

## **The South/Southeast Asia Research Initiative (SARI) Update and Meeting Objectives**

Krishna Prasad Vadrevu, NASA Marshall Space Flight Center, Alabama

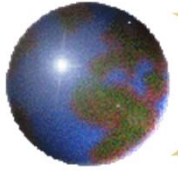
### **Abstract**

Land Use/Cover Change (LU/CC) is one of the most important types of environmental change in South and Southeast Asian countries. Several studies suggest that LU/CC in these countries is in large part driven by population growth and economic development. In the region, changes that are most common include urban expansion, agricultural land loss, land abandonment, deforestation, logging, reforestation, etc. To address the research needs and priorities in the region, a regional initiative entitled South Southeast Asia Regional Initiative (SARI) has been developed involving US and regional scientists. The initiative is funded by NASA Land Cover, Land Use Change program. The goal of SARI is to integrate state-of-the-art remote sensing, natural sciences, engineering and social sciences to enrich LU/CC science in South Southeast Asian countries. In the presentation, LU/CC change research in SARI countries will be highlighted including the drivers of change. For example, in South Asia, forest cover has been increasing in countries like India, Nepal and Bhutan due to sustainable afforestation measures; whereas, large-scale deforestation in Southeast Asian countries is still continuing, due to oil palm plantation expansion driven by the international market demand in Malaysia and Indonesia. With respect to urbanization, South and Southeast Asian countries contain 23 megacities, each with more than 10 million people. Rapid urbanization is driving agricultural land loss and agricultural intensification has been increasing due to less availability of land for growing food crops such as in India, Vietnam, and Thailand. The drivers of LUCC vary widely in the region and include such factors as land tenure, local economic development, government policies, inappropriate land management, land speculation, improved road networks, etc. In addition, variability in the weather, climate, and socioeconomic factors also drive LU/CC resulting in disruptions of biogeochemical cycles, radiation and the surface energy balance of the atmosphere. The presentation will also highlight SARI collaborative activities with space agencies, universities and non-government organizations including data sharing mechanisms in the region.

# The South/Southeast Asia Research Initiative (SARI) Update and Meeting Objectives

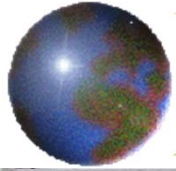
**Krishna Prasad Vadrevu**  
**NASA Marshall Space Flight Center**





## Presentation topics

- **Background to the SARI initiative**
- **Meeting Objectives**



## How it started - strong interest in a SARI from local scientists



**Jan-10-13th, 2013-Regional Science Meeting, Coimbatore**

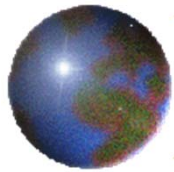
**Total participants =120**

**US – 18 researchers**

**Nepal-3; Srilanka-2; Myanmar-1; Afghanistan, Myanmar, Bangladesh-1 each**

**Pakistan, China invited but could not attend – Visa issues**

**India – University Researchers, Government, Non-Government, NGO's**



# Meeting Summary-Need for SARI NASA The Earth Observer

## Summary of the 2013 NASA Land Cover/Land Use Change Regional Science Meeting, South India

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Chris Justice, University of Maryland, College Park, [justice@hermes.geog.umd.edu](mailto:justice@hermes.geog.umd.edu)  
Prasad Thenkabail, United States Geological Survey, [pthenkabail@usgs.gov](mailto:pthenkabail@usgs.gov)  
Garik Gutman, NASA Headquarters, [ggutman@nasa.gov](mailto:ggutman@nasa.gov)

### Introduction

The 2013 NASA Land Cover/Land Use Change (LCLUC) Regional Science Meeting was held in South India and had three components:

- a focused workshop on water resources at the Centre for Water Resources Development and Management (CWRDM), held in Kozhikode, Kerala in India, from January 7-8, and a Land Use (LU) Transect Study from Kozhikode, Kerala, to Coimbatore, Tamil Nadu, in India<sup>1</sup>, on January 9;
- a NASA international regional meeting, held January 10-13, at Karunya University in Coimbatore, Tamil Nadu; and
- a training workshop titled *Remote Sensing and Geospatial Technologies for Land Cover and Land Use Change Studies and Applications*, held January 14 at Karunya University.

The goal of the meeting was to discuss land cover/land use change (LCLUC) issues and impacts in the South Asia region. The meeting was organized around eight technical sessions:

1. Agricultural land-use change;
2. LCLUC-related Earth observations (missions, data, and products);
3. Atmosphere/land-use interactions (aerosols, greenhouse gases);

<sup>1</sup> Kerala and Tamil Nadu are two of the 28 states in India.



Water resource-focused workshop participants. Images Credit All photos in this article were taken by author or other members of the LCLUC team.

4. LCLUC and the carbon cycle;
5. Forests and LCLUC in mountainous areas;
6. Coastal zones and water resources;
7. Urban LCLUC; and
8. Working towards a Regional Global Observation for Forest and Land Cover Dynamics (GOC-GOLD) South Asia Regional Information Network (SARIN) (including prospects, opportunities, and challenges).

The meeting was a joint effort of the NASA LCLUC Program; GOC-GOLD Program; International System for Analysis Research and Training (START) Program; Monsoon Asia Integrated Regional Studies Program (MAIRS); University of Maryland College Park (UMD); Centre for Water Resources Development and Management (CWRDM) in Kozhikode, Kerala; and Karunya University, in Coimbatore, Tamil Nadu.

### NASA LCLUC Workshop on Water Resources and Land Use Transect

Thirty top-level delegates from different institutes and universities in India attended the meeting in addition to twelve researchers from the U.S. **Narasimha Prasad** (CWRDM), welcomed the participants and highlighted the CWRDM water research activities.

After the welcome, **Garik Gutman** [NASA Headquarters] addressed the workshop's participants, presenting an overview of LCLUC issues in South Asia, with focus on agricultural land-cover conversion.



*Rhizophora mangle*, known as the "red mangrove," near Kadalundi bird sanctuary in Kerala.

forest-cover loss, increasing urbanization, and air pollution. **Chris Justice** [UMD] stressed that much needs to be done in terms of the underpinning science of LCLUC and the linkages with global climate change in South Asia.

Some highlights from the workshop are summarized here:

- The most important LCLUC issue impacting agriculture in south India is *paddy fields* (wetlands) being converted to urban areas and/or left abandoned, with the attendant deficit in rice production.
- This *paddy conversion* is complex, and crosses economic, ecological, sociocultural, structural, and class dimensions.
- Economic return from paddy cultivation does not tend to encourage conservation—due to labor costs.
- At present, land is seen only as real estate needed for residence status, and is the safest and best investment to maximize profits.
- Coconut farming is shrinking due to the unavailability of skilled labor.
- Pollution and sedimentation from *anthropogenic* activities seriously affects aquatic systems/wetlands in South India. This requires more-stringent regulations and greater wetland protection.
- The roles of coastal vegetation and mangroves in protecting lives and property require more research to address contamination—possibly due to saline water intrusion, likely from inadequate drainage systems and poor maintenance of the well surroundings.

The CWRDM arranged several field visits to highlight local LCLUC issues and responses, including urban green park and wetlands conservation, mangrove conservation, and coastal and riparian land use management.

On January 9, participants departed for a Land Use Transect Study from Kozhikode, Kerala, to Coimbatore, Tamil Nadu, involving local scientists. The processes of urban expansion and forest degradation were quite evident during the transect study. During the transect, the participants observed forest fires in the mountains, 50 km (~31 mi) away from Coimbatore.



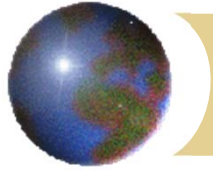
Coconut, arecanut, banana, and yam plantations, Kozhikode, Kerala.



Smoke from forest fires, Palakkad, Western Ghats, Kerala.

