policy, planning, and decision making by a wide range of users.
• The product will showcase SERVIR-Mekong collaboration with the Greater Mekong Sub-region Core Environment Program (CEP) as an example of synergies within the Sustainable Mekong Program and many other partners.

Project End Users
• ADB: Greater Mekong Sub-region Core Environment Program
• Forestry/Agriculture Ministries/Departments in Mekong region
• Mekong River Commission (MRC)
• International and local NGOs (Natural Heritage Institute: NHI)

Sample Expected Outputs

Cambodia example: Forest is dark green, water is dark blue, urban is purple, shrubland is light green, rice field is yellow.

Global Example: Global Land Cover Map over Lower Mekong Countries using MODIS (UMD-IGBP).

Earth Observations & Other Inputs
• LandSat-7, LandSat-8
• MODIS
• Context Data
• SAR
• High-Resolution Satellite Imagery
Myanmar maintains substantial forest cover compared to other Southeast Asian countries, but severe logging, expanding plantations, and forest degradation pose increasing threats. To assess how these rapid changes are affecting Myanmar, new, accurate, and detailed information about the condition of remaining intact forests is urgently needed.

### Background

Myanmar maintains substantial forest cover compared to other Southeast Asian countries, but severe logging, expanding plantations, and forest degradation pose increasing threats. To assess how these rapid changes are affecting Myanmar, new, accurate, and detailed information about the condition of remaining intact forests is urgently needed.

### Land Cover Classification

<table>
<thead>
<tr>
<th>Static land cover from 2002-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intact Forest</strong></td>
</tr>
<tr>
<td><strong>Degraded Forest</strong></td>
</tr>
<tr>
<td><strong>Water</strong></td>
</tr>
<tr>
<td><strong>Non-Forest</strong></td>
</tr>
<tr>
<td><strong>Plantations</strong></td>
</tr>
</tbody>
</table>

Forest land cover conversions

- New Non-Forest: Intact forest in 2002 to <10% canopy cover in 2014
- New Plantations: Intact forest in 2002 to plantation in 2014
- New Degraded Forest: Intact forest in 2002 to degraded forest in 2014
- New Water: New reservoirs, changes in rivers, and hydro-electric projects


### Changes in Forest Cover

- Forest still covers 63% of Myanmar, making it one of the most forested countries in the region. However, only 38% of all forest is intact, covering 24% of the country.
- Between 2002 and 2014, intact forest declined at a rate of 0.95% annually, totaling nearly 3 million ha of forest loss.
- Overall forest cover (both intact and degraded forest) had an annual net loss of 0.55% between 2002 and 2014. Declines have accelerated over the last decade. Leimgruber et al. (2005) found a 0.30% annual rate of forest loss between 1990 and 2000.

### The Future of Forests in Myanmar

Myanmar is at a crossroads where overall forest cover remains high, but intact forest is quickly being lost or degraded. Protection of remaining intact forest, restoration of degraded forest, and sustainable forest use are critical to the long-term future of Myanmar’s forest ecosystems and their associated biodiversity.
Undisturbed Forests in the United States – Assessment and Predictions Based on Landsat Observations

Introduction and Background

Forest provides many important ecosystem services. Logging, fire, and other disturbances can disrupt or even diminish the provision of these services. Although many map products and inventory data are available to estimate forest area at some specific time points, it is not clear how much forest in the United States remained and will remain undisturbed.

Recently, the North American Forest Dynamics (NAFD) study produced annual forest disturbance maps for the conterminous US (CONUS) over the time period 1986-2010. These 30-m, wall-to-wall maps were derived by analyzing 25,000+ Landsat images selected from over 150,000+ Landsat acquisitions available for the spatial and temporal domains of the NAFD study using the NASA Earth Exchange (NEX) cloud computing facility (https://etl.nasa.gov/nex). In this study, we used these NAFD-NEX maps to identify and characterize “undisturbed” forests that were not disturbed between 1986 and 2010 according to the NAFD methods.

NAFD-NEX Disturbance Products

The NAFD-NEX products are distributed from the ORNL DAAC at https://daac.ornl.gov/NACP/guides/NAFD

Analysis of “Undisturbed” Forest

Undisturbed forests (UDF) are distributed following ecoregion boundaries in many areas.

