NASA South/Southeast Asia Research Initiative (SARI) Updates

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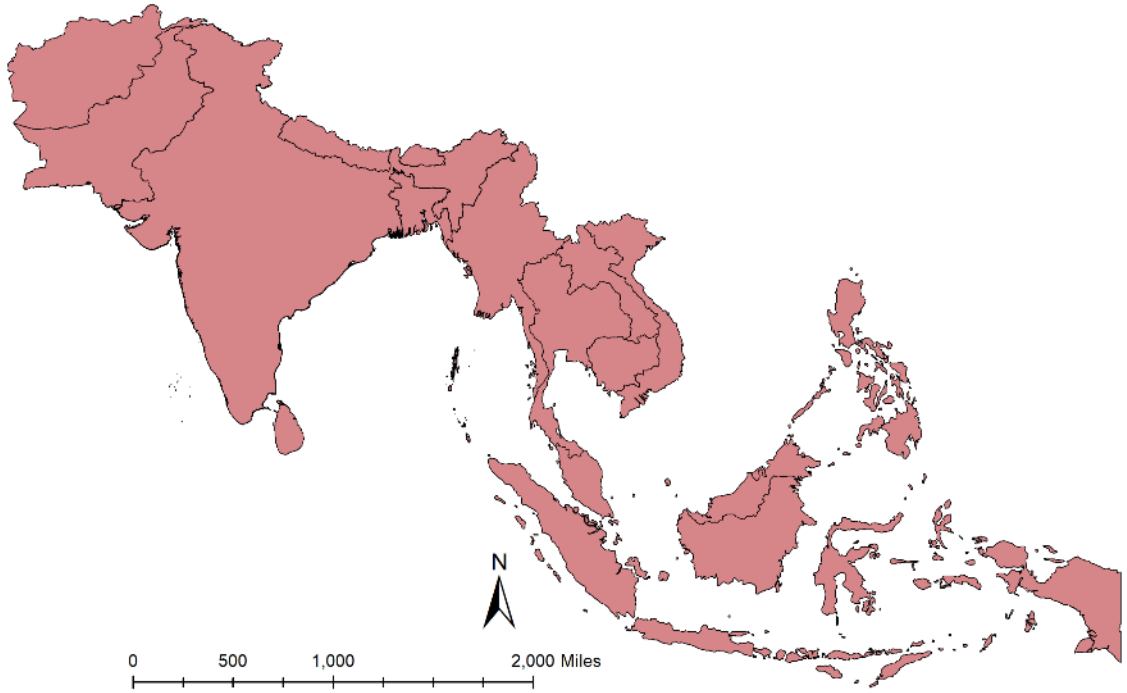
SARI

Land-Cover / Land-Use Change Program

Outline

- Background to the South/Southeast Asia Research Initiative(SARI)
- SARI Outputs and Updates
- SARI Synthesis Meeting Objectives



Thematic Meeting on LCLUC and Air Pollution in Asia, Feb-2023 – Summary Published

International Meeting on Land Cover/Land Use Change (LCLUC) in South/Southeast Asia and Synthesis

Local Host
Vietnam National Space Center (VNSC)
Hanoi, Vietnam

Hanoi, Vietnam

Meeting Date:
01/31/2024 to 02/02/2024

Venue:
Vietnam National Space Center, Hanoi, Vietnam

Training Start Date:
01/29/2024

Training End Date:
01/30/2024

Training Location:
Vietnam National Space Center, Hanoi, Vietnam

South/Southeast Asia Meeting on Air Pollution in Asia—Inventories, Monitoring and Mitigation

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Garik Gutman, NASA HQ, ggutman@nasa.gov
Chris Justice, University of Maryland College Park, USA; cjustice@umd.edu

Introduction

The 2023 **NASA Land Cover and Land Use Change** (LCLUC) program's **South/Southeast Asia Research Initiative** (SARI) thematic meeting was held February 1–3, 2023 in Hanoi, Vietnam—see **Photo 1** *below*. The Vietnam National University of Engineering and Technology (VNU-ET), the Vietnam National Space Center (VNSC), and the Vietnam Academy of Science and Technology (VAST) served as local meeting hosts. The meeting had 90 participants from several South/Southeast Asian countries and the U.S. It was organized into eight different sessions over three days. The content included invited presentations, reports from the SARI Principal Investigators (PIs), and reports from regional scientists.