March/April 2013

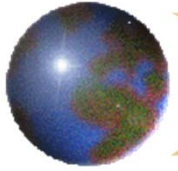
[http://eosps0.gsfc.nasa.gov/eos\\_homepage/for\\_scientists/earth\\_observer.php](http://eosps0.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php)



## SARI - Goal

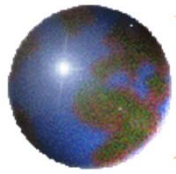
*SARI is NASA LCLUC Program funded regional initiative*

To develop an innovative research, education, and capacity building program involving state-of-the-art remote sensing, natural sciences, engineering and social sciences to enrich LCLUC science in South/Southeast Asia.



## *SARI Priority*

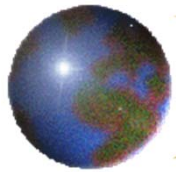
- ✦ Involving National Researchers and Practitioners – Universities, Institutes and Operational Agencies;
- ✦ Strong emphasis on Applied Research with regional / national societal applications and benefits.
- ✦ Facilitate strengthening regional/national projects through co-design and collaborations;



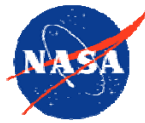
# SARI Regional Needs Meetings funded by NIES, Japan and several international/regional partners







# Collaborations are the Key !



VNU UNIVERSITY OF ENGINEERING AND TECHNOLOGY



## *SARI Agriculture Meeting – New Delhi*



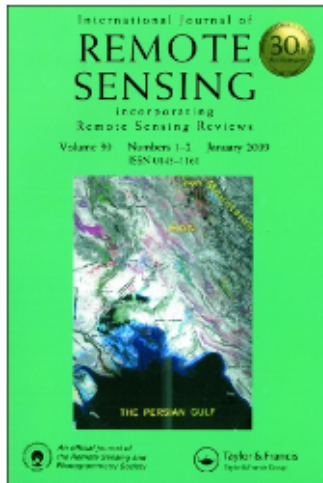
- Total Meeting Participants = 94
- Total Presentations – 42;
- Meeting Outputs – IJRS Special Issue

# International Journal of Remote Sensing

Submit your papers to this special issue on Remote Sensing of Agriculture in South/Southeast Asia

Deadline: 31 December 2017

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South/Southeast Asian countries are growing rapidly in terms of population, industrialization and urbanization. One of the key challenges in the region is food security. Although total food production and productivity has increased in the region because of additional land area converted to agricultural land use during 1960's to 2000 and improved varieties and crop management, growth rate of food production in recent times has slowed down, mostly due to loss of agricultural lands related to increasing urbanization and industrialization and less optimal use of available technology. Further, the weather and climate systems in the region, driven primarily by monsoon variability are characterized by extreme weather events, resulting in droughts or flooding which can impact agricultural production. In this region, monitoring the agricultural crop production in a timely manner is essential to predict and prepare for disruptions in the food supply. Further, improved and up-to-date information on

agricultural land cover and associated land use practices can help in understanding the role and response of the agricultural sector to environmental change and for improved land management and planning.

Despite the progress in remote sensing and geospatial technologies, little emphasis has been placed on developing robust methods for operational mapping/monitoring of cropped areas and forecasting crop production. In most countries of South/Southeast Asia, the mapping efforts have focused on the classification of land cover types and generalize cropland areas into a single or limited number of thematic classes. Crop-specific LULC information is currently limited to very few countries in

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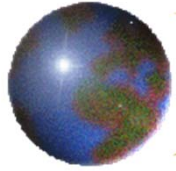
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<http://explore.tandfonline.com/cfp/est/tres-remote-sensing-in-asia-cfp>

*Eds: Krishna Vadrevu, Vinay Dadhwal, Garik Gutman and Chris Justice*



## NASA ROSES – 2015-2018 LCLUC South Asia Projects

### Agriculture and Food security

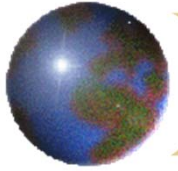
- Landscapes In Flux: The Influence of Demographic Change and Institutional Mechanisms on Land Cover Change, Climate Adaptability and Food Security in Rural India
- The Future of Food Security in India: Can Farmers Adapt to Environmental Change?
- Understanding Changes in Agricultural Land Use and Land Cover in the Breadbasket Area of the Ganges Basin 2000-2015: A Socioeconomic-Ecological Analysis

### Urban

- Urban Growth, Land-Use Change, and Growing Vulnerability in the Greater Himalaya Mountain Range Across India, Nepal, and Bhutan

### Human Health

- Understanding the Role of Land Cover/Land Use Nexus in Malaria Transmission Under Changing Socio-Economic Climate in Myanmar

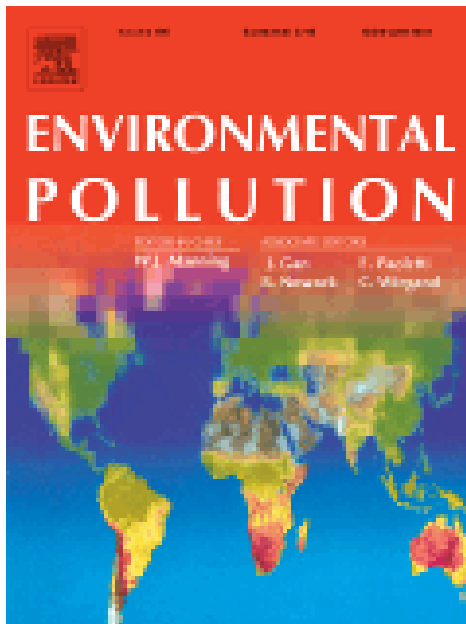
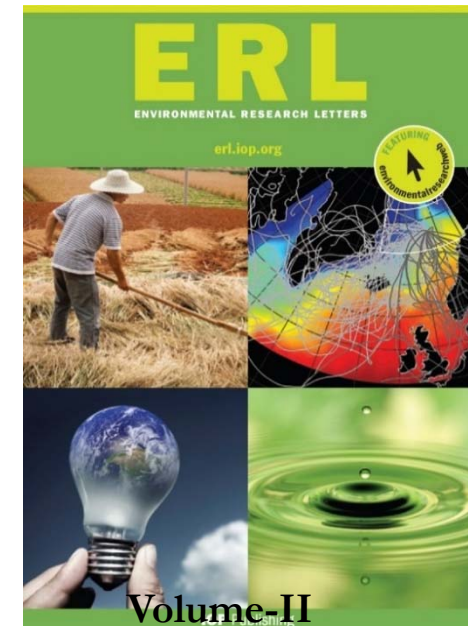
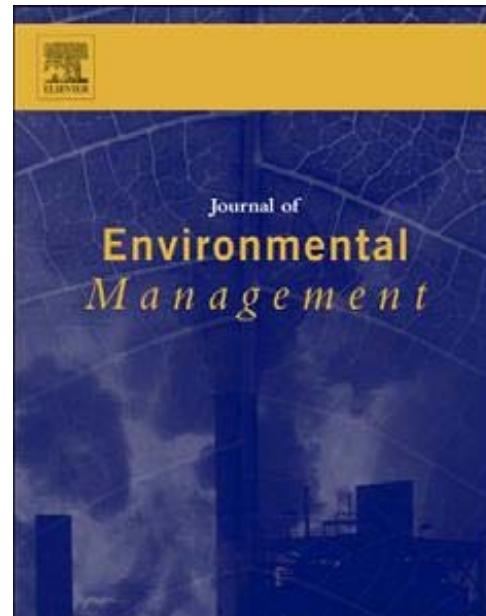
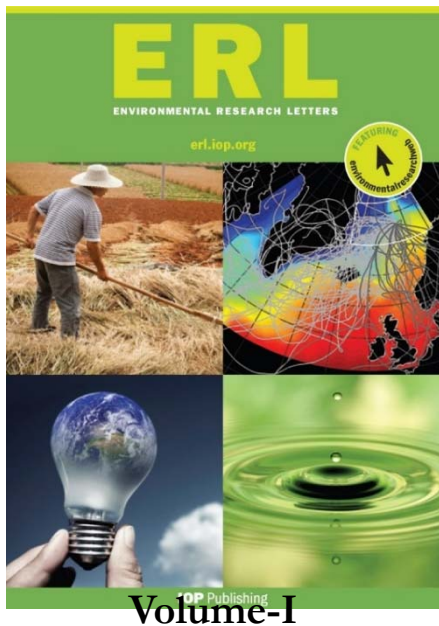