Percent forest remaining undisturbed (PFUD) within a time interval decreased following an exponential decay function as the time interval increased:

\[
\ln(\text{PFUD}_t) = \ln(\text{PFUD}_0) - \lambda t
\]

Table: Percent forest remaining undisturbed (PFUD) within a time interval decreased following an exponential decay function as the time interval increased.

<table>
<thead>
<tr>
<th>Region</th>
<th>Forest Area (km²)</th>
<th>Forest Density (%)</th>
<th>UDF Area (km²)</th>
<th>UDF Density (%)</th>
<th>PFUD (%) at year 25</th>
<th>Predicted PFUD at year 100 and 95% confidence interval</th>
<th>Predicted PFUD at year 200 and 95% confidence interval</th>
<th>Coefficients of fitted eq. (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>812,795</td>
<td>32.4</td>
<td>675,077</td>
<td>83.1</td>
<td>49.1 (47.5, 50.3)</td>
<td>24.4 (22.2, 25.5)</td>
<td>9.0 (8.3, 9.7)</td>
<td>98.1 0.007 0.999</td>
</tr>
<tr>
<td>Southern</td>
<td>340,982</td>
<td>42.7</td>
<td>480,958</td>
<td>51.1</td>
<td>4.6 (5.6, 3.6)</td>
<td>0.9 (0.4, 0.5)</td>
<td>49.2 0.024 0.999</td>
<td>99.1 0.009 0.999</td>
</tr>
<tr>
<td>Interior West</td>
<td>475,599</td>
<td>21.3</td>
<td>348,320</td>
<td>73.2</td>
<td>29.7 (28.6, 30.8)</td>
<td>9.0 (8.3, 9.7)</td>
<td>97.2 0.011 0.999</td>
<td>99.0 0.011 0.999</td>
</tr>
<tr>
<td>Pacific Northwest</td>
<td>344,608</td>
<td>41.2</td>
<td>210,864</td>
<td>61.4</td>
<td>14.3 (13.5, 15.2)</td>
<td>2.1 (1.9, 2.4)</td>
<td>95.8 0.018 0.999</td>
<td>99.9 0.015 0.998</td>
</tr>
<tr>
<td>CONUS</td>
<td>2,573,984</td>
<td>33.1</td>
<td>1,715,168</td>
<td>66.6</td>
<td>18.8 (17.7, 20.0)</td>
<td>3.6 (3.2, 4.1)</td>
<td>95.4 0.015 0.998</td>
<td>99.9 0.015 0.998</td>
</tr>
</tbody>
</table>

Results and Conclusions

- Two thirds, or 1.7 million km², of the forests in CONUS remained undisturbed between 1986 and 2010.
- Protected areas and stream buffer zones kept more forest undisturbed than outside those areas.
- Assuming disturbance rates remain relatively stable over time, the percentage of forest remaining undisturbed (PFUD) in CONUS will be reduced to 18.8% and 3.6% in 100 and 200 years, respectively, with large variations among regions.
- Management approaches aimed at reducing timber harvest rates in the south and mitigating fire risks in the west are needed to maintain higher levels of undisturbed forests.
Large-Scale Land Acquisitions (LSLAs): Global analysis and Cambodia case study

Evan Ellicott, Katie Haviland, Honglin Zhong, Ariane de Bremond, Kuishuang Feng, Klaus Hubacek

University of Maryland, College Park, MD

Introduction

Large-scale land acquisitions (LSLAs) are occurring across the globe by transnational investors and governments seeking to secure access to land, primarily in developing countries, for a variety of investment intentions [1, 2]. While estimates vary as to the scope of LSLAs [3], data collected by the Land Matrix (www.landmatrix.org) suggest that a globally significant land change phenomenon is underway, with more than 40 million hectares of land being acquired by foreign investors under long-term lease contracts since 2000, and announced intentions totaling 16 million hectares [4]. For this poster, we present results from our analysis of LSLAs globally and in Cambodia. We conclude with potential implications for Myanmar.

Global Analysis

Global LSLA data was obtained from the Land Matrix (Fig. 1). Analysis was performed for concluded deals with all and agriculture-only investment intentions. (Eg: All intentions = 1573; Countries = 81). Multivariate logistical regression analysis was conducted with the intention of developing a probabilistic model for LSLA occurrence. Independent variables (Table 1) included political, social, economic, and biophysical factors. For this presentation, the analysis period was 2000-2008.

Table 1: Independent variables used in logistical regression analysis.

