

South/Southeast Asia Research Initiative (SARI) LCLUC Research Updates

Krishna Prasad Vadrevu

SARI Lead

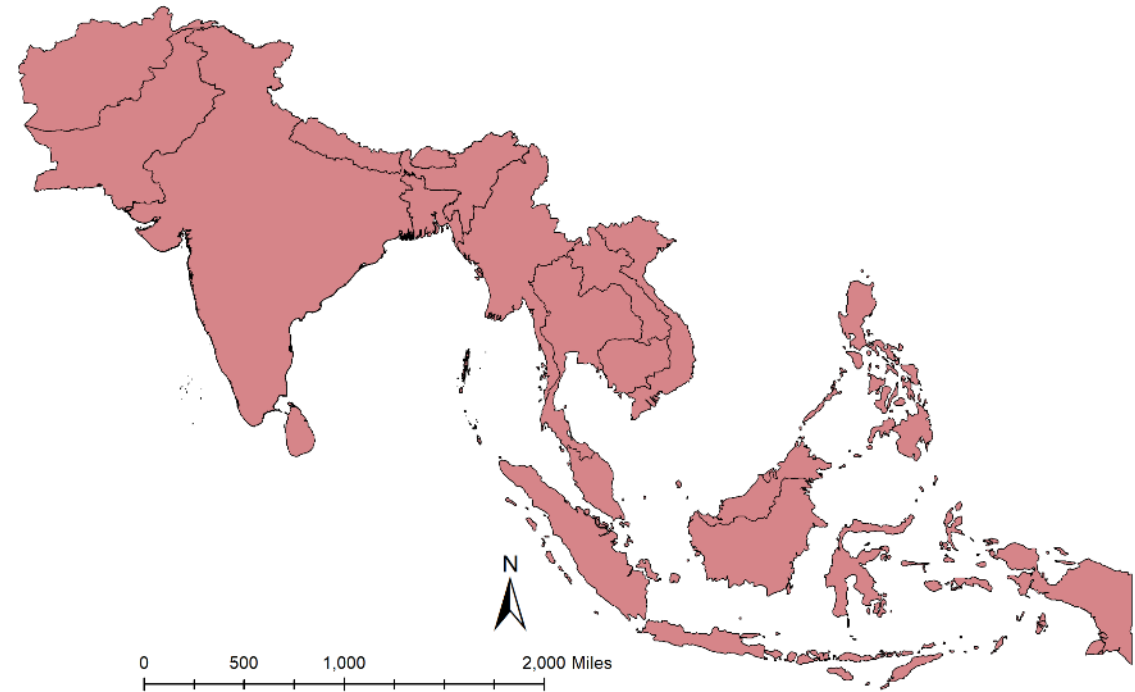
NASA Marshall Space Flight Center

Huntsville, Alabama



Outline

- Background to the SARI initiative
- SARI Projects
- Science updates and LCLUC Drivers
- SARI project outputs
 - Algorithms
 - Datasets
 - Capacity building
 - Collaborations
 - Publications



How SARI started-Strong interest from regional scientists



Jan-10-13th, 2013-LCLUC 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

Krishna Prasad Yadava, University of Maryland, College Park, krishna@hermes.gso.nasa.gov
 Chris Justice, University of Maryland, College Park, justice@hermes.gso.nasa.gov
 Prasad Thenkabail, United States Geological Survey, prtkabail@usgs.gov
 Garik Gutman, NASA Headquarters, 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 India¹, 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);

¹ Kerala and Tamil Nadu are two of the 28 states in India.



Water resource-focused workshop participants. Image 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 (GOFC-GOLD) South Asia Regional Information Network (SARIN) (including prospects, opportunities, and challenges).

The meeting was a joint effort of the NASA LCLUC Program; GOFC-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 mangrove, known as the "red mangrove," near Kadalsandi 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 area 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, banana, and palm plantations, Kozhikode, Kerala.



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

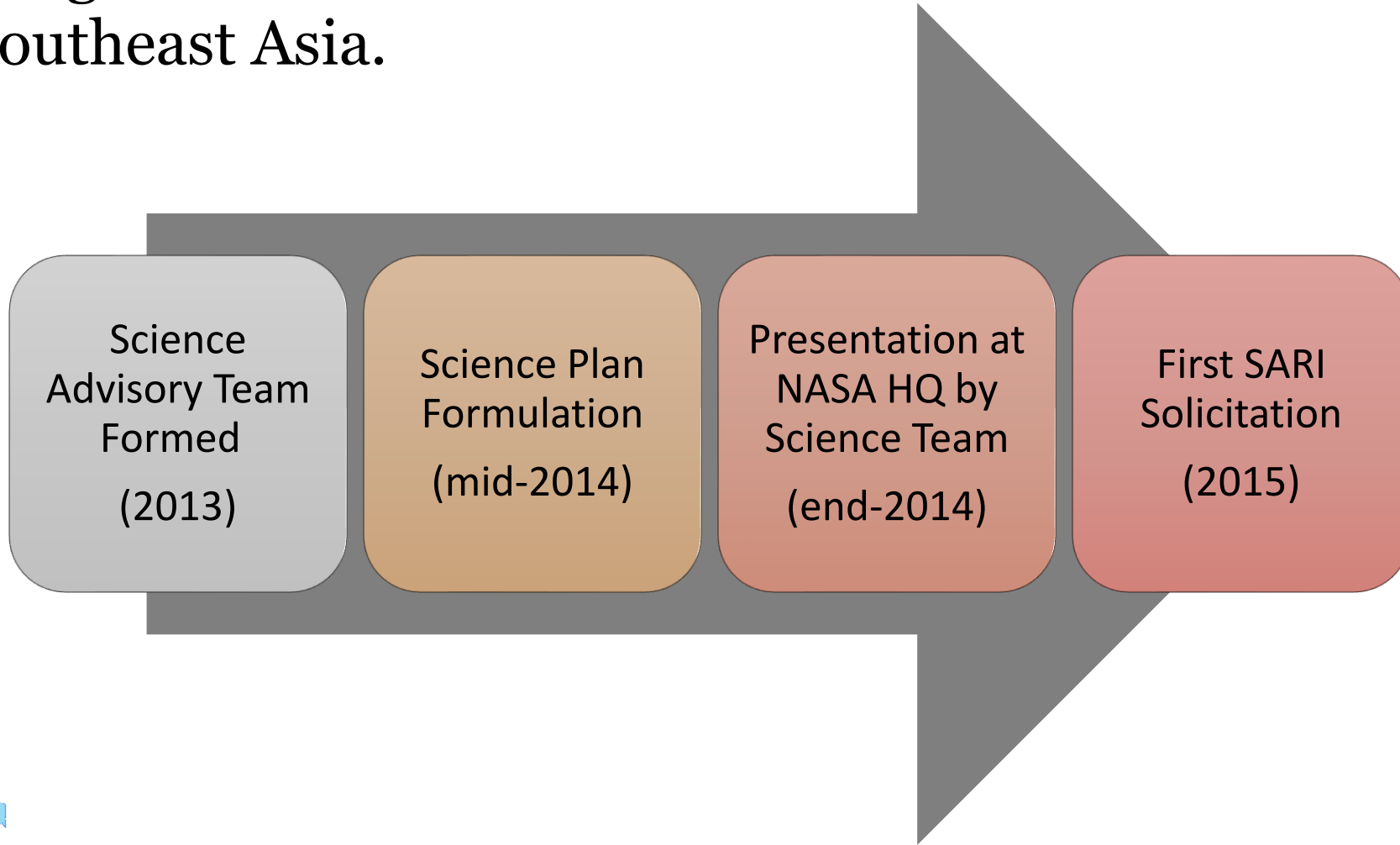
March/April 2013

http://eosps0.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php



SARI - Timeline

Goal: 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 Projects - ROSES-2015 Selections