## **2015-2016 LCLUC South Asia Projects**

### **Forests**

- **Spatiotemporal Drivers of Fine-Scale Forest Plantation Establishment in Village-Based Economies of Andhra Pradesh**
- **Consequences of Changing Mangrove Forests in South Asia on the Provision of Global Ecosystem Goods and Services**
- **Complex Forest Landscapes and Sociopolitical Drivers of Deforestation - The Interplay of Land-use Policies, Armed Conflict, and Human Displacement in Myanmar**
- **Impacts of Afforestation on Sustainable Livelihoods in Rural Communities in India**
- **Tropical Deciduous Forests of South Asia: Monitoring Degradation and Assessing Impacts of Urbanization**

# SARI - Peer Reviewed Publications



 Springer [springer.com](http://springer.com)

**Land-Atmospheric Interactions in Asia**  
Book Series: Springer Remote Sensing/Photogrammetry  
Editors: Krishna Prasad Vadrevu, Toshimasa Ohara, Chris Justice  
*Forthcoming, Summer 2016*

- Maximizes reader insights into the quantification of land cover/land use changes (LC/LUC) and greenhouse gas emissions in Asia.
- Focuses on large spatial scales integrating satellite remote sensing and ground based approaches.
- Broadens understanding on integrated approaches combining top down and bottom up methodologies including modeling for characterizing LC/LUC and emissions.
- Explores the causative factors and impacts of LC/LUC and emissions due to population growth, industrial activities and energy demand in Asia.

In Asia, high population growth together with rapid economic development are causing immense pressure to convert land from natural and agricultural areas to residential and urban uses with significant impact on emissions and ecosystem services. This edited volume sheds new light on the causative factors and impacts of LC/LUC on the greenhouse gas (GHG) and aerosols in Asia. The volume will also focus on the use of remote sensing, geospatial technologies, and integrated approaches to characterize LC/LUC and emissions.

Articles are invited from international researchers working on remote sensing of LC/LUC, fires, GHG emission inventories, aerosols, and land-atmospheric interactions in Asia.

Submission Deadline: December 31<sup>st</sup>, 2015  
Email: [kpv@umd.edu](mailto:kpv@umd.edu)

**Dr. Krishna Prasad Vadrevu** ([kpv@umd.edu](mailto:kpv@umd.edu)), Associate Research Professor, Department of Geographical Sciences, University of Maryland, College Park, USA.

**Dr. Toshimasa Ohara** ([ohara@nies.go.jp](mailto:ohara@nies.go.jp)), Researcher, National Institute of Environmental Studies (NIES), Japan.

**Dr. Chris Justice** ([cjustice@umd.edu](mailto:cjustice@umd.edu)), Head, Department of Geographical Sciences, University of Maryland, College Park, USA.

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**remote sensing**

Title Keyword  Remote Sensing  Volume  Page   
Author  Journal  Section  Issue  Number   
Article Type  Special Issue Mapping, Monitoring

**Special Issue "Mapping, Monitoring and Impact Assessment of Land Cover/Land Use Changes in South and South East Asia"**

**Quicklinks**

- Special Issue Editors
- Special Issue Information
- Published Papers

A special issue of Remote Sensing (ISSN 1072-4202)

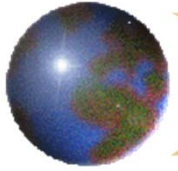
**Deadline for manuscript submissions: 30 July 2016**

**Special Issue Editors**

**Guest Editor**  
**Dr. Krishna Prasad Vadrevu**  
Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA  
Website: <http://geog.umd.edu/faculty/prof/vadrevu/krishna>  
Interests: satellite remote sensing of land use/cover changes, land atmospheric interactions, remote sensing of fires, biogeochemical cycling, agroecosystems

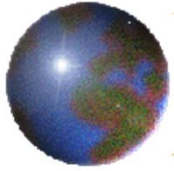
**Guest Editor**  
**Dr. Rama Nemani**  
Ecological Forecasting Laboratory, NASA Ames Research Center, MS 242-4, Moffett Field, CA 94035, USA  
Website: <http://forecast.ec.riasa.gov/jprnema.php>  
Interests: ecological forecasting, collaborative computing, big-data analysis

**Guest Editor**  
**Prof. Chris Justice**  
Dept. of Geographical Sciences, University of Maryland, College Park, MD 20742, USA  
Website: <http://geog.umd.edu/faculty/prof/cjustice/cjustice>  
Interests: global change research; land use/cover change; satellite based agriculture monitoring; satellite based fire monitoring; terrestrial observing



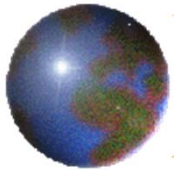
## **SARI forthcoming meetings (2017-2018)**

- **2018 - SARI LCLUC regional meeting in Philippines**
  - Meeting: March 17-18-19
  - Training: March 20-21-22
  
- **2018 - LCLUC and Emissions Meeting in Laos**
  - Dates: TBD
  - Training
  
- **2018 - LCLUC in Mountain Environments, Bhutan**
  - Dates: TBD
  - Training

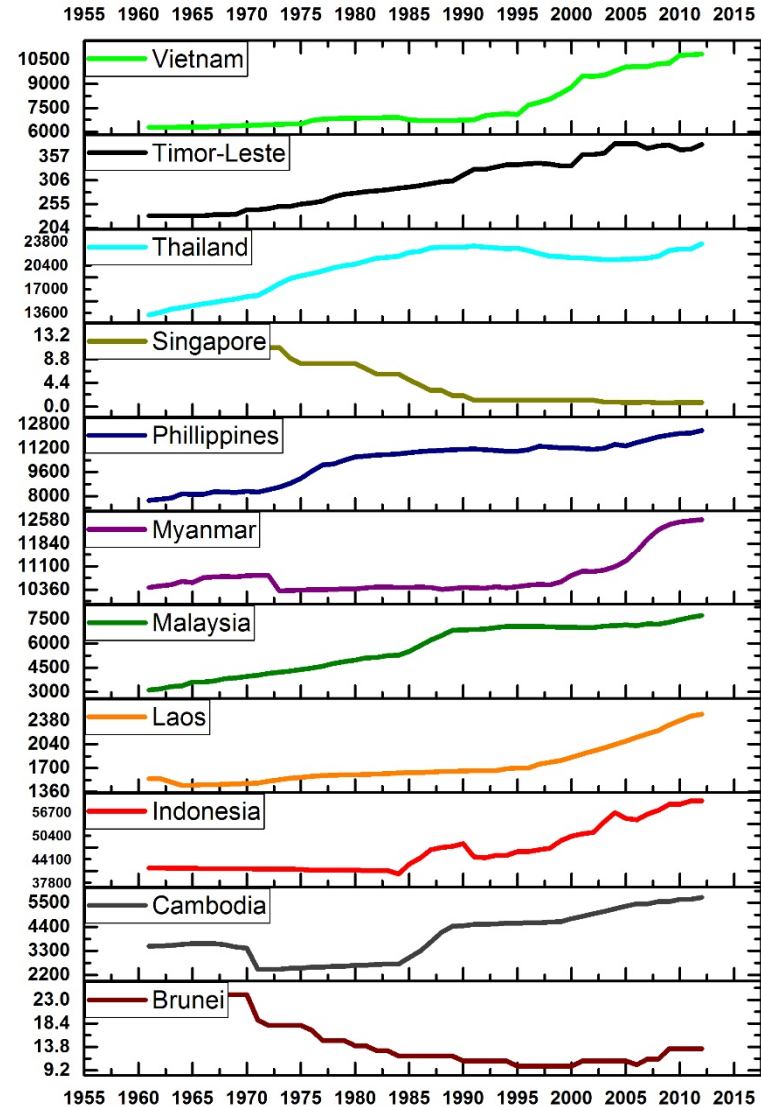
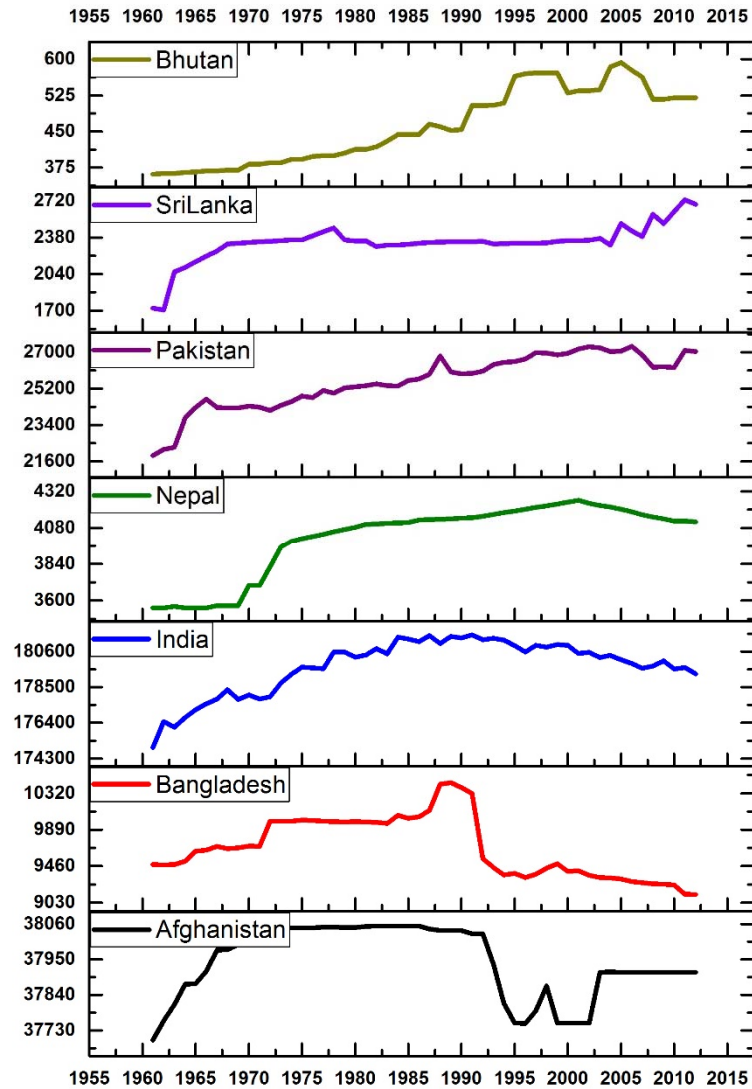