Deals were imported into ArcGIS and ENVI and interrogated with remotely sensed data to detect and monitor land cover change. The steps are summarized below and in Figure 5. The MODIS EVI time-series pointed to 19 deals which had some level of abrupt vegetation change. Fig. 3 provides an example from one of these 19 deals.

The MODIS VCC product for the same area as the EVI temporal segmentation is also shown in Figure 3. The difference between 2009 and 2014 is obvious. The red arrow is pointing to the specific area of interest in this example.

Analysis of the Cambodia deals included use of the Global Forest Change product [4] to examine the amount and year of loss. Forest cover loss has been rapid for the past several years, but saw a steep decline in 2014 (Fig 6a) and (Fig 6b); policy change a likely explanatory factor.

Preliminary analysis suggests a strong degree of collinearity between variables (e.g. Fig. 2), but at the same time, when this is accounted for, several factors prove to be important in predicting LSLA occurrence.

Step-wise (both directions) logit regression was conducted in R and has some evidence, showing the number of deals in a country (n=81) as a function of that country's mean governance score.

Cambodia Analysis

Cambodia LSLA data is from the Land Matrix (n=114) and Open Development Cambodia (ODC) (n=223). Of the 114 transnational deals in Cambodia 103 are concluded with the vast majority (88%) intended for agriculture (see Table 2). However, for this study we focused on 33 deals which had the greatest certainty as to spatial location (Fig 4). The total intended area for these deals is 192,458 ha with 2011 being the mean and median year of the contract. The intention of investment for 29 of the 33 deals is rubber and the dominant investor country is Vietnam.

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Impacts of Ecotourism on land use in the High Himalaya

Jodi S. Brandt¹, Volker C. Radeloff², Teri Allendorf²

Research Question and Theoretical Framework

Ecotourism is a common “Sustainable Development” strategy across the Himalaya, because it offers potential for economic development and environmental protection.

- Theoretically, ecotourism will lessen degradation that occurs with economic development, because there is economic incentive to protect natural resources that tourists come to experience (Balmford 2009).

- However, ecotourism requires infrastructure, and stimulates economic development and population growth, all of which are known drivers of deforestation (Lambin 2001).

What is the impact of ecotourism on land use systems in the High Himalaya?

1. What were ecotourism impacts in Shangri La, China?

We conducted in-depth land use change mapping, social surveys, and econometric modeling in the Chinese Himalaya.

Take-home: Ecotourism led to a trade-off between economic development and forest protection.

2. Can we accurately detect changes in different forest types?

Take-home: Change detection of different forest types was performed with high accuracy.

3. Was ecotourism associated with high deforestation in other sites across the Himalaya?

Take-home: Ecotourism impacts vary widely, indicating some tourism models are more sustainable.

Future Work – Ecotourism impacts and forest change across the Trans-Himalaya Region

1. Ecotourism varied widely, by site and by country. Why?
   • We will establish four new ecotourism case study sites in Nepal, Bhutan, India, and Myanmar. We will conduct original land use change, economic, and social survey analysis at each site.

2. The High Himalaya lacks regional maps for change detection of different forest types.
   • We will perform regional-scale mapping of forest type and change across the High Himalaya. We will test novel techniques including Automated Terrain Correction Algorithms and Textural Analysis. Products will be made freely available, and will be used for econometric modeling of land use change in the Trans-Himalaya region.

Affiliations

¹ Boise State University
² University of Wisconsin-Madison

Contact Information
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Human Environment Systems Initiative, Boise State University
Forest Cover Status of Myanmar (FRA 2010)

<table>
<thead>
<tr>
<th>Area (,000 ha)</th>
<th>% of total country area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed forest</td>
<td>13,445</td>
</tr>
<tr>
<td>Open forest</td>
<td>18,329</td>
</tr>
<tr>
<td>Total forest</td>
<td>31,773</td>
</tr>
<tr>
<td>Other Wooded</td>
<td></td>
</tr>
<tr>
<td>land</td>
<td>20,113</td>
</tr>
<tr>
<td>Others</td>
<td>13,869</td>
</tr>
<tr>
<td>Water body</td>
<td>1,903</td>
</tr>
<tr>
<td>Total</td>
<td>67,658</td>
</tr>
</tbody>
</table>

Forest Cover Status of Myanmar (FRA 2015 Draft)