The tagline for the meeting was *Air Pollution in Asia—Inventories, Monitoring and Mitigation*. Meeting participants included SARI researchers as well as representatives of several other international programs, e.g., the **Global Observations of Forest and Land Use Dynamics** (GOFC-GOLD), **South/Southeast Asia Regional Information Networks**, researchers from Japan's **National Institute of Environmental Studies** (NIES), Regional and Space Agencies—including the **Association of Southeast Asian Nations** (ASEAN) intentionally gathering such a diverse group of participants allowed the meeting to achieve its objectives which were to:

- review greenhouse gas (GHG) and short-lived climate pollutant (SLCP) emission estimates and methodologies from different sources, including biomass burning in the Asian region;
- understand the impact of GHGs and aerosols on local climate, including health effects;
- explore the potential of satellite remote-sensing datasets for quantifying pollutants, aerosols, and pollution episodes;
- review modeling approaches for characterizing emissions; and
- strengthen regional information exchange and training activities through effective collaborations.

Photo 1. Participants at the NASA LCLUC SARI International Meeting on Air Pollution in Asia: Inventories, Monitoring and Mitigation, held February 1–3, 2023 in Hanoi, Vietnam. **Photo credit:** VNU-ET staff

2011

2014

2016

A Success Story – Kristofer Lasko, Ph.D 2014-2018 (UMd)
Joint Supervision – Chris Justice and Krishna Vadrevu

Mapping and estimating rice residue burning and associated emissions scenarios in the greater-Hanoi region of Vietnam.

5-publications from Ph.D
-3 greater than 100 citations
-2 greater than 130 citations

<u>Currently, Deputy Branch Manager</u>
Geospatial Engineer Research and Development Center, US Army, Virginia

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

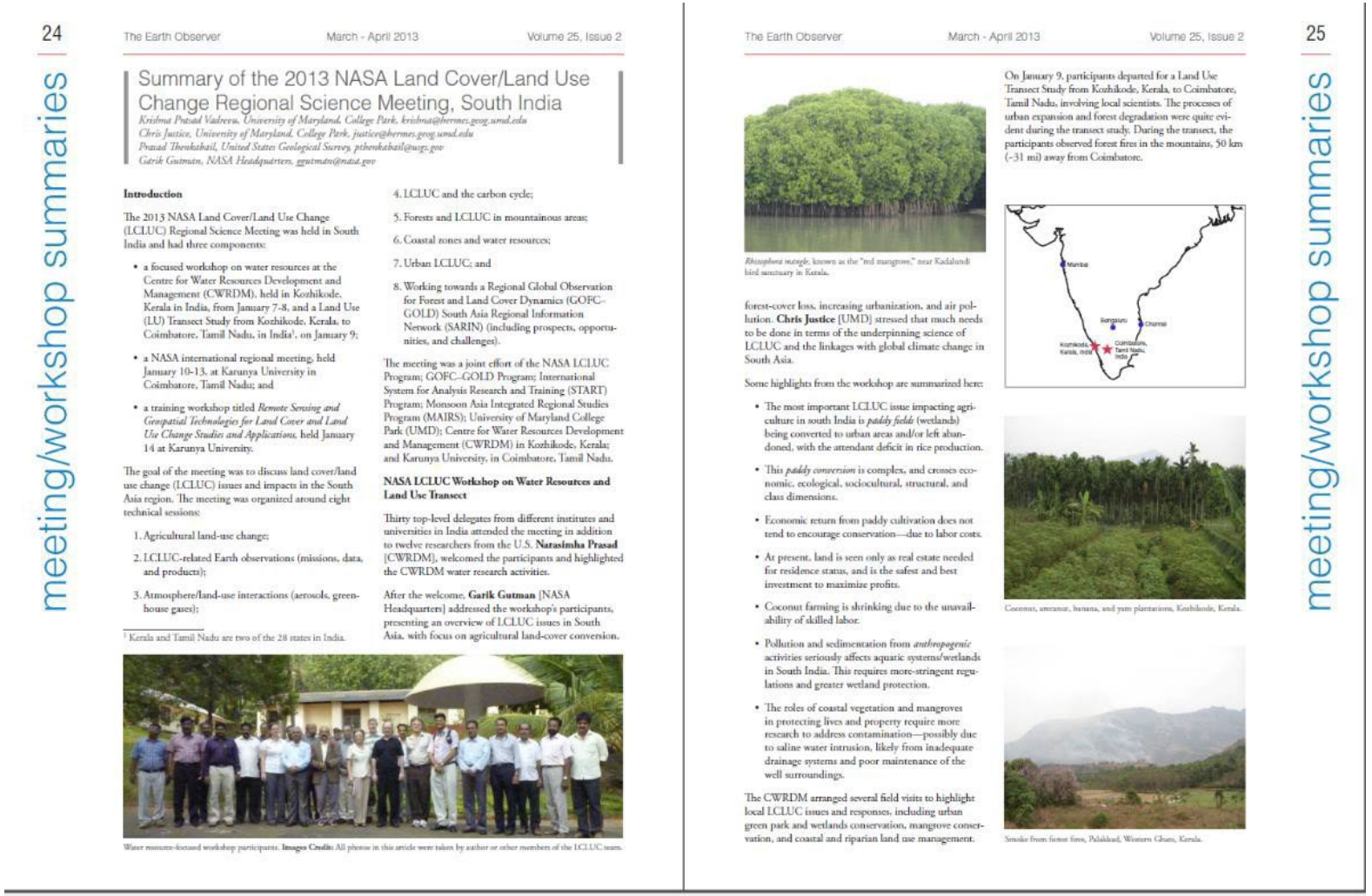
Pakistan, China invited but could not attend – Visa issues