S.No	2015	Region	PI	Theme
1	Tropical Deciduous Forests of South Asia: Monitoring Degradation and Assessing Impacts of Urbanization	South Asia	Ruth De Fries, Columbia University	Forest degradation and urbanization
2	Understanding Changes in Agricultural Land Use and Land Cover in the Breadbasket Area of the Ganges Basin 2000-2015: A Socioeconomic-Ecological Analysis	South Asia	Li Ping Di	Agricultural land use
3	Impacts of Afforestation on Sustainable Livelihoods in Rural Communities in India	South Asia	Forrest Fleischman/Texas A&M University	Afforestation and sustainable livelihoods
4	The Future of Food Security in India: Can Farmers Adapt to Environmental Change?	South Asia	Meha Jain, University of Michigan	Food security and adaptation
5	Complex Forest Landscapes and Sociopolitical Drivers of Deforestation - The Interplay of Land-use Policies, Armed Conflict, and Human Displacement in	South Asia	Peter Leimgruber/Smithsonian Institution	Deforestation, armed conflicts and policy
6	Understanding the Role of Land Cover/Land Use Nexus in Malaria Transmission Under Changing Socio-Economic Climate in Myanmar	South Asia	Tatiana Loboda/University of Maryland	Malaria
7	Urban Growth, Land-Use Change, and Growing Vulnerability in the Greater Himalaya Mountain Range Across India, Nepal, and Bhutan	South Asia	Karen Seto/Yale University	Urbanization and vulnerability
8	Landscapes In Flux: The Influence of Demographic Change and Institutional Mechanisms on Land Cover Change, Climate Adaptability and Food Security in Rural India	South Asia	Philip Townsend/University of Wisconsin-Madison	Food security and adaptation
9	Consequences of Changing Mangrove Forests in South Asia on the Provision of Global Ecosystem Goods and Services	South Asia	Jeffrey Vincent/Duke University	Mangroves and Ecosystem services
10	Spatiotemporal Drivers of Fine-Scale Forest Plantation Establishment in Village-Based Economies of Andhra Pradesh	South Asia	Randolph Wynne/Virginia Polytechnic Institute and State University	Plantations and agricultural transitions

(10 projects over South Asia)



SARI Projects - ROSES-2016 and 2018 Selections

S.No	2016	Region	PI	Theme
11	Agricultural Land Use Change in Central and Northeast Thailand: Effects on Biomass Emissions, Soil Quality, and Rural Livelihoods	Southeast Asia	Varaprasad Bandaru/University of Maryland, College Park	Emissions, soil quality
12	The Agrarian Transition in Mainland Southeast Asia: Changes in Rice Farming - 1995 to 2018	Southeast Asia	Jefferson Fox/East West Center	Rice Farming
13	A Cobra in the Forest? Quantifying the Impact of Perverse Incentives from Indonesia's Deforestation Moratorium, 2011 to 2016	Southeast Asia	Matt Hansen, Umd	Deforestation, moratorium policies
14	Land-Cover/Land-Use Change in Southern Vietnam Through the Lenses of Conflict, Religion, and Politics, 1980s to Present	Southeast Asia	Jessica McCarty, Miami University	Land use change, religion conflicts and policies
15	Land Use Status, Change and Impacts in Vietnam, Cambodia and Laos	Southeast Asia	Son Nghiem/Jet Propulsion Laboratory	Land use change
16	Assessing the Impacts of Dams on the Dynamic Interactions Among Distant Wetlands, Land Use, and Rural Communities in the Lower Mekong River Basin	Southeast Asia	Qj, Michigan State University	Water resources

S.No	2018	Region	PI	Theme
17	Land-Use Transitions in Indonesian Peatlands	Southeast Asia	Mark Cochrane/University of Maryland, Cambridge	Peatlands and land use
18	Divergent Local Responses to Globalization: Urbanization, Land Transition, and Environmental Changes in Southeast Asia	Southeast Asia	Peilei Fan, Michigan State University	Urbanization, land use and pollution
19	Sowtime: Climate Adaptive Agriculture in the Eastern Gangetic Plains	South Asia	Josh Gray, North Carolina State University	Agriculture and climate
20	Shifting Cultivation at a Crossroad: Drivers and Outcomes of Recent Land-Use Changes in Laos PDR	Southeast Asia	Peter Potapov, University of Maryland, College Park	Shifting cultivation, land use drivers
21	New Transitions in Smallholder Agricultural Systems that Promote Increased Tree Cover Outside of Forests	South Asia	David Skole, Michigan State University	Small holder agriculture and Trees outside forests
22	Forced and Truncated Agrarian Transitions in Asia Through the Lens of Field Size Change	Southeast Asia	Lin Yan, South Dakota State University	Agriculture and field size change

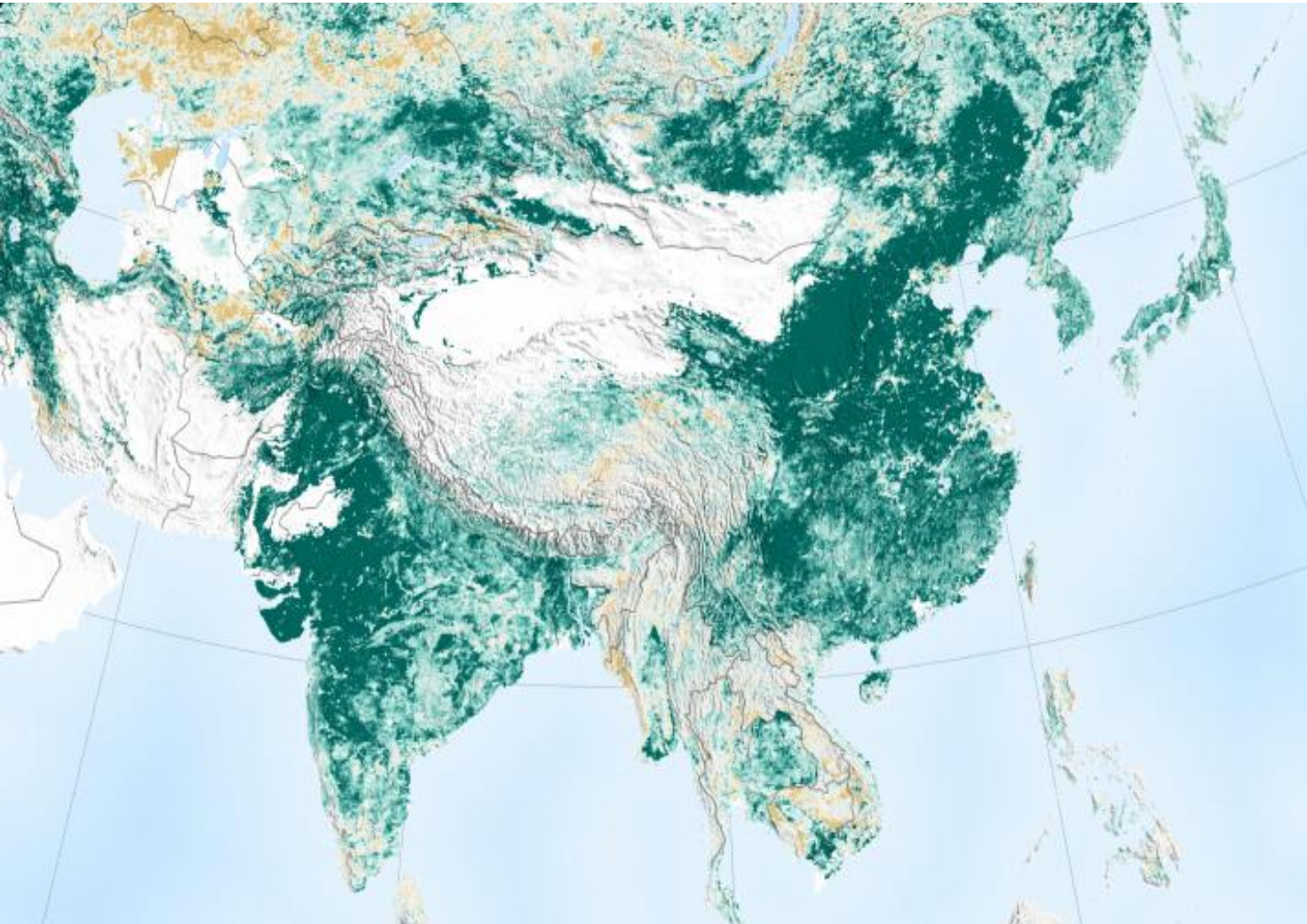
(6 projects on Southeast in 2016; 4 on Southeast and 2 on South Asia in 2018)