<table>
<thead>
<tr>
<th>Area (,000 ha)</th>
<th>% of total country area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed forest</td>
<td>15,306</td>
</tr>
<tr>
<td>Open forest</td>
<td>15,167</td>
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<tr>
<td>Total forest</td>
<td>30,473</td>
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<tr>
<td>Other Wooded</td>
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<td>land</td>
<td>14,524</td>
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<tr>
<td>Others</td>
<td>20,759</td>
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<td>Water body</td>
<td>1,903</td>
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<tr>
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</tr>
</tbody>
</table>

Projected Data for FRA 2015

Forest Cover Changes in Myanmar

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (000 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>57,97%</td>
</tr>
<tr>
<td>2000</td>
<td>51,54%</td>
</tr>
<tr>
<td>2005</td>
<td>49.25%</td>
</tr>
<tr>
<td>2010</td>
<td>46.96%</td>
</tr>
<tr>
<td>2015</td>
<td>45.04%</td>
</tr>
</tbody>
</table>

Projected Data for FRA 2015

Land use and Land cover change Ayeyarwady Delta

- 2007 Land use
- 2009 Land use

Mangrove assessment in Wunbaik RF

- 1990
- 2000
- 2009
- 2011
Land Cover Mapping Using Different Classification Techniques
Kyaw Zaya Htun, Zin Mar Lwin, Myint Myint Khaing, Remote Sensing Department, Mandalay Technological University, Mandalay, Myanmar

Introduction
• Land cover data represent a fundamental data source for various types of scientific research.
• Monitoring the location and distribution of land cover change is important for establishing link between policy decisions and regulatory actions and subsequent land use activities.
• It is also used to monitor deforestation, farming, urbanization and human induced climate change (Story and Congalton 1986).

Research Questions
• What are the distribution and potential land cover in the study area in 2015?
• Which classification method is the best one for land cover mapping?

Study Area (Mandalay)
• located at the centre of Myanmar, a second biggest city with the industrial and commercial center
• lies on the Plain, and between the Shan plateau and the Ayeyarwady River
• 438 miles from Yangon
• 44.59 square miles or 28,538.59 acres in area
• about 1.7 million in population
• 9.7 miles from north to south and about 4.9 miles from east to west.

Methodology
• Landsat 8 image (2015) was download and extract the study region.
• Atmospheric correction for image was done in QGIS.
• Six classes are defined for Land Cover Mapping.
• Define the region of interest (ROI) for study area using semi-automatic Classification Plugin in QGIS, Google earth and field data.
• Half of them are used for different classification methods and the rest are used for accuracy assessment.
• Classification process were done using QGIS and R studio.

Classification Methods
In this study, the following classification techniques were used to compare the results.
• Maximum likelihood classification
• Minimum distance classification
• Random forest
• Using Advanced Technique: Converting the Image Classification Raster Output to Image Objects using Segmentation
• Using Earth engine

Conclusions
• Landsat TM is an important source of data for mapping trends in land cover change in tropical areas. Classification of multispectral Landsat satellite data and comparison of land cover maps is an essential tool for assessing large-scale land cover/land use changes.
• Land cover mapping is useful for change detection that has many applications ranging from vegetation mapping, timber harvesting plans, urban sprawl detection, flood monitoring, mining and natural disaster damage assessment.
• According to accuracy assessment and field experience of this study, maximum likelihood classification method is the best one for this study area among the other classification methods. But we can also conclude that random forest classification is also the fastest one in comparing time and classification using earth engine is effective way for large area for rapid mapping. Image Objects using Segmentation method is suitable for classification based on high resolution image.
**Myanmar’s Natural Capital**

Stacie Wolny, Lisa Mandle (Natural Capital Project, Stanford University), Hanna Helsing, Sai Nay Won Myint (WWF Myanmar), Nirmal Bhagabati (WWF US).

Natural capital is the stock of natural assets - including land, water, soil, plants and animals - that yields a flow of benefits to people. These benefits that nature provides to people are known as ecosystem services. They include clean water and food, protection from natural hazards such as flooding and landslides, and opportunities for nature-based tourism and recreation.

Natural capital assessments show where and how nature matters for human well-being and economic productivity. This information is essential for making decisions that secure or enhance these assets for economic and social development. WWF and the Natural Capital Project are developing preliminary national natural capital assessments for Myanmar, linking information on where natural capital is located to the people and infrastructure that depend on its benefits. These results can be the starting point for designing policies and plans that protect critical natural capital assets and avoid development that leads to harmful losses of ecosystem service benefits.