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

Needs Identified

- Focus LCLUC thematic areas
- Need for products
- Strengthen Research ties
- Training opportunities
- Student opportunities
- How to strengthen ISRO – NASA collaborations ?
- Data access (how to access ISRO satellite data)

Meeting Summary- SARI Research Needs and Priorities - The Earth Observer



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meeting/workshop summaries

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

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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[1], 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);
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).

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

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.

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

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meeting/workshop summaries

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

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.

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.

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

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

March/April 2013

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

NASA Land Cover/Land Use Change (LCLUC) Program
South/Southeast Asia Research Initiative (SARI)

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.

Dr.Krishna Vadrevu, SARI Lead, NASA MSFC

- Science Advisory Team Formed (2013)
- Science Plan Formulation (mid-2014)
- Presentation at NASA HQ by Science Team (end-2014)
- First SARI ROSES Solicitation (2015)
- SARI Synthesis Solicitation (2021)

-Balancing Act

-Research + outreach activities should be blended to achieve successful science outputs

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 Ecosysltem 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	Qi, 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; 3 more in 2019)

S.No	2020	PI	Theme
23	Where are the Missing Burned Areas? Global Hotspots of Burned Area - A	David Roy, Michigan State U	Burned area mapping
	Multiresolution Analysis		
24	Global Hotspots of Change in Mangrove Forests	Marc Simard, JPL	Mangrove mapping
25	Multi-Resolution Quantification and Driver Assessment of Hot Spots of Global Forest Disturbance	Alexandra Tyukavina, UMD	Forest disturbance mapping

Synthesis Project – South Asian Countries-2022-2026

- **South Asian smallholder forests and other tree-based systems: synthesizing LCLUC data and approaches to foster a natural climate solution that improves livelihoods – David Skole (MSU)**

- **Southeast Asia Synthesis – Dr. Nghiem and Dr. Fan – This Session Presentations**
  - Synthesis Study of Land Cover, Land Use, and Demographic Change under Multi-Dimensional Developments and Climate Pressures in Southeast Asia - Son Nghiem (JPL, USA)

  - Decoding Land Transitions across the Urban-Rural Continuums (URC): A Synthesis Study of Patterns, Drivers, and Socioenvironmental Impacts in Southeast Asia - Peilei Fan (Tufts University, USA)

- What are the major outputs of the SARI ?
  - Novel projects and Algorithms fine tuned for Asian Environments
  - Major LCLUC drivers identified
  - Products and Datasets
  - Capacity building
  - Collaborations
  - Publications