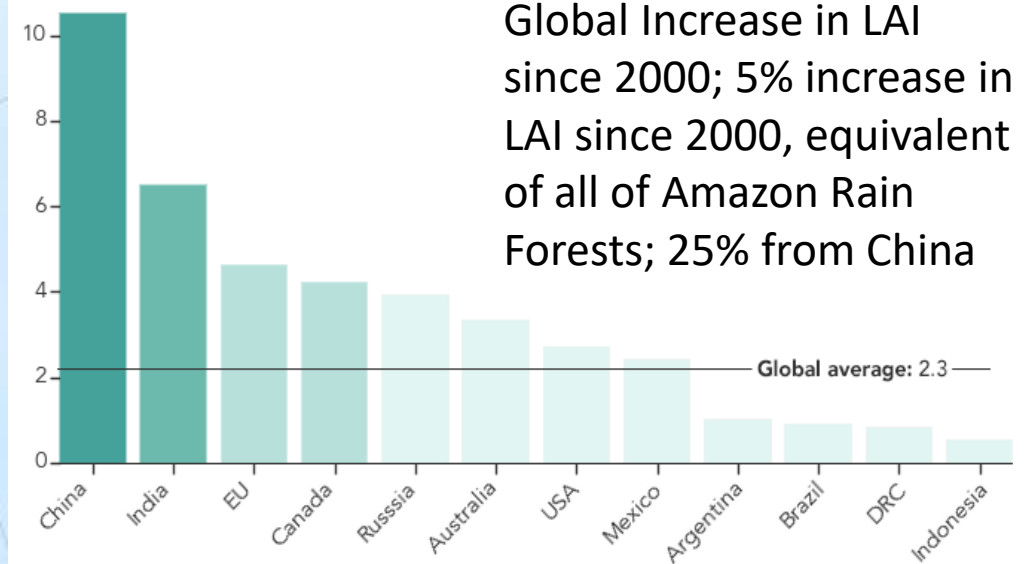
- Some on-going LCLUC issues in South/Southeast Asia



China and India Lead in Greening



China and India Lead in Greening Due to Human Activity
Change in Leaf Area (% per decade)



Global Increase in LAI since 2000; 5% increase in LAI since 2000, equivalent of all of Amazon Rain Forests; 25% from China

Global green leaf area has increased by 5 percent since the early 2000s, an area equivalent to all of the Amazon rainforests. At least 25 percent of that gain came in China.

China and India—the world’s most populous countries—are leading the increase in greening on land. The effect comes mostly from ambitious tree-planting programs in China and *intensive agriculture in both countries*. (Myneni et al., Nature, 2019)

Carbon is traded like any other Commodity – Thus, accurate mapping and monitoring of forests is important

UN questions India's forest cover data over lack of transparency & clarity

India had submitted data to access potential funds from global carbon trade under Paris Agreement after 2020

Nitin Sethi | New Delhi

Last Updated at January 3, 2019 01:17 IST

f 725 t in + 12



Doubts have been raised by a UN body over India's claims that its forest cover has been increasing steadily for years.

Questions have been raised by experts of the UN Framework Convention on Climate Change at a time when future claims of increase and enrichment of India's forest cover could lead to potentially millions of dollars of easy income annually once the Paris Agreement is implemented. The global agreement envisions setting up a global mechanism for countries to trade in the greenhouse gas emissions avoided by either growing more forests, enriching existing ones or ...



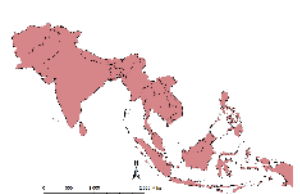
Biennial Forest cover mapping since 1987

Recheck forest cover data, UN body tells India; flags concern about definition

India's definition of forests has been criticised by scientists in the past on the grounds that it doesn't provide an accurate picture of the extent of biodiversity in rich natural forests.

INDIA Updated: Jan 10, 2019 07:29 IST

ht Jayashree Nandi
Hindustan Times, New Delhi



India's proposed Modified Submission on Forest Reference Levels for REDD+ - Results Based Payments under UNFCCC

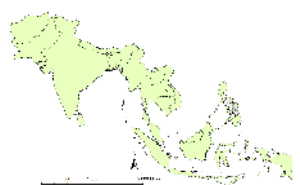
3.2 Definition of forest

As per 13/CP.19, Annex, paragraph 2 (g), the forest definition used for the construction of the FRL should be consistent with definition used for GHG inventory. India has used the same definition as was used for GHG inventory, which is given as follows:

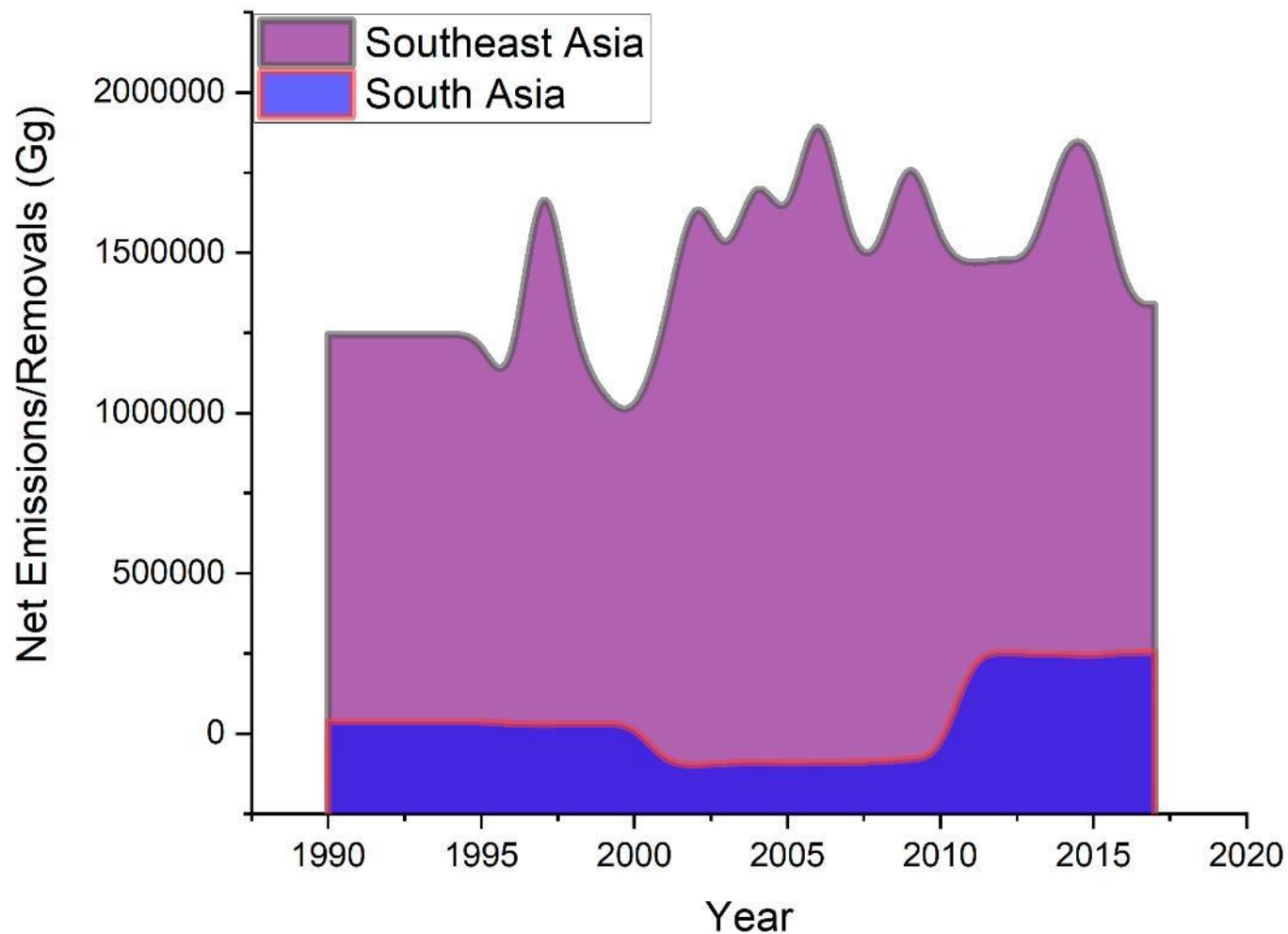
“All lands, more than one hectare in area, with a tree canopy density of more than 10 percent irrespective of ownership and legal status. Such lands may not necessarily be a recorded forest area. It also includes orchards, bamboo and palm.”