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**Erosion on the current landscape**

Natural Capital Project’s InVEST models were used to estimate potential ecosystem services across Myanmar. Here are two results from applying the Sediment model to the current landscape: The first map shows the amount of erosion that is likely to end up in streams each year, reducing water quality. The second shows places where the landscape is retaining sediment, keeping it from eroding into streams, potentially providing a service to people.

---

**Forests help keep drinking water clean**

The Sediment model can show where forests help keep soil out of streams, where it can impact people who rely on surface water for their drinking water supply. The first map shows how many downstream households use surface water. Combining this information with model results shows where forests provide the greatest service of keeping people’s drinking water clean.

---

**Forests help keep sediment out of reservoirs**

The Sediment model can also show where forests help retain soil on the landscape so it does not end up in reservoirs, where it can impact drinking water sources and hydropower production. The first map shows some of the country’s dams and their servicesheds. The second shows the sediment retention service provided by the forests in those servicesheds.

---

**Coastal habitats help protect people from storms**

The InVEST Coastal Vulnerability model shows how coastal habitats such as mangroves, coral reefs and seagrass, help protect coastal populations from storms by decreasing flooding. The first map shows the locations of these three habitat types, and the second map shows the population density along the coast.

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**Servicesheds**

A serviceshed is an area that provides a particular ecosystem service to a specific beneficiary.

For water-related services like clean drinking water, watersheds can also be servicesheds. In this example, if towns take their water from two points on the river, the areas upstream of those points (#1 and 2) are servicesheds providing clean drinking water to those towns.

Servicesheds can also apply to other ecosystem functions. The serviceshed for pollination is the distance that pollinators will fly to benefit crop production. In the case of carbon sequestration, the serviceshed is the whole world.
Urbanization and sustainability under global change and transitional economies: Synthesis from Southeast, East, and North Asia (SENA)
Peilei Fan (PI) & Jiquan Chen (Co-PI), Michigan State University, 2015-2018, Grant #: NNX15AD51G

Research Questions:
1. What are the spatiotemporal changes of urban expansion within transitional economies?
2. What are the key socioeconomic and biophysical drivers of urbanization and urban sustainability? More specifically, which institutional mechanism is unique and crucial? How well do our models and data explain these changes through the interactions and feedback mechanisms of human and natural systems?
3. How well can we predict the changes in urban LCLUCs and functions based on the derived structure and functions of LCLUC, human systems, and natural systems?
4. What socioeconomic and institutional adaptations have been implemented and how effective have they been? What policy recommendations can be offered to enhance urban sustainability in the near future?

Key research findings (partial, from Fan et al, 2015, Environmental Research)
(1) the co-evolution of urbanization, economic development, and environmental change;
• while economic development serves as an essential driver for urban growth, its impact on urbanization seems to decrease over time
• E.g., concentrations of air pollutants initially increased and then decreased as GDPpc increased, can be partly explained by the Environmental Kuznets Curve concept (air pollution first gets worse but then gets better when GDPpc increases)
(2) the urbanization of transitional economies has been driven by the change of the economic structure, i.e., the development by both manufacturing and tertiary sectors and the change in the primary sector. This is different from either developed countries whose urbanization was mainly pulled by industrialization or from low-income, developing countries whose urbanization was pushed by poverty in rural areas.
(3) the increasing integration with the global economy in the recent decade and the institutional force, despite the transition from central planning to the market paradigm, have stood out remarkably as key determinants for urbanization
Introduction

- Land Cover Land Use Change (LCLUC) is associated with various societal, political, economic, biological and physical changes through a series of transitions (Raskin et al., 2002).
- LCLUC is a complex phenomenon which occurs at spatial and temporal scales as a result of many factors.
- The process of land use change is neither stochastic nor a deterministic in nature. Transition needs to be considered as development paths influenced by policy and other specific circumstances (Martens and Rotmans, 2002).
- Understanding the drivers of LCLUC and developing better models to predict future changes is an important challenge to the scientific community (Elliot et al., 2010).
- There is a growing need for inter-disciplinary and multi-disciplinary research to address the challenges in LCLUC modelling (Ellis, 2010).
- LCLUC in many places is a localized phenomenon, influenced by global factors. Thus, modelling the regional changes and integrating it to the regional and global level is a better way to address the challenges.