SARI – Novel Project Studies and Algorithms Specific to S/SEA Countries

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

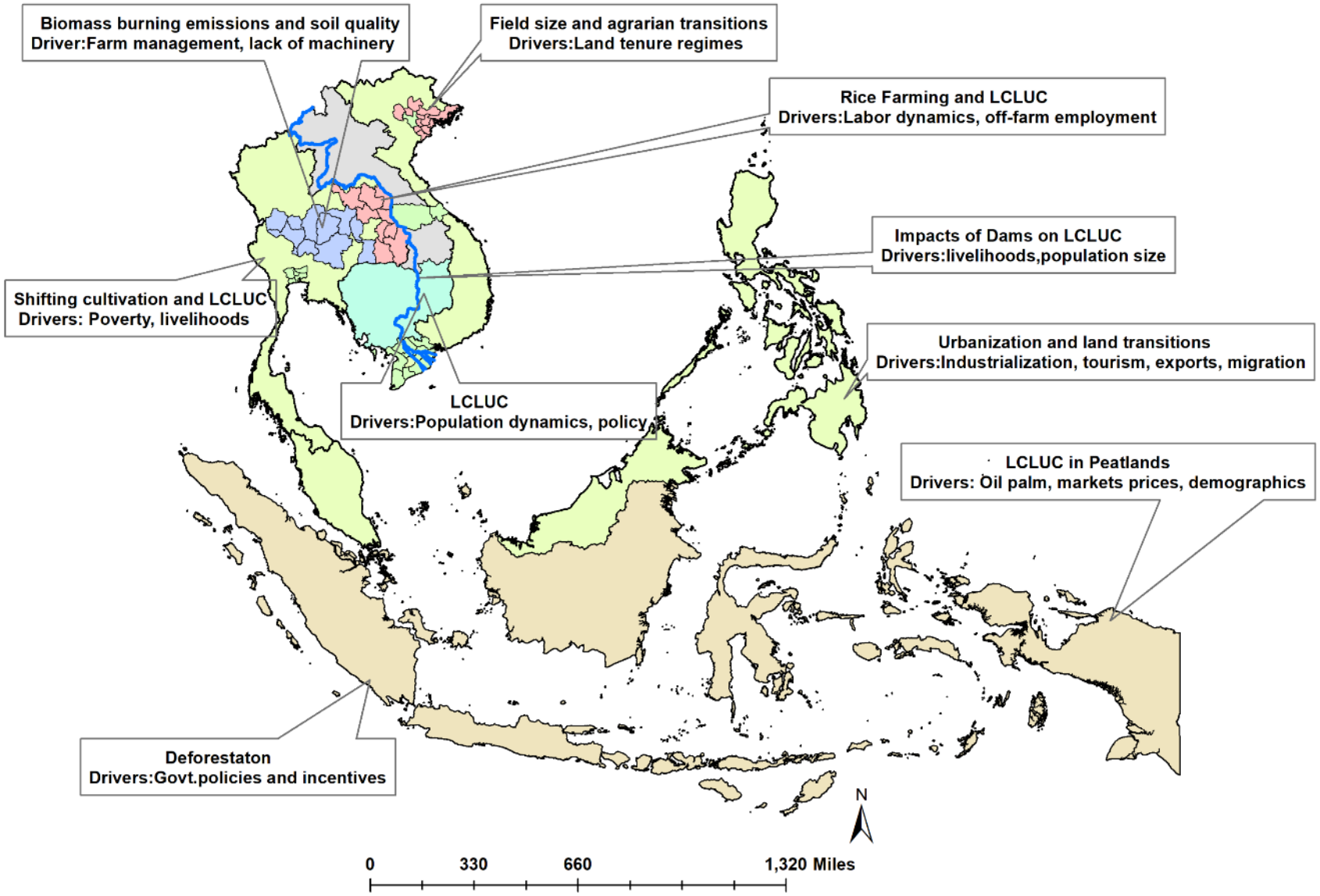
Deforestation in Indonesia – Landsat and Machine Learning Methods