# LCLUC in SARI Countries and Meeting Objectives





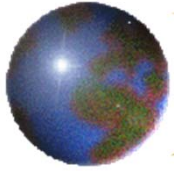
# Agricultural land use in South/SE Asia



Significant increase in Agricultural Land Area (x 1000ha) in Several South and Southeast Asian Countries

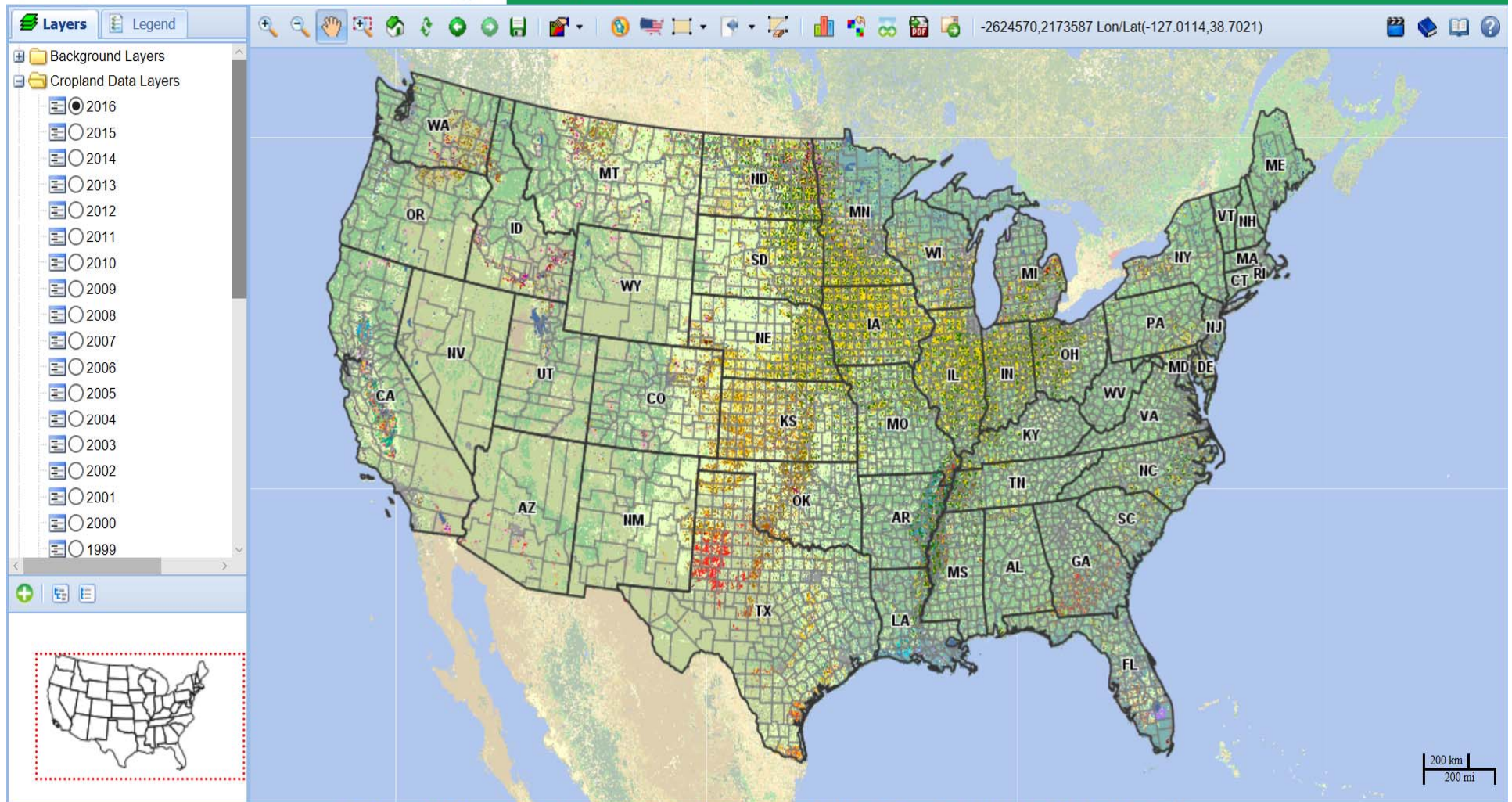
Vadrevu et al., 2017, ERL (in press)