Research Questions

What are the drivers that influence Land Cover Land Use Change?
- How does climate change impact Land Cover Land Use Change?
- What would be the future status of land cover and land use?
- What is the impact of LCLUC on socio-economic development?

Objectives

- Identifying the key drivers of land use/land cover change through literature review and participatory research techniques.
- Identifying suitable LCLUC model to predict the future status of land resources.
- To model the impact of LCLUC on sustainable socio-economic development.

Study Area

- Anantapur district of Andhra Pradesh state, India is selected as the study area.
- Consists of 63 sub-districts (Taluka).
- Geographical Area: 19,130 km².
- Total Population: 40,81,148.
- Sex Ratio: 977 Female for 1000 male.
- Literacy Rate: 63.52%.
- The second most backward and drought prone district in the country.
- The district is dominated by shallow red soils with more than 78 percent coverage and the remaining area is covered by black soils.

Datasets

- Landsat imagery for generating LCLUC maps.
- Bio-Physical drivers
  - Soil Type and depth
  - Drainage density
  - Elevation
  - Slope and Aspect
  - Road length and Railways length
- Socio-Economic drivers
  - Household population
  - Education and health infrastructure
- Climate drivers
  - Rainfall

Methodology

- Work carried out so far
  - Prepared Bio-Physical and Socio-economic datasets.
  - Communicated with the local authorities and procured field level meteorological data.
  - Conducted questionnaire survey to identify the processes involved in agricultural land use change.
  - Conducted questionnaire survey to understand the farmers awareness, perception, mitigation and adaption capability towards climate change.

- Work to be executed
  - To evaluate the driver data set.
  - Identifying a suitable modelling for predicting LCLUC.
  - Validating the results.
  - Publication in peer-reviewed journal.

Acknowledgement

- We thank NASA LCLUC team for organizing International LCLUC regional science meeting in South and Southeast Asia and providing an opportunity to present our poster. We thank START international secretariat, GOF-COLC, USGS and Boston university for their data initiative and advanced training. We extend our thanks to all the organizations and people for helping us a lot during our field visits and data collection.

References


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Figure 1: Location map of the study area

Figure 2: Decadal population growth from 1901 to 2011

Figure 3: Land Cover Land Use map of 2004-2005 and 2013-2014

Table: Area statistics of 2004-2005 and 2013-2014

<table>
<thead>
<tr>
<th>CLASS NAME</th>
<th>2004-2005 (Area in Sq. Km)</th>
<th>2013-2014 (Area in Sq. Km)</th>
</tr>
</thead>
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<tr>
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<tr>
<td>KHARIF</td>
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<td>RAMI</td>
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<tr>
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<tr>
<td>WATERBODIES</td>
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<td>27.4367</td>
</tr>
<tr>
<td>TOTAL Area (Sq. Km)</td>
<td>19130</td>
<td>19130</td>
</tr>
</tbody>
</table>

Figure 4: Methodology flow-chart

Figure 5: Photographs during field visits
The Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) partnership promotes use of satellite earth observations (EOs) to advance scientific knowledge. START and partners work to bridge capacity needs in the developing world related to EOs and their applications. The GOFC-GOLD partnership fosters organic networks of scientists and practitioners in Asia, Africa, Eastern and Central Europe and Latin America through promoting capacity building to enhance skill building and knowledge in remotely sensed data management and data and image analysis as well as through promoting knowledge and information sharing among the different regional networks. The GOFC-GOLD partnership also enables research collaborations between US and developing country scientists on land cover and land use change dynamics, including validation of NASA data sets and methods.

**FOSTERING EARTH OBSERVATION REGIONAL NETWORKS - INTEGRATIVE AND ITERATIVE APPROACHES TO CAPACITY BUILDING**

The Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) partnership promotes use of satellite earth observations (EOs) to advance scientific knowledge. START and partners work to bridge capacity needs in the developing world related to EOs and their applications. The GOFC-GOLD partnership fosters organic networks of scientists and practitioners in Asia, Africa, Eastern and Central Europe and Latin America through promoting capacity building to enhance skill building and knowledge in remotely sensed data management and data and image analysis as well as through promoting knowledge and information sharing among the different regional networks. The GOFC-GOLD partnership also enables research collaborations between US and developing country scientists on land cover and land use change dynamics, including validation of NASA data sets and methods.
STUDY AREA: The study area covers the entire Northeast part of India which needs an urgent need for actions that promote the conservation and sustainable use of the region’s endangered forest and watersheds. The region's forest are experiencing an extensive process of forest fragmentation, degradation and outright deforestation and forest conservation.