(The definition of forest has been taken exactly as was used for GHG inventory and FRA 2015. The only difference in above definition is that it has been explained further.

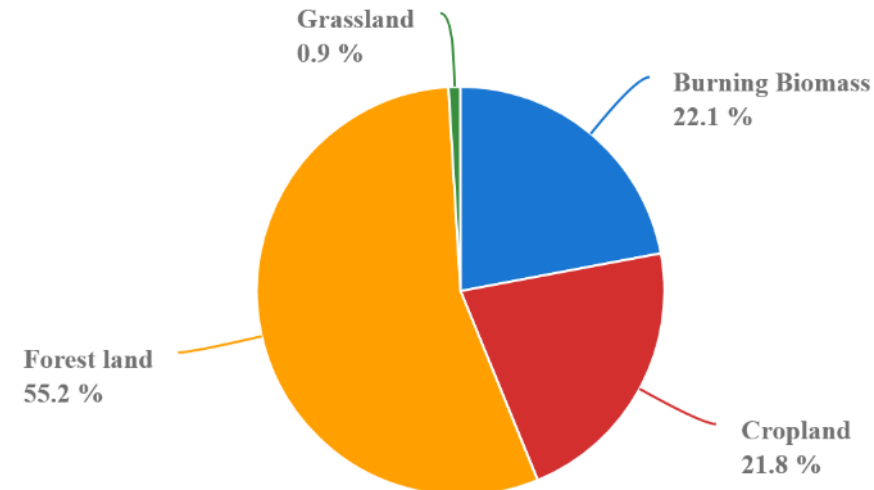
The separate area under orchards, bamboo and palm are not available as it is not possible to delineate these areas from satellite. However, the area under TOF/plantation given under forest types includes these areas partly based on the ancillary information from State Forest Departments, toposheet etc. Scrubs and shrubs are not the part of the forest cover.)



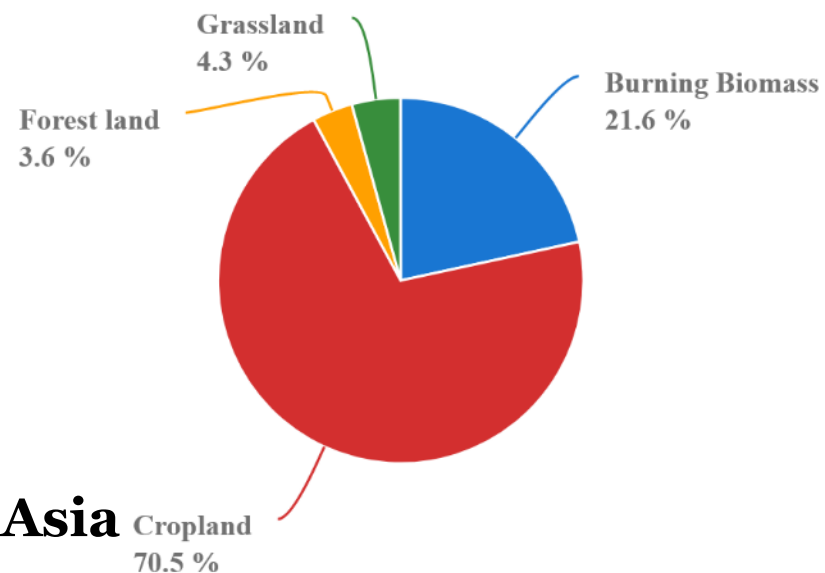
Net emissions/removals from Agriculture, Forestry and Other Land Use (Total CO2 Eq.),- Average (1990-2017) (FAOSTAT, 2020)



Southeast Asia



South Asia



AFOLU still is a significant source of net CO2 Emissions in Asia

COVID-19 impacts yet to be understood

Negative Impacts

- Mortality and health infrastructure failures
- Disrupted economies, job losses
- Migration to rural areas
- Increased dependence on Forests/deforestation
- Biomass burning continued
- Planting and harvesting delays due to shortage of labor
- Increased food prices
- Increased domestic solid waste
- Market failures

Positive Impacts

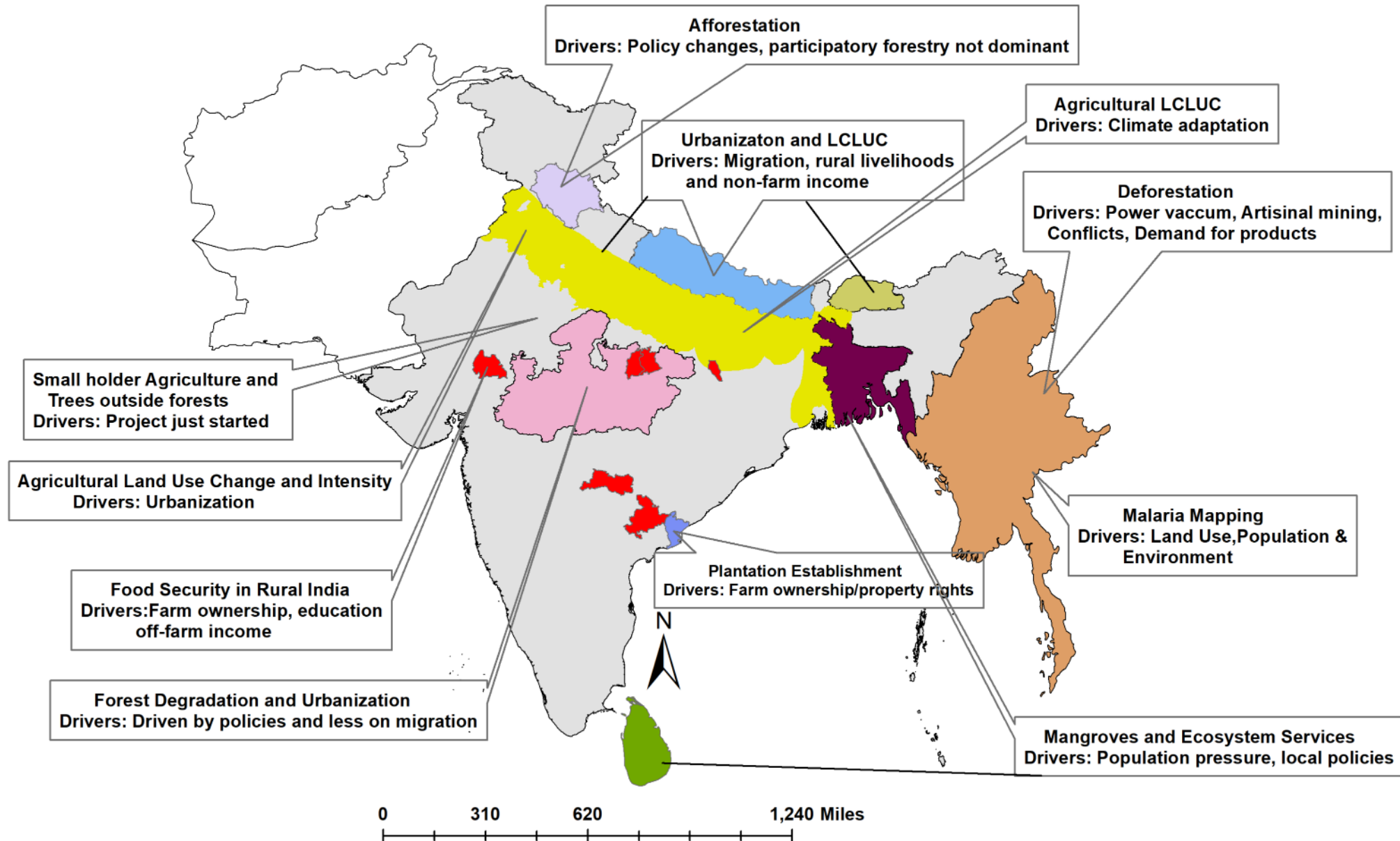
- Decreased fossil fuel dependence
- Decreased urban pollution
- Decreased water pollution
- Favored local foods
- Decreased construction activities
- Adverse impacts of tourism on environment reduced (eg: clean beaches)
- Reduced urban footprint