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

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

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

Southeast Asia – LCLUC Drivers Identified by SARI PI's



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

NIES JAPAN

GOFC-GOLD

UNIVERSITY OF MARYLAND

START

Local Host

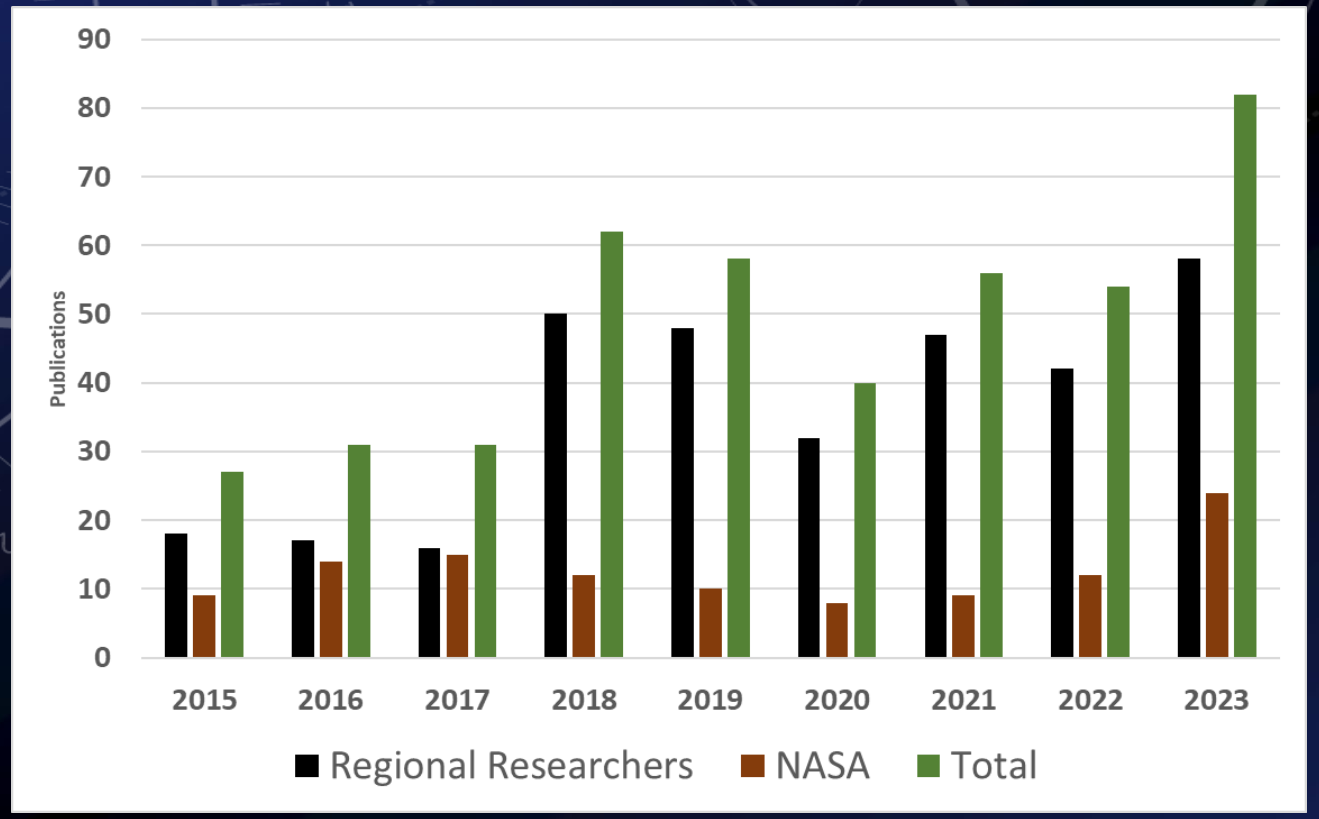
VNU UNIVERSITY OF ENGINEERING AND TECHNOLOGY