Data Source: FAO, 2015

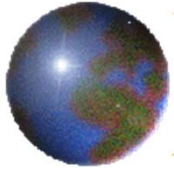


# *Agriculture*

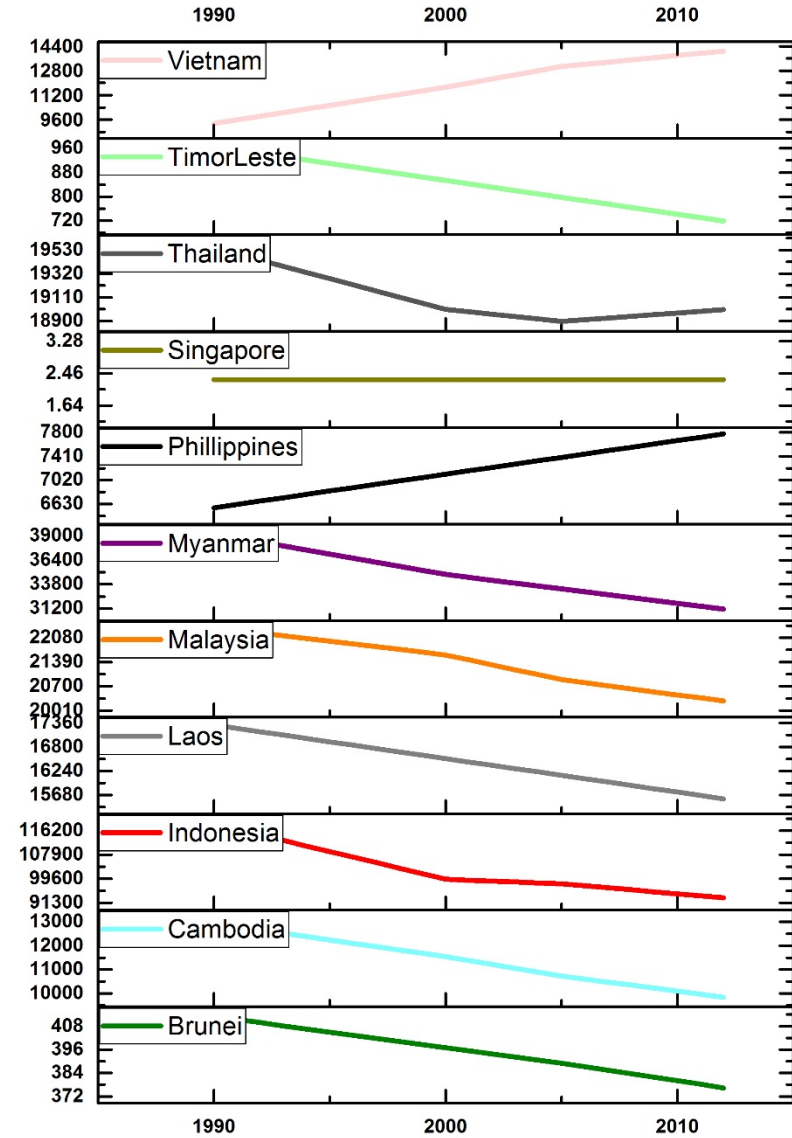
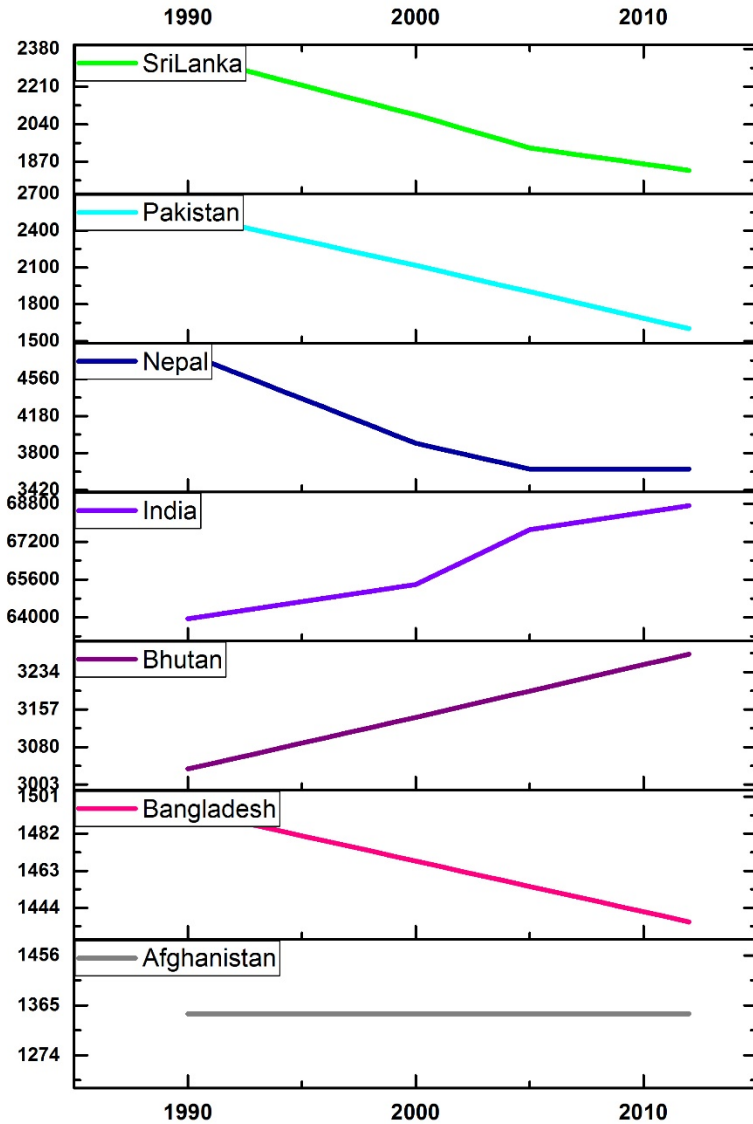
- ✦ Long- term Food Security is a major concern for the region;
- ✦ Agricultural production and land use is changing
  - ✦ Crop water requirements;
  - ✦ Extreme events (flooding and drought (almost every year!))
  - ✦ Adaptation options needs to be explored to address food security questions
- ✦ RS data needed to monitor agriculture (within season) and forecast crop production (integrating Landsat+ Sentinel + other high resolution data);
- ✦ Transitioning from research to operational products
  - ✦ 3-year research projects (eg: 6-different teams working on Rice mapping in Mekong; coordination required and transitioning from research to operations;
    - Crop type and area statistics
    - Production estimates
    - Yield forecasting
      - GEOGLAM working on some of the above activities.



**1997-2016 – possible because of strong validation data at a plot scale from Farm service bureau; such data may not be available in S/Seast Asia**



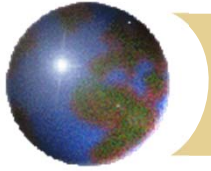
# Forest Area in South/SE Asia



Significant decrease in Forest Area (x 1000ha) in Several South and Southeast Asian Countries

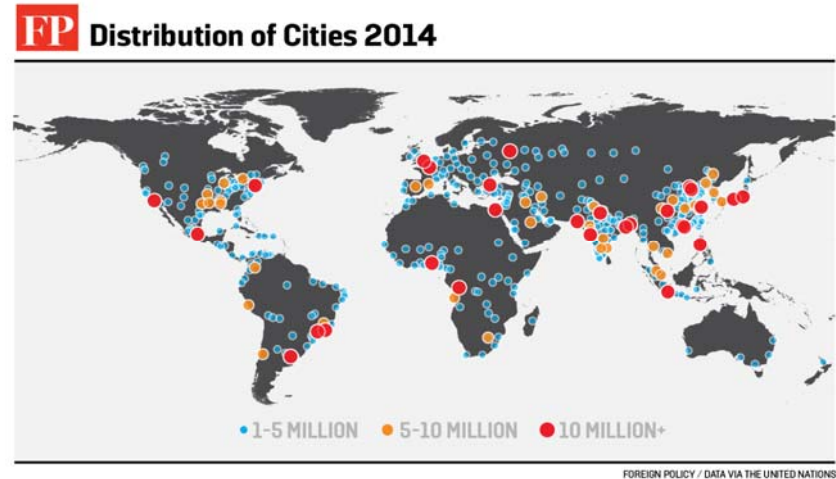
Vadrevu et al., 2015, ERL (in review)