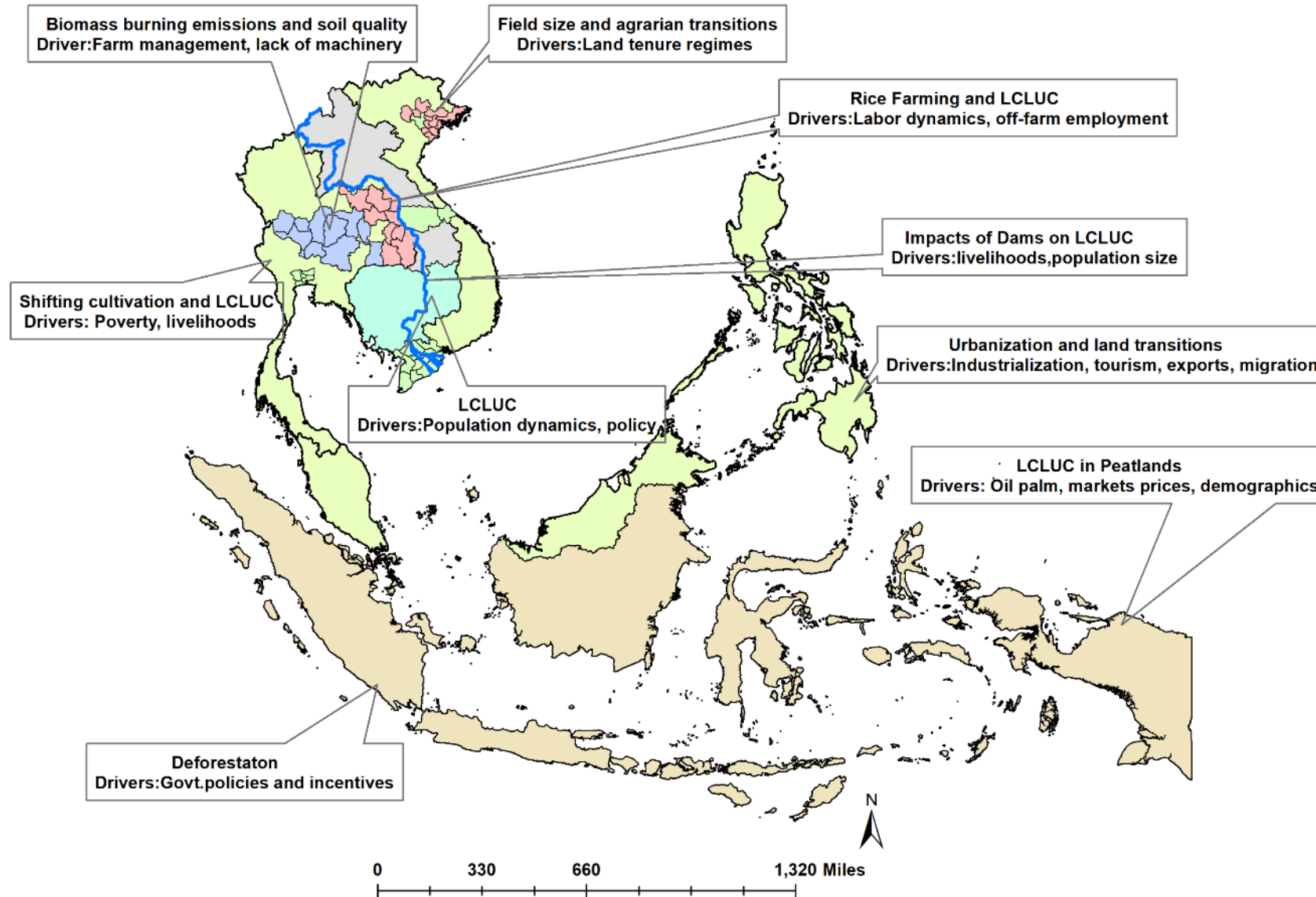
- What are the major drivers of LCLUC in South and Southeast Asian countries?



South Asia – LCLUC Drivers Identified by SARI PI's



Southeast Asia – LCLUC Drivers Identified by SARI PI's



- What are the major outputs of the SARI ?
 - Novel projects and Algorithms
 - Products and Datasets
 - Capacity building
 - Collaborations
 - Publications



SARI – Novel Project Studies and Algorithms

Agricultural field size mapping – VHR data and modified Geographic Object Based Image Analysis (GEOBIA) approach

Smallholder – Plantations mapping - VHR + MuSLI in combination with Deep Learning

Agricultural sensitivity to climate change – Multi-sensor data integration for mapping agricultural intensity

Urbanization in the Himalayas– Landsat and VHR - Timeseries analysis methods

Deforestation in Indonesia – Landsat and Machine Learning Methods

Urban built-up Volume in Southeast Asia – QuikSAT Scatterometer Dense Sampling studies

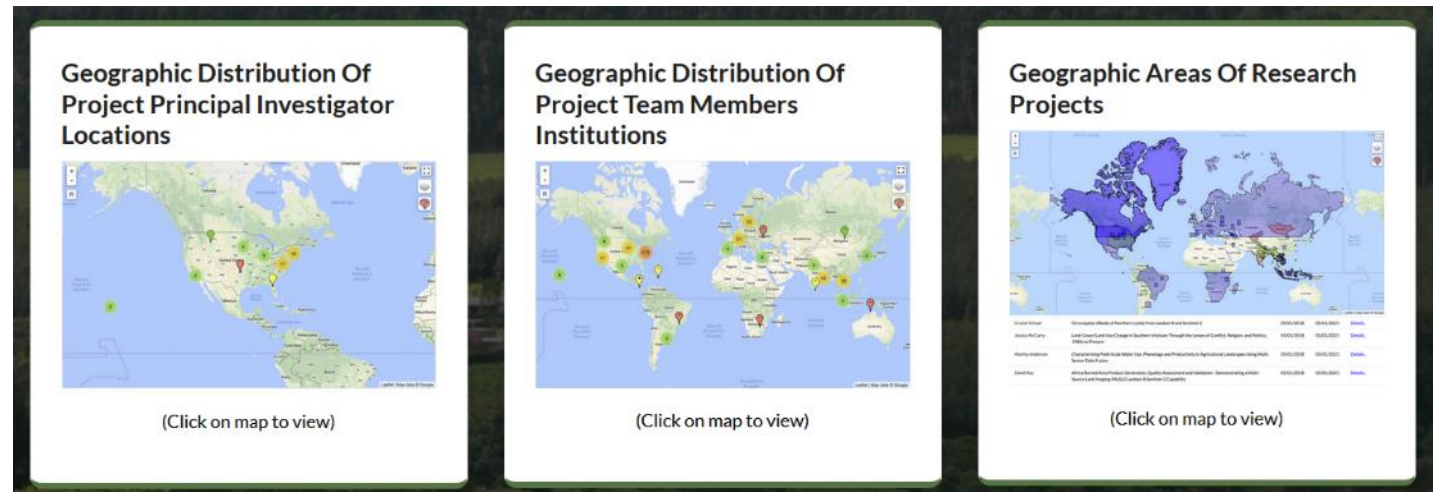
Agrarian transitions in Southeast Asia– Harmonics for identifying phenology and Multi-sensor data integration for mapping