OBJECTIVES:
- to assess the forest cover change dynamics in the study area

MATERIALS:
All the data and statistics are used from open source http://bhuvan.nrsc.gov.in/gis/thematic/index.php

RESULTS: In northeastern region about 450,000 families annually cultivate 10,000 km2 forest whereas total area affected by jhumming is 44,000 km2. Degraded secondary forest, bamboo thickets and weeds or simply barren land dominate jhum scapes and as hill farmers shift to such cash crops as ginger, pineapple and broom grass, lands once allowed to regenerate as forests are permanently converted to agriculture, reducing total forest cover. It has found that in Assam, Manipur and Mizoram there is decrease in forest cover during 1997 to 1999 (Table-1). During 2005 to 2012 all the four states shows a positive change in forest cover confirming Government initiative in afforestation drive on jhum lands.

CONCLUSION:
Though an increase in the forest cover is a positive change during 2005 to 2012 but it has been observed that built-up land is increasing and agricultural land, open space is decreasing thereby an increase in flash flood is witness in recent times in many urban centers.
Poster Presentation
on
Digital Orthophoto Production for Acquisition of Accurate Spatial Data
ABSTRACT

- Role of digital softcopy with current mapping tool
- Advancement of Digital Camera and Sensor
- Usage of fully digital imagery instead of scanned photo
- Process of digital orthophoto production

INTRODUCTION

- Rapid development of technology in the field of photogrammetry
- Map was only the basic foundation of GIS in the past
- Digital orthophoto become an important part of spatial databases
- Basic idea to get accurate spatial information from aerial photo product
- Highlight to orthophoto images rather than single aerial images

BACKGROUND

- Main responsibility and future plan of Survey Department ,MOECAF
- A servicing one to render services to the government departments and enterprises
- Distribution of aerial photos to Universities, Organizations and Private Agencies
WORKFLOW OF DIGITAL ORTHOPHOTO PRODUCTION

**Acquisition**
- **Flight Planning**
  - The Tracker’s SnapPLAN
- **Photography Mission**
  - GNSS Support Aerial Photography
  - UltraCam-Eagle Digital Camera
- **GPS Field Observation**
  - GPS Data Acquisition with and without Targets
  - Trimble R10

**Image Processing**
- Processing with Raw Images
  - (Level-0 to Level-02)
  - UltraMap (RDC)

**Data Processing**
- Processing with GNSS, IMU
  - Airborne Data and GCPs
  - Applanix POSpacMMS

**Image Processing**
- Processing with Level-02 images
  - UltraMap (RAD)

**Aerial Triangulation**
- Processing with Level-02 images
  - UltraMap (AT)

**Radiometry**
- Processing with Level-02 images
  - UltraMap (RAD)

**Aerial Triangulation**
- Processing with Level-02 images
  - UltraMap (AT)

**Generate BaseLayer**
- Generate Low Resolution DSMOrtho

**Dense Matching**
- Generate Point cloud DSM/DTM

**Ortho Pipeline**
- Generate Final Ortho Mosaic
  - UltraMap (OP)

**Generate BaseLayer**
- Generate Low Resolution DSMOrtho

**Ortho Pipeline**
- Generate Final Ortho Mosaic
  - UltraMap (OP)

**Generate BaseLayer**
- Generate Low Resolution DSMOrtho

**Ortho Pipeline**
- Generate Final Ortho Mosaic
  - UltraMap (OP)

**DMA Pipeline**
- Generate Tiled Ortho images

**Export**
- DSM Ortho Geotif

**Export**
- DTM Ortho Geotif

**Seamline Editing**
- DSM Ortho Tiled Ortho images
- DTM Ortho Tiled Ortho images
MATERIALS AND METHODS

Data Processing

Image Processing

Aerial Triangulation Adjustment

Orthophoto Production

Seam Editing
RESULT AND OUTPUT

- Several tiles which are 400 square meters at 30 cm resolution on each tile
- 2070 tiles in 120 images for a 1: 50000 scale UTM national map
- 30 cm GSD is possible to see each land parcel boundary (paddy dyke) on image
DISCUSSION

- The importance of the accuracy of the original images
- Precision depends upon full photogrammetric process
- True advantage is to predict the accuracy beforehand