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

SARI 8 YEARS OF SCIENCE

~30projects and more being added
>400 scientists
>200 institutions

16-different Special Issues in Journals

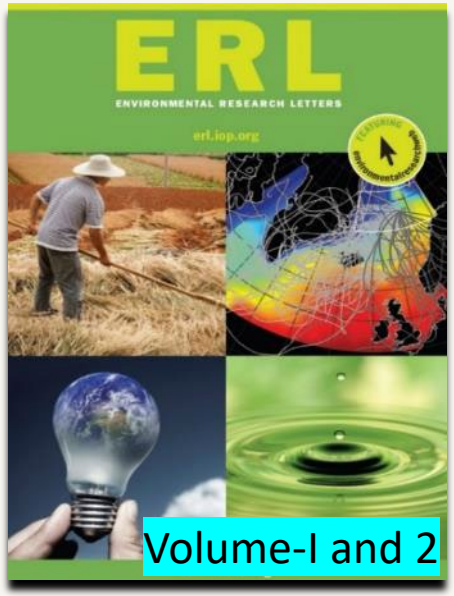


Nearly 450 publications in Peer reviewed journals and Books

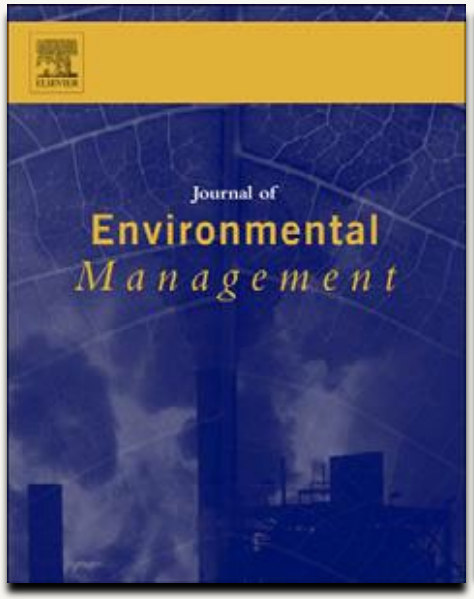
South-Southeast Asia

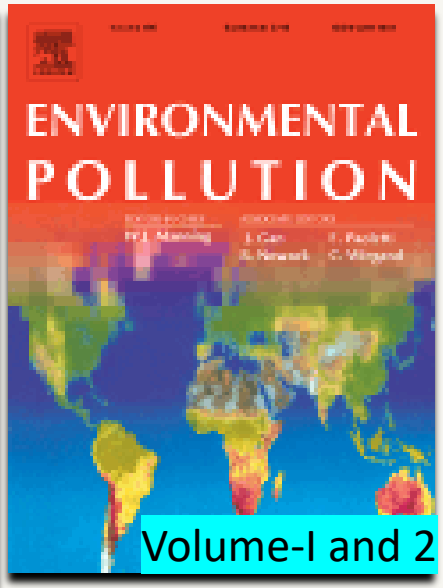
Oct-2013 – India Meeting – SARI idea proposed
2015-SARI First SARI Solicitation