Slash and burn agriculture in Laos– Landsat, Sentinel and VHR data, decision trees and stratified sampling approach

LCLUC Products and Metadata Efforts

- All data/products to be shared through the LCLUC website
- Data includes both remote sensing/non-remote sensing
- Metadata being created for each product with citation
- If already distributed through DAAC's, only weblinks to be provided
- Product sharing being made mandatory through NASA grants (grant award letter)
- 18-different PI's already responded and shared their data/products

LCLUC Website



SARI Meetings



June 24th-26th, 2014



Logos and text for the workshop:

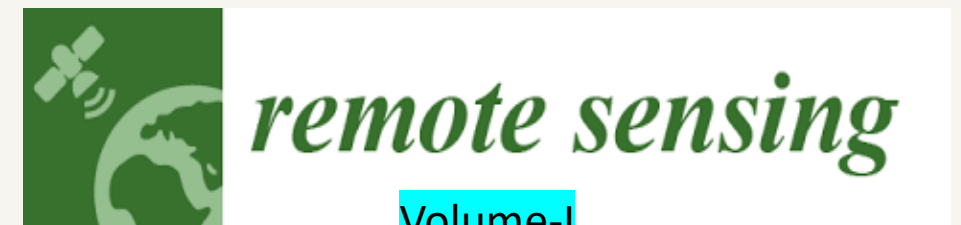
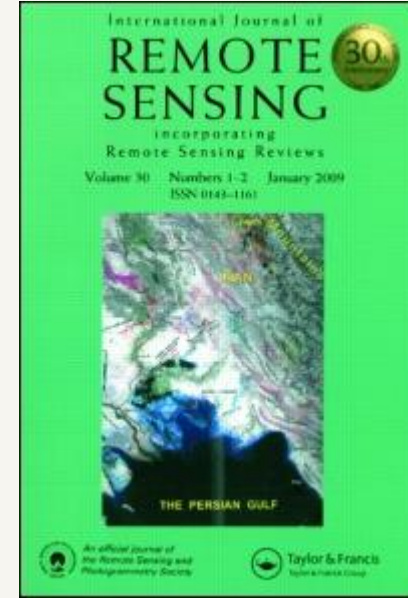
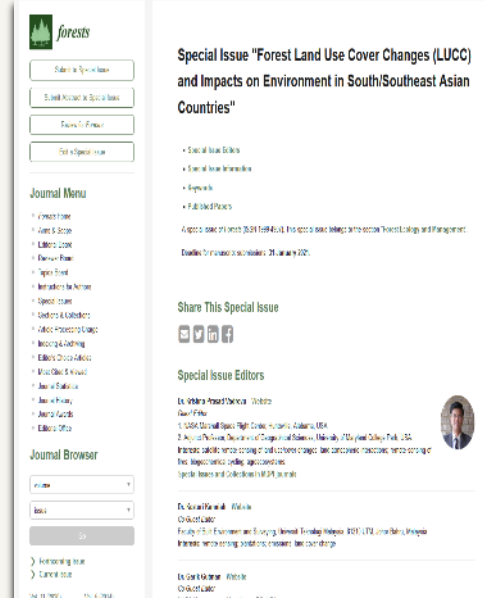
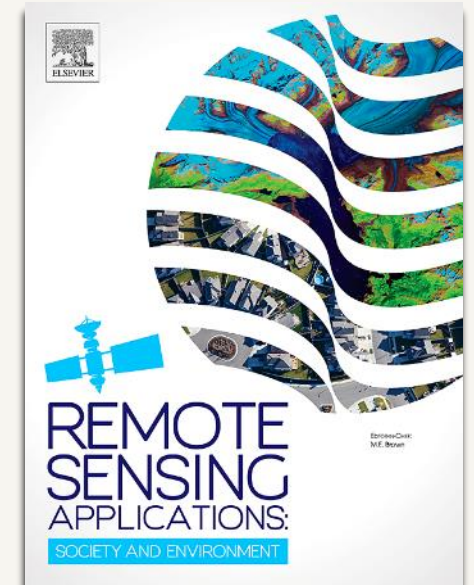
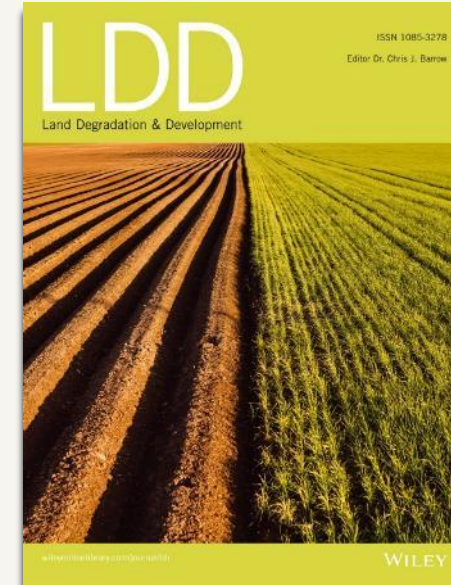
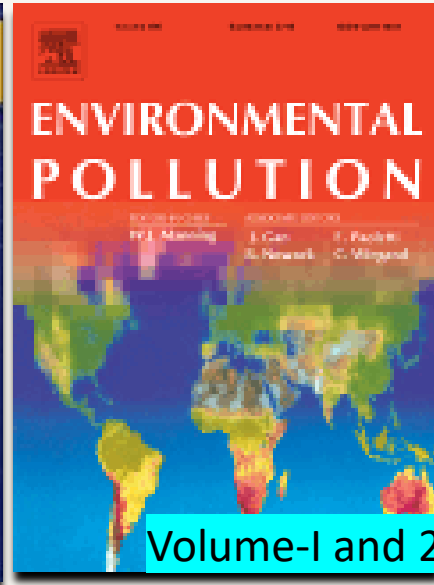
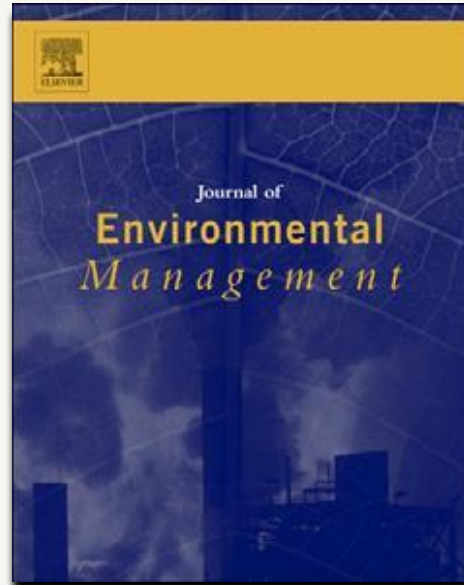
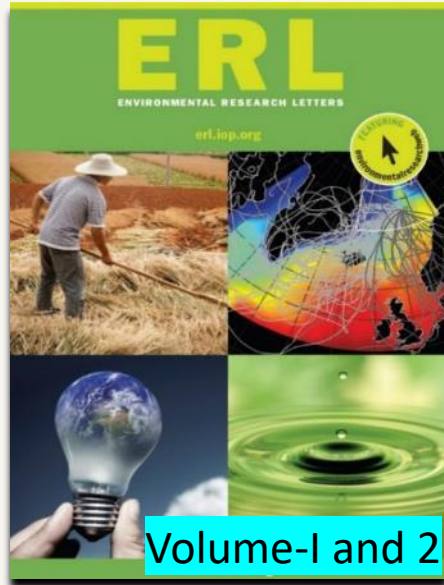
- NIES JAPAN
- GOFC-GOLD
- UNIVERSITY OF MARYLAND
- START
- Local Host: VNU UNIVERSITY OF ENGINEERING AND TECHNOLOGY