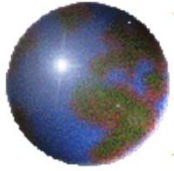
Data Source: FAO, 2015



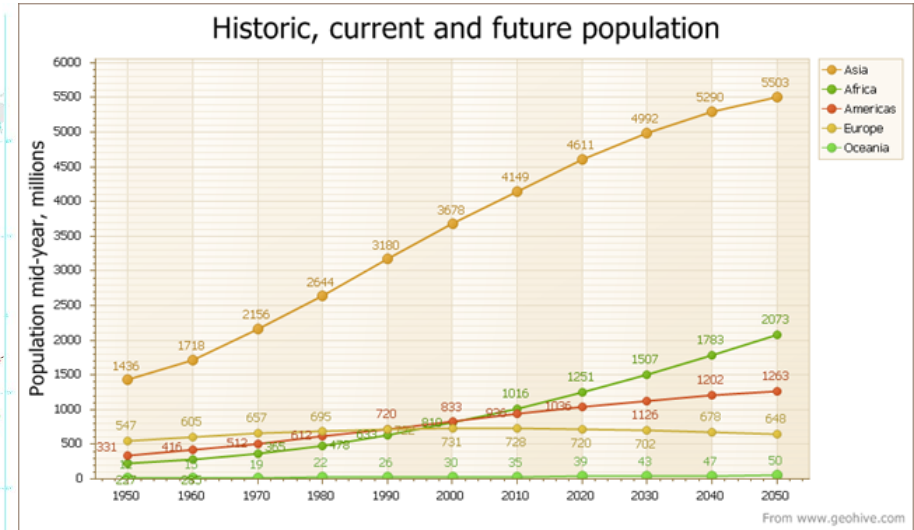
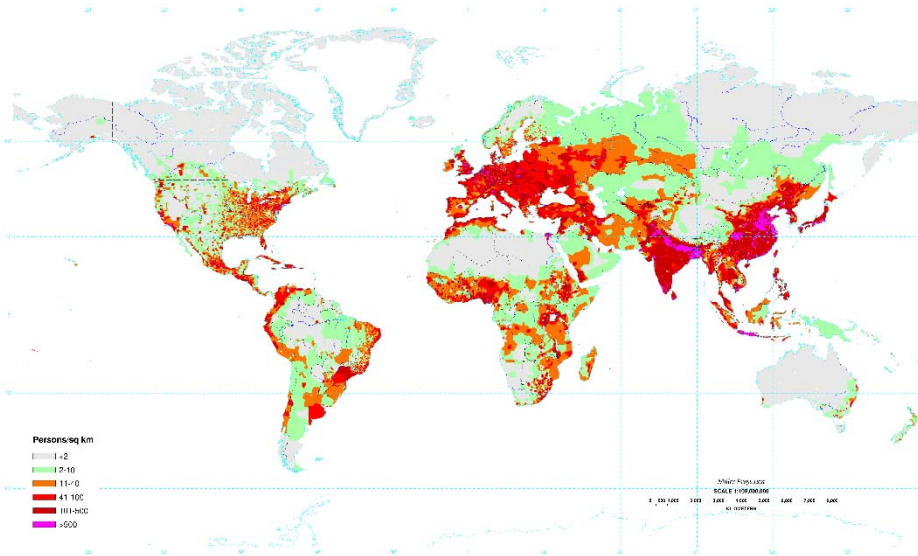
# Urbanization and LCLUC

- Urbanization is occurring rapidly at the cost of agriculture and forest lands.
- Currently, 28.33% of South/Southeast Asian population lives in urban areas and it is estimated that by 2030, more than 55% of the population will be urban.
- Urban sprawl has been increasing in different cities at the cost of agricultural lands, ecologically sensitive and natural areas.
- Increasing Urbanization is resulting in air, water and solid waste pollution problems in most cities.
- *LCLUC interactions in urban environments are poorly understood and need immediate attention.*





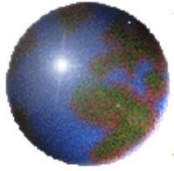
# Population and Pollution



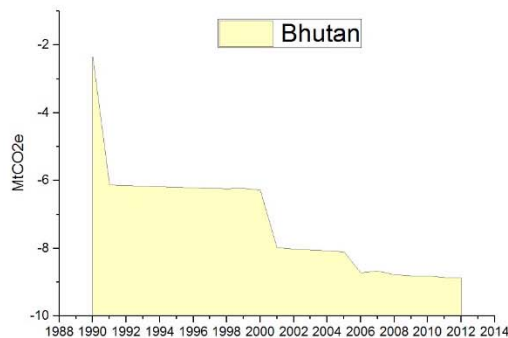
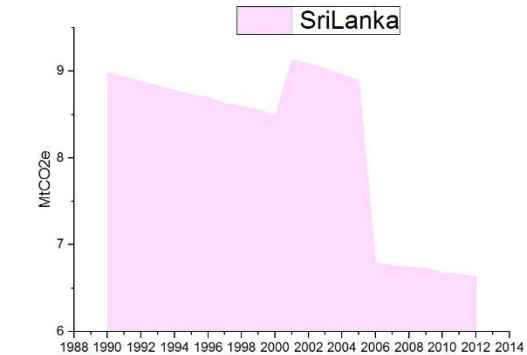
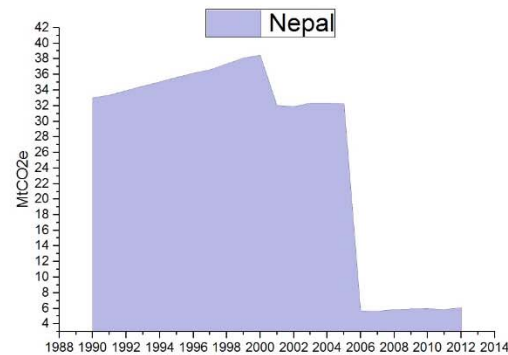
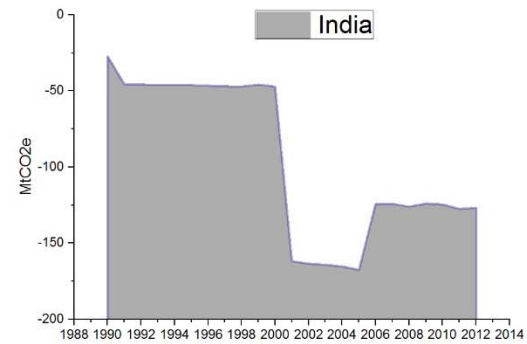
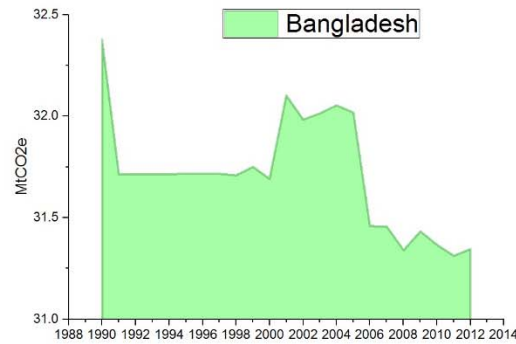
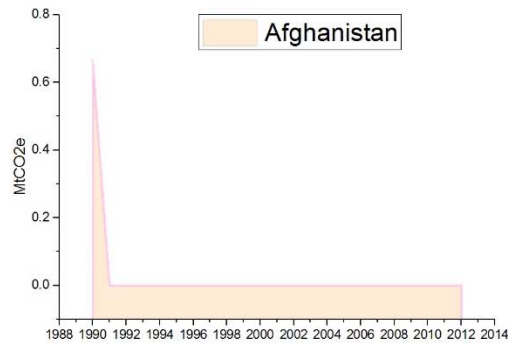
*Nearly 60% of worlds population is in Asia (4.5 billion people)*

*Nearly 2/3rd of world population growth is in Asia*

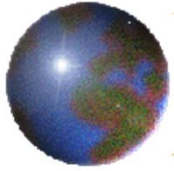
*Nearly 50 million people are being added every year!*