CONCLUSIONS

- Good interpretation for extraction GIS spatial data
- High accuracy digital orthophoto rely on large scale high resolution image, high precision Control Points
- The resolution of digital aerial photos is mostly higher than satellite band image and good for high accuracy works like parcel based GIS
- Take up time and cost to get aerial photos and preparation phases

REFERENCES
Evaluation of decadal Land Cover and Land Use Changes (LCLUC) over last 50 years in High Altitude Regions of Garhwal Himalaya and Assess their Impact on Vegetation Distribution in different altitudinal zones using Geospatial Techniques

Yogita Shukla, P J Navin Kumar, Vasudeva Rao, P L N Raju, Shalini Singh, P S Roy
**Introduction**

- Urban expansion is one of the challenges in the developing countries as it takes place due to rapid population growth, economic development, and infrastructural development initiatives. [1]
- This study is carried out to monitor land use/land cover and urban expansion during 2001-2015.

**Methodology**

- Landsat TM image (2001)
- Landsat 8 image (2015)
- Preprocessing
- Band layer stacking
- Land use/land cover classification
  - Normalized Difference Built up Index (NDBI)
- Built-up area extraction

**Land use/Land cover Maps of 2001 & 2015**

**Data Used**

- Landsat TM image (2001)
- Landsat 8 image (2015)

**Software Used**

- ArcGIS 10.1
- QGIS

**Results & Discussion**

- During the study period, built-up area is more expanded toward South and South East part of Mandalay municipal boundary according to directional change map.
- Urban expansion area is increased 17.54 sq-km and rate of expansion is 1.2 km²/year.
- Normalized Built up Index (NDBI) is useful for built-up area extraction.
- Remote Sensing & GIS techniques are powerful tools to monitor urban expansion.

References:

Analysis of Land Cover Change Detection Using Landsat Images in Paukkaung Township Area

by Aung Myo Win, Assistant Lecturer
University of Forestry, Yezin, Naypyitaw

INTRODUCTION

- Deforestation strongly influences the occurrence of global warming and also leads to a reduction in biodiversity, disturbances in water regulation, and destruction of the livelihood of farmers (Dong et al., 2011; Haughton, 2005).
- Reducing deforestation would not only reduce GHG emissions, but would also provide additional benefits to the climate (Eagor et al., 2010).
- Programs that aim to reduce the emissions from deforestation and forest degradation are being considered as a cost-effective way to mitigate anthropogenic GHG emissions (Werf et al., 2005).

For this purpose, forest monitoring is an important tool for evaluation of the state of forest resources, carbon sequestration, and forest management programs.

The remote sensing (RS) technique using satellite imagery has been recognized as an effective and powerful tool in monitoring and detecting land use and land cover changes (Duong, 2004; Pol and Marvine, 1996; Sader et al., 2002).

- By using satellite image data, the geographic information system (GIS) and RS technique comprise a valuable tool for the detection and prediction of changes in forest cover and the identification of areas under risk of invasion (Adubofour, 2011).

According to the 2010 Forest Resources Assessment (FRA 2010) report, Myanmar is included in the list of ten countries with the largest annual net loss of forest area between 1990 and 2010.

Although Myanmar has established more than 30,000 hectares of various types of forest plantations and has conducted forest conservation operations, it is needed to make the assessment of forest cover changes at the township level.

OBJECTIVES

- To assess the loss and gain of forest cover status and to detect how it changed in the Paukkaung township area from 1999 to 2013 by using RS and GIS technology.
- To demonstrate the analysis of the land cover change detection in township level by using Landsat satellite images.

MATERIALS AND METHODS

- Paukkaung township area was chosen as study area.
- Post-classification change detection method was used. In post-classification comparison method, images of different dates were initially classified and individually labeled. Then, the classified images were compared and the data on the changed areas were extracted (Eric and Adubofour, 2012; Serra et al., 2002).
- Supervised classification method for land cover classification.
- Field ground truth data collection to get reference for each class of area of interest.
- Accuracy assessment expressed by user’s accuracy, producer’s accuracy, overall accuracy, and Kappa.
- Producer’s accuracy refers to the probability that a certain land cover of the ground is classified as such, whereas user’s accuracy refers to the probability that a pixel labeled as a certain land cover class in the map is really of this class (Congalton, 1991). Kappa values range from 0 to 1 and those > 0.7 indicate strong agreement (John et al., 2002).

RESULTS AND DISCUSSIONS

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