Collaborations are the Key – SARI Meetings Facilitated by Regional and International partners



SARI Special Issues Published in Multiple Journals

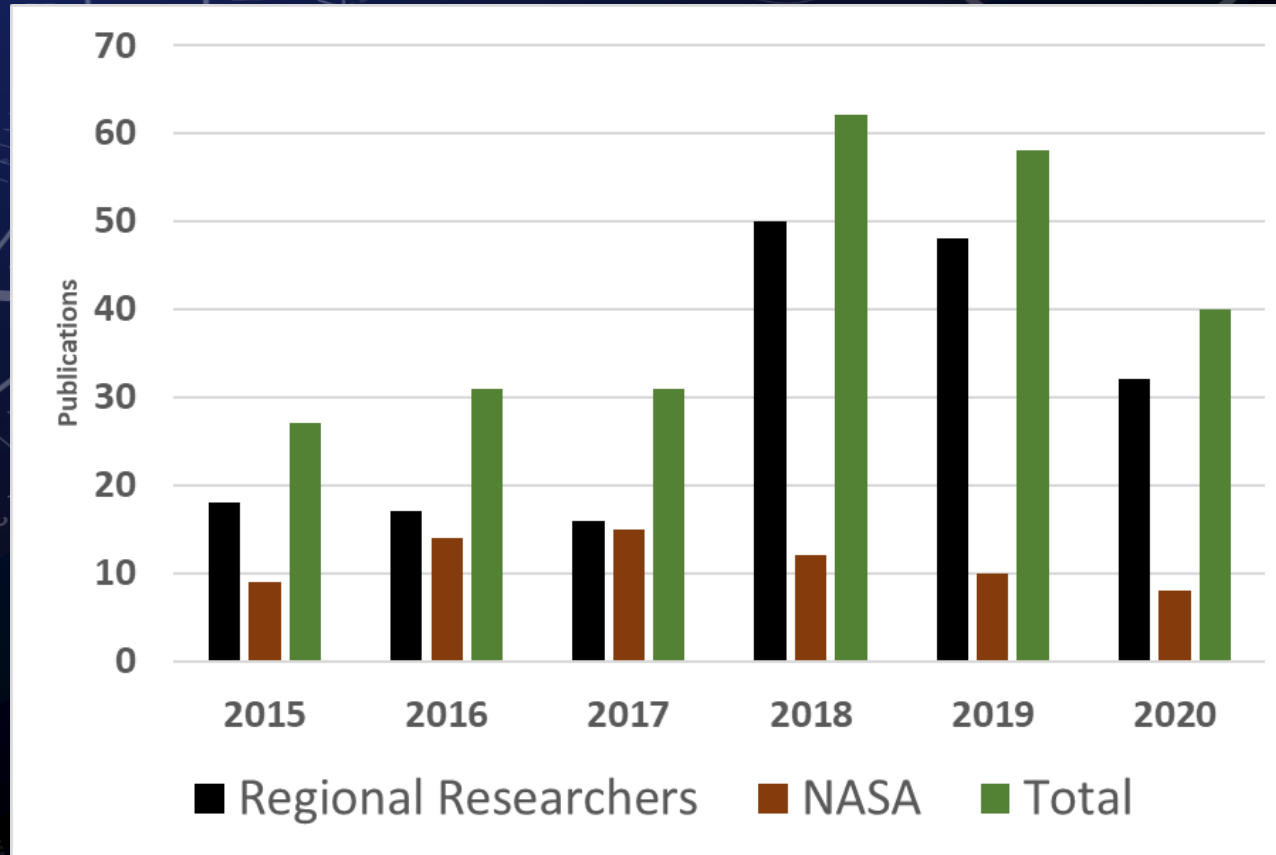


~200 peer reviewed publications in 5-years

SARI 4.5 YEARS OF SCIENCE

-22 projects
>250 scientists
>150 institutions

12-different
Special
Issues in
Journals



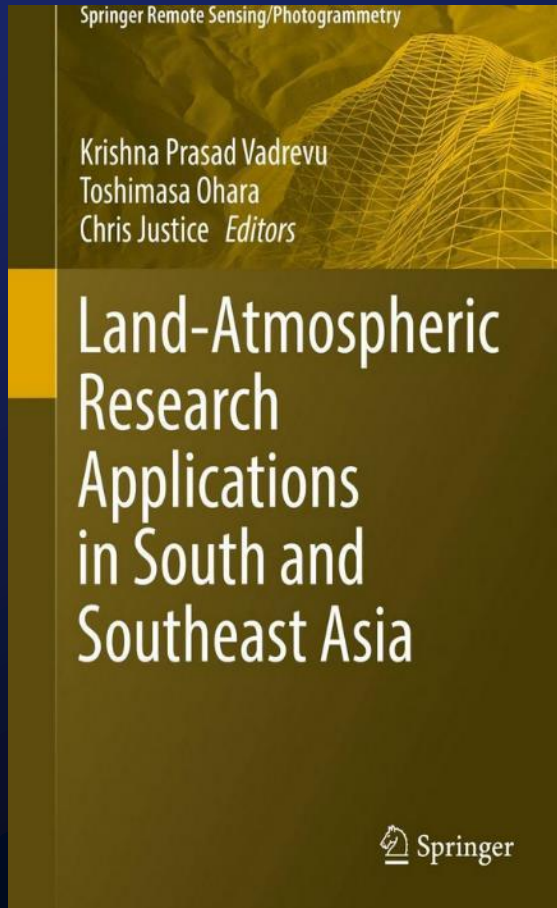
Nearly 250
publications
in Peer
reviewed
journals
and Books

South-Southeast Asia

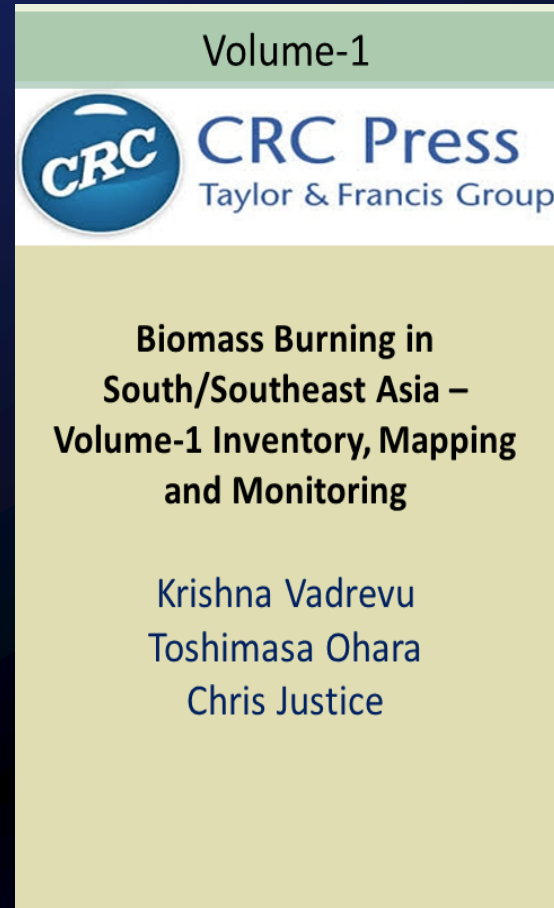
Oct-2013 – India Meeting – SARI idea proposed
2015-SARI First SARI Solicitation