# *GHG emissions from LUCF in South Asia*

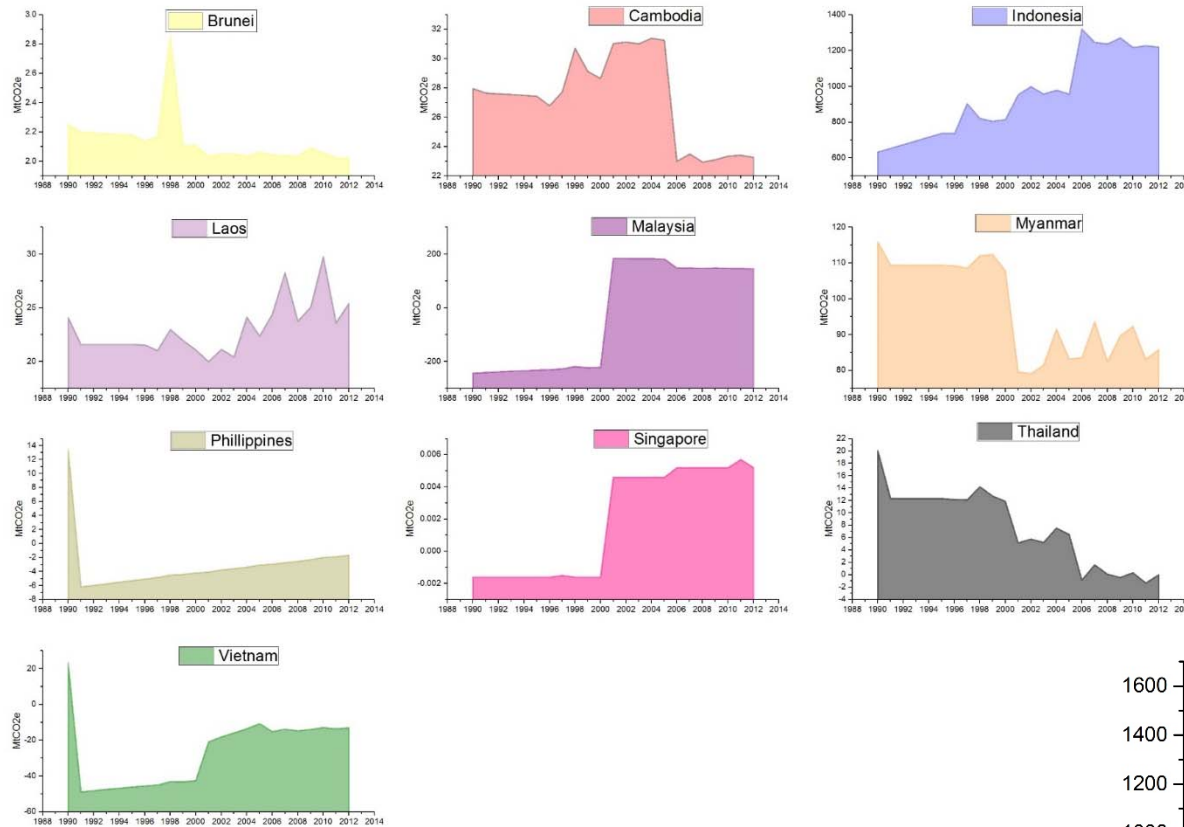


**GHG emissions from LUCF sector seems decreasing significantly in South Asia**

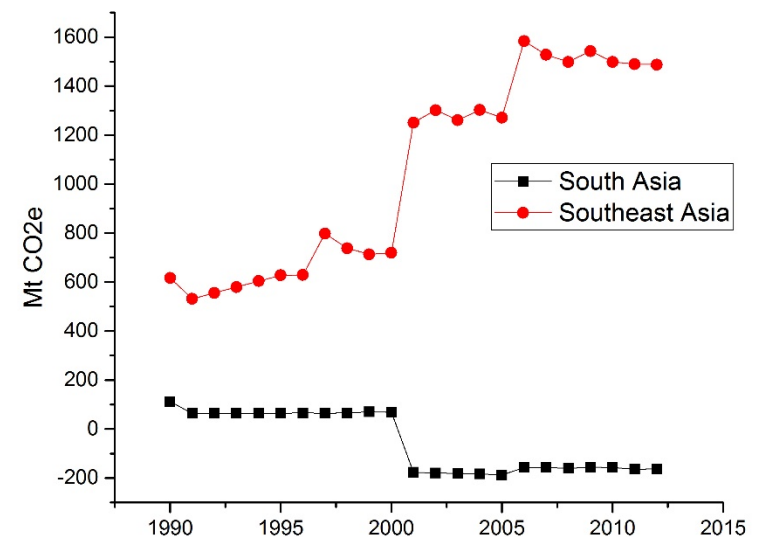


## GHG emissions from LUCF in Southeast Asia

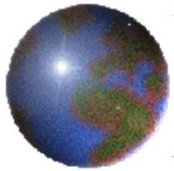
GHG emissions from LUCF sector seems decreasing in Southeast Asia too, however, not rapidly as in South Asia



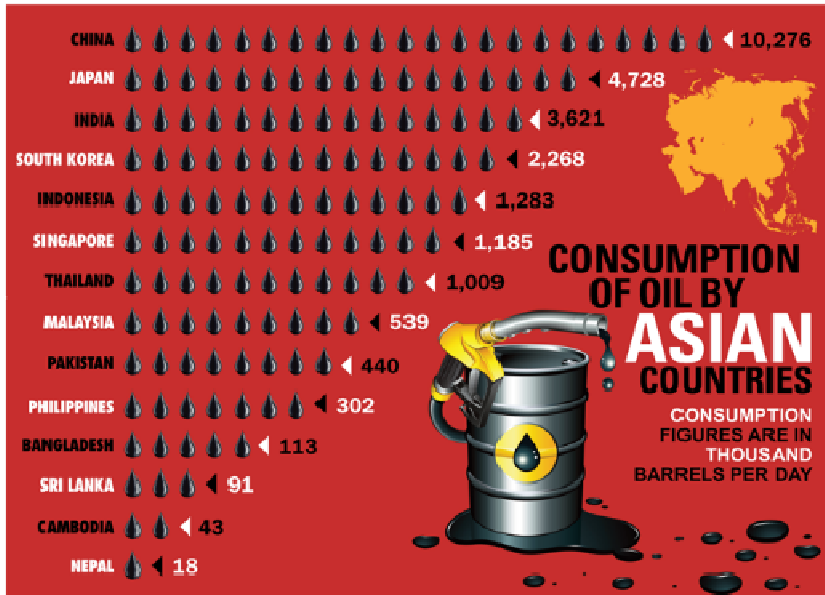
Some of the drivers to be discussed in this meeting



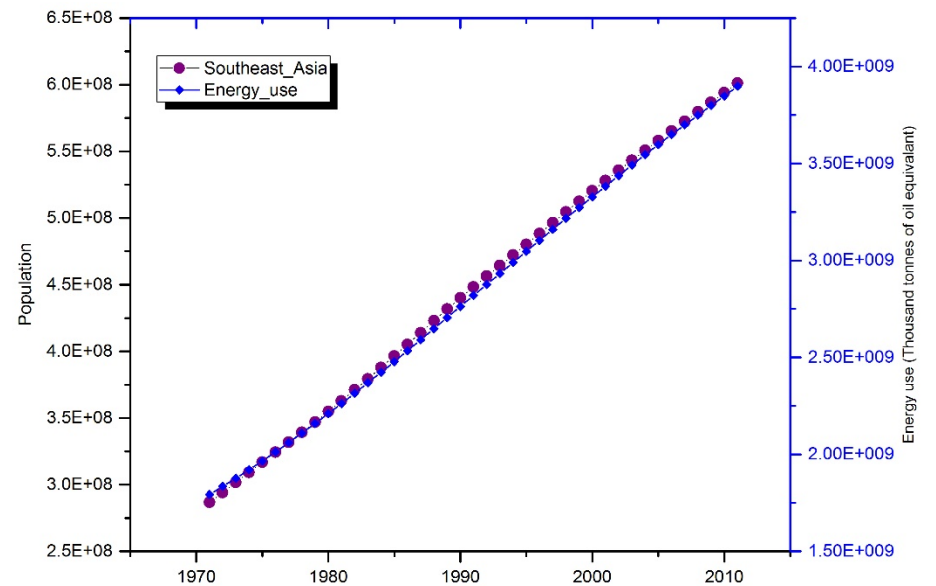
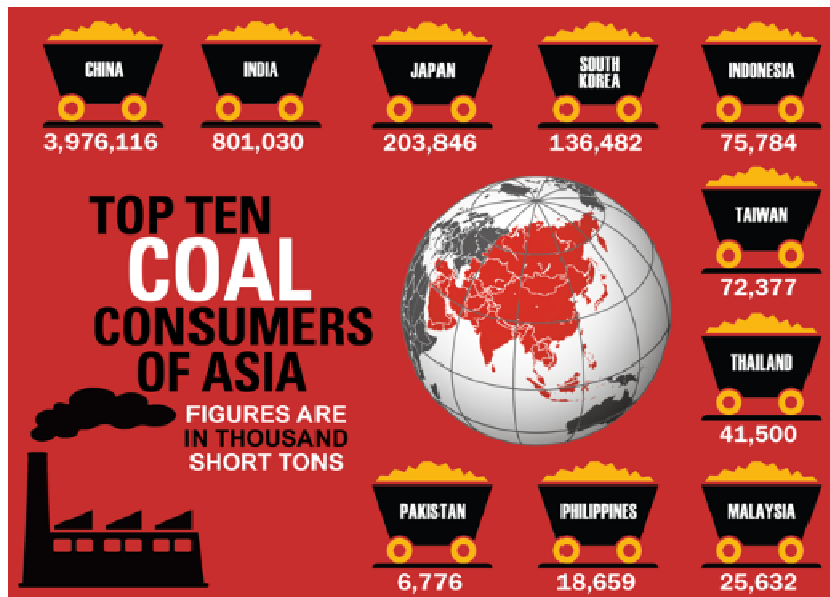
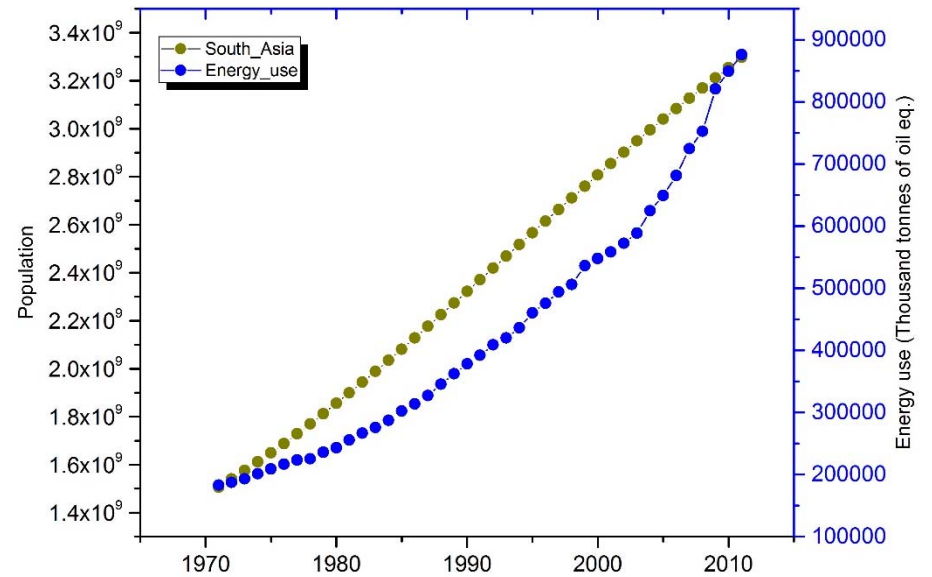