SARI Special Issues Published in Multiple Journals

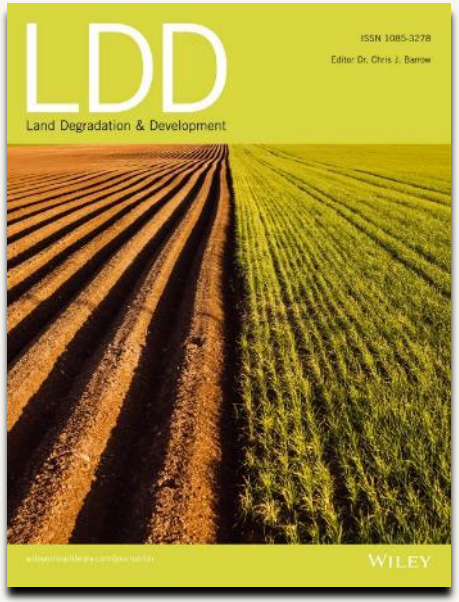


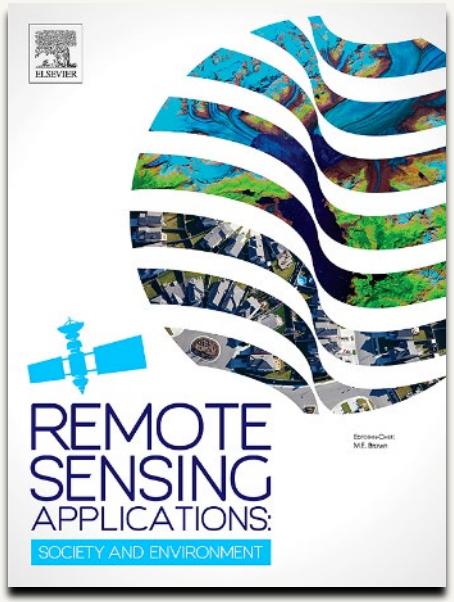
Volume-I and 2

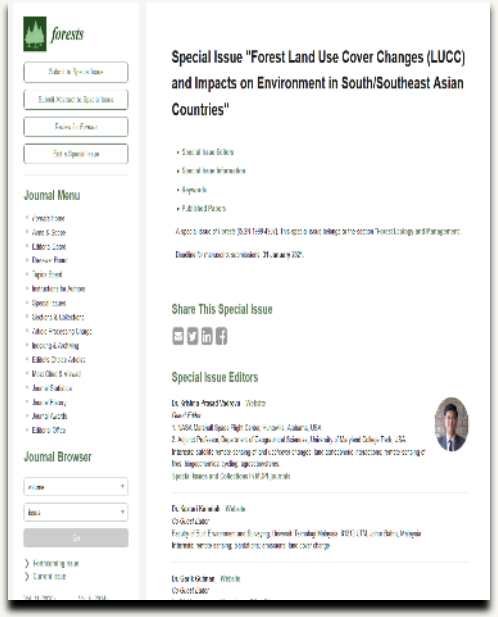


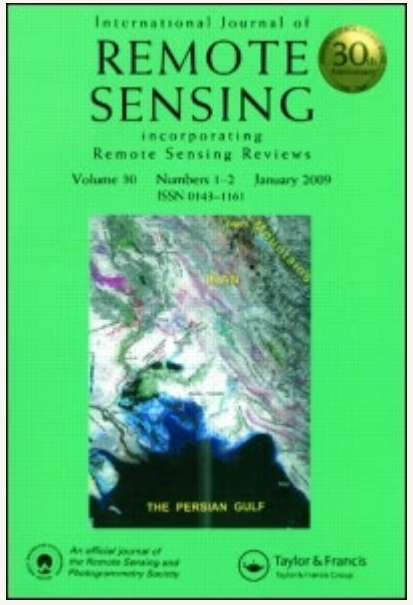


Volume-I and 2









remote sensing

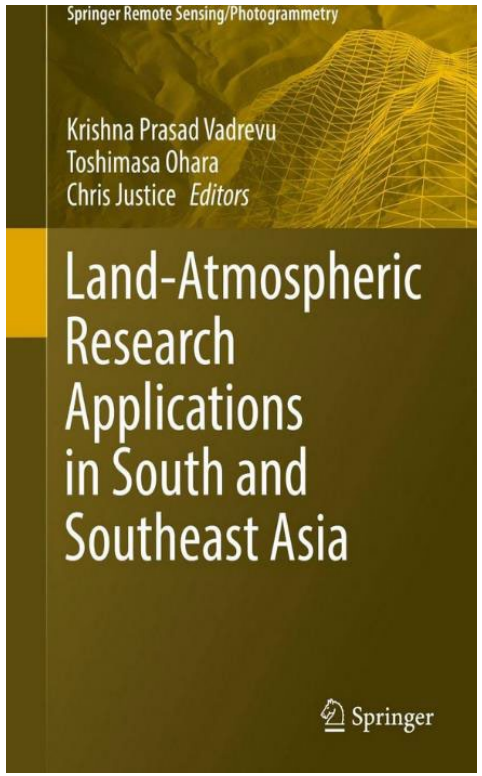
Volume-I