SARI-LCLUC BOOKS



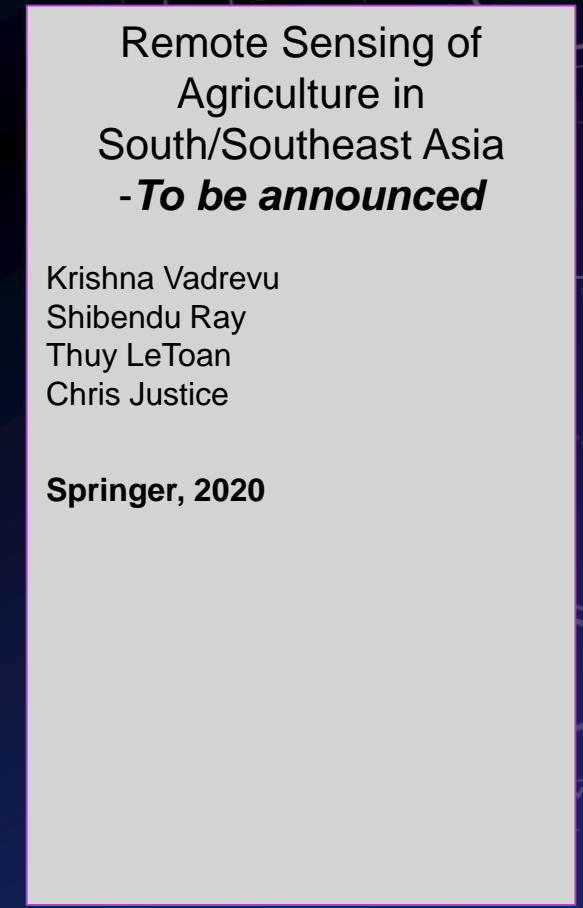
Springer 2018



CRC Press, 2020



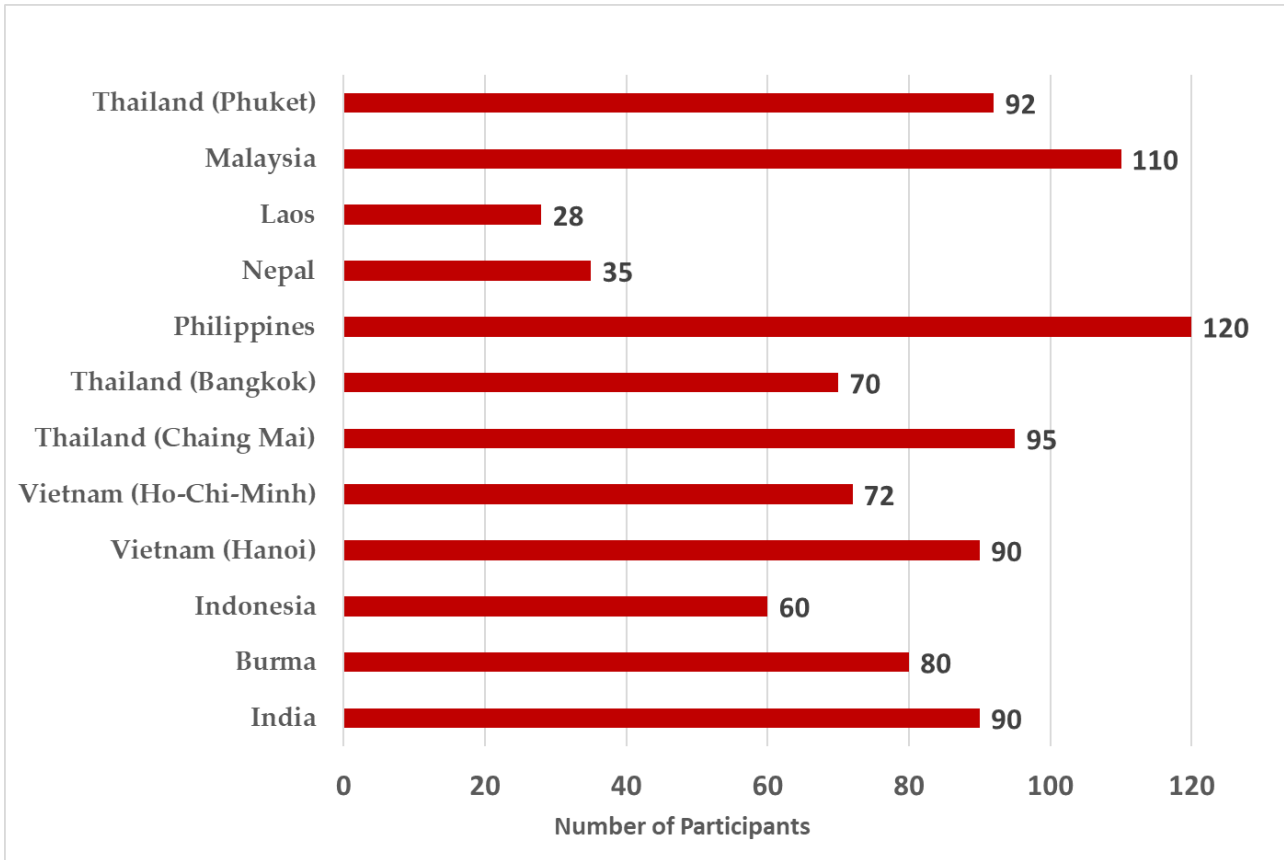
CRC Press, 2020



Springer, 2021



SARI – LCLUC Training Events



Promoting Open Source Tools and Cloud Computing Platforms For LCLUC Research (Ex: GEE)



PSU PRINCE OF SONGKLA UNIVERSITY PHUKET CAMPUS

Certificate of Participation

Awarded to
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

For participating in the international regional science training entitled
“Remote Sensing of Land-use/Cover Change and Climate Impacts In Coastal Zone”, 17-19th December, 2020, Phuket, Thailand

Garik Gutman
NASA LCLUC Program Manager, USA

Werapong Koedsin
Dean, Faculty of Technology and Environment, Prince of Songkla University, Thailand

Krishna Vadrevu
NASA MSFC, SARI Program Scientist, USA

START GOFC-GOLD LCLUC SARI GISTDA

Recent Example on the Integrated SARI Training Event

Remote Sensing of Land-Use/Cover Change and Climate Impacts In Coastal Zone
17-19th December, Prince Songkla U, Thailand

Remote Sensing of Land-Use/Cover Change



- 15-Partners came together to organize a training event in Phuket, Thailand - all under SARI
- Involving SARI, SERVIR, Local Universities, Government, Non-Government, International and Regional Organizations
- We also made it a WGCapD event. It is mandatory to have at least 2 space agency involvement in WGCapD events. Through effective coordination from SARI, we could bring Trainers from 4-different space agencies: NASA + ISRO + GISTDA + JAXA
- **Total Days:** 3 days + 1-day field trip
- **Total Participants:** 92 (university students, govt and participants from non-govt agencies)
- **Logistics:** food provided freely to all
- **Training topic:** advanced remote sensing methodologies for Land use/cover change + cloud computing
- Pre-and post evaluation surveys to get feedback for improving future training events.



Priorities

- Publications (*yet to see from some PI's!*)
- Land use outcomes feedback effects and interactions
- **IMPACTFUL** research and strong stories linking policy
- Synthesis and Meta-analysis

*Dr. Gutman (NASA HQ) and
Prof. Justice (UMd)*



*Vision, support and
guidance to build
the SARI regional
science initiative*