# Population and Energy Use



(SOURCE: US ENERGY INFORMATION ADMINISTRATION, 2012)

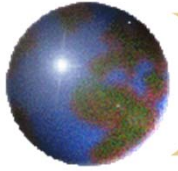


**Fires and smoke in Indonesia  
(6/19/2016) – Also a Recurring  
Event**



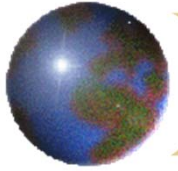
Fires, Riau province, Indonesia, June, 2013, 2016





## *Meeting Focus*

- ✦ Review regional and national science initiatives, relating to LCLUC in the region;
- ✦ Review the causes and impacts of LCLUC specific to agriculture, forests, urban and coastal ecosystems in the Asian region;
- ✦ Review GHG and SLCP emission estimates from different sources in the Asian region;
- ✦ Review latest updates on atmospheric correction algorithms;
- ✦ Review latest research specific to aerosols; biomass burning and emissions modeling;
- ✦ Strengthen the SARI activities in the region.



# Meeting Sessions

- ⊕ **Session-1** – Agricultural Land Use/Cover Changes
- ⊕ **Session-2** – Land Atmospheric Interactions
- ⊕ **Session-3** – Urban Land Use/Cover Changes
- ⊕ **Session-4** - Forest Land use/Cover Changes
- ⊕ **Dedicated Poster Session**
- ⊕ **Panel Discussions (Day-2)** : Research needs;
- ⊕ **Discussion Session (Day-3)**: User needs and priorities.

# Current Meeting Outputs



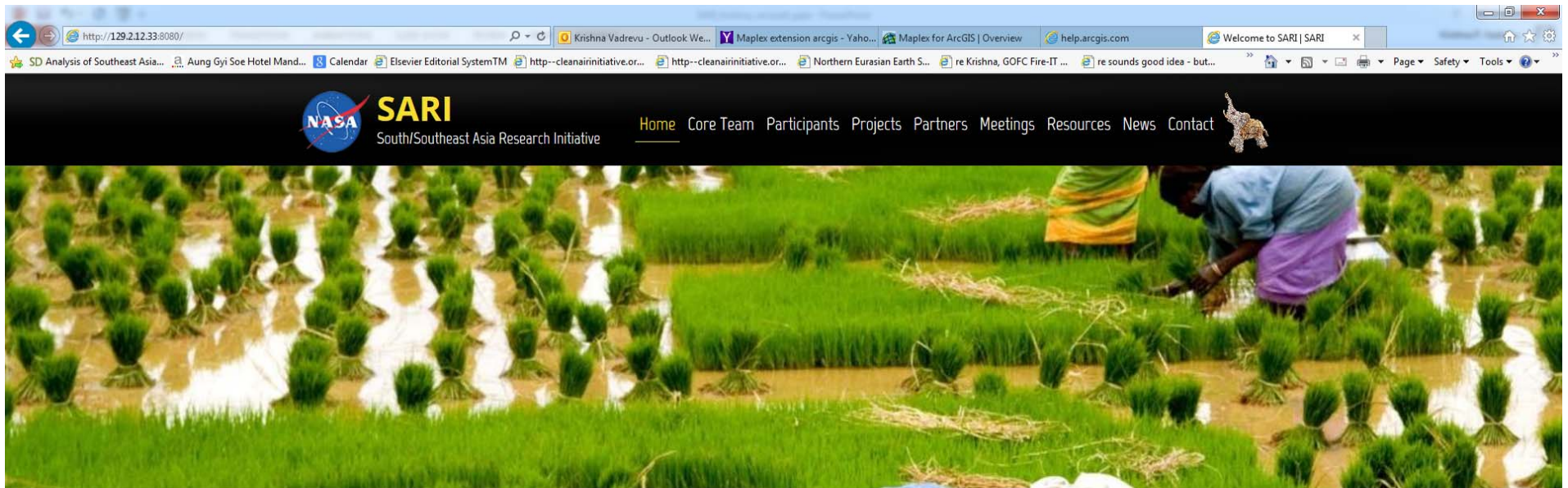
Special Issue:

Remote Sensing of Land Use/Cover Changes (LU/CC) in South/Southeast Asia

Editors:

- Krishna Vadrevu, NASA MSFC)**
- Andreas Heinemann (Univ. of Bern, Switzerland)**
- Chris Justice (Univ. of Maryland, USA)**
- Garik Gutman (NASA HQ)**

**Deadline: March 31<sup>st</sup>, 2018**



## Welcome to SARI

The goal of SARI is to develop an innovative regional research, education, and capacity building program involving state-of-the-art remote sensing, natural sciences, engineering and social sciences to enrich Land Cover/Land Use Change (LCLUC) science in South Asia. Our objectives are twofold. First, we aim to advance LCLUC science in the region. Second, we endeavor to strengthen existing and build new collaborations between US and South Asia researchers in the areas of LCLUC research. To address LCLUC science, SARI will utilize a systems approach to problem-solving that examines both biophysical and socioeconomic aspects of land systems, including the interactions between land use and climate and the interrelationships among policy, governance, and land use. A central component of this initiative will be the use of geospatial data from both remotely sensed and in situ sources and models. To strengthen the theoretical underpinnings of LCLUC science in the South Asian region, SARI will facilitate:

- a) new partnerships with space agencies, universities and non-government organizations;
- b) novel and regionally-appropriate methodologies and algorithms for LCLUC products;
- c) data sharing mechanisms;
- d) leadership training;
- e) international workshops to identify regional priorities, discuss and share scientific findings;
- f) capacity building programs; and
- g) international student/researcher exchanges, including among LCLUC scientists in the region.

SARI will serve as a facilitator and catalyst for LCLUC research in South Asia. The outputs will be beneficial to the U.S., South Asia and international researchers and will serve as a model for interdisciplinary research that links LCLUC science with NASA assets.

# SARI website

# www.sari.umd.edu