remote sensing

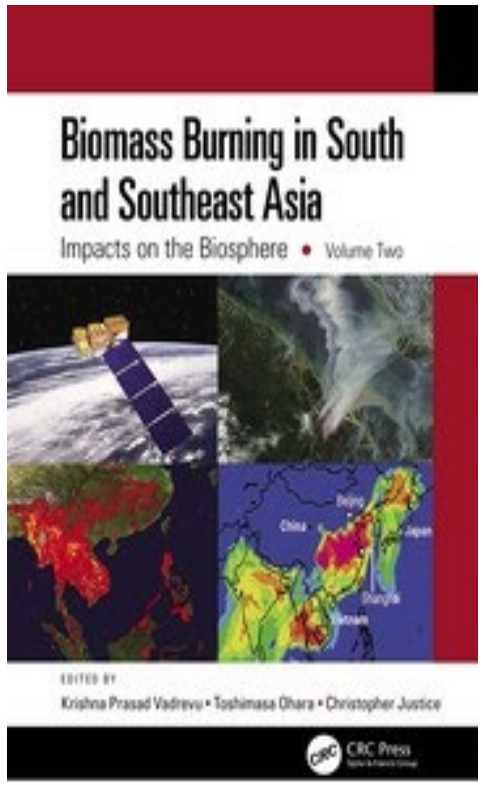
Volume-II

~250 peer reviewed publications in 7-years

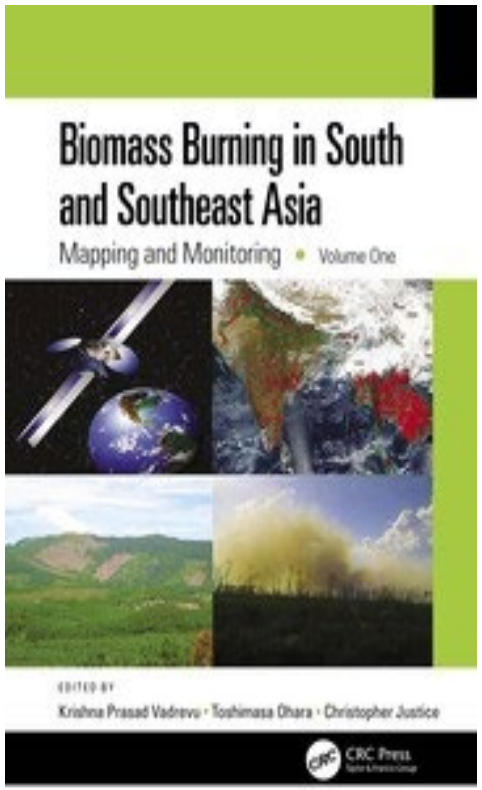
LCLUC/SARI Books



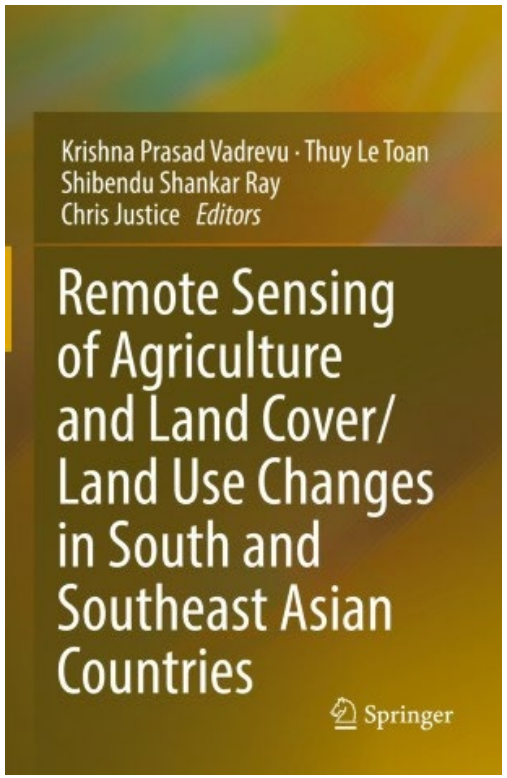
Springer 2018



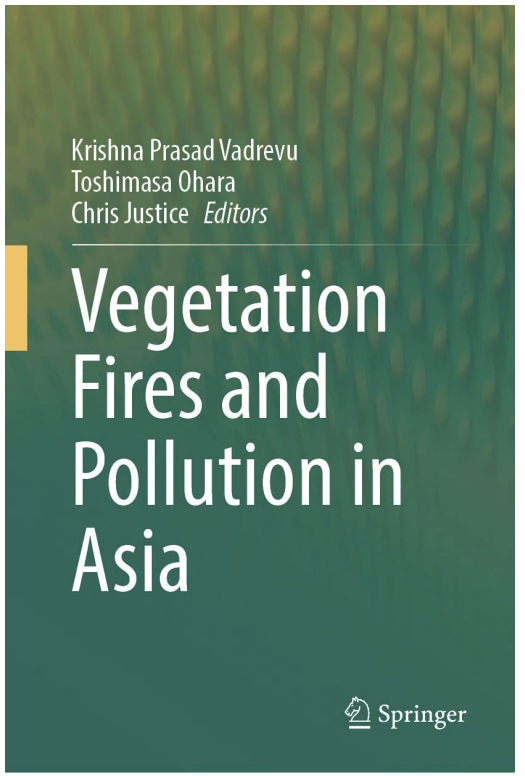
CRC Press, 2021



CRC Press, 2021



Springer, 2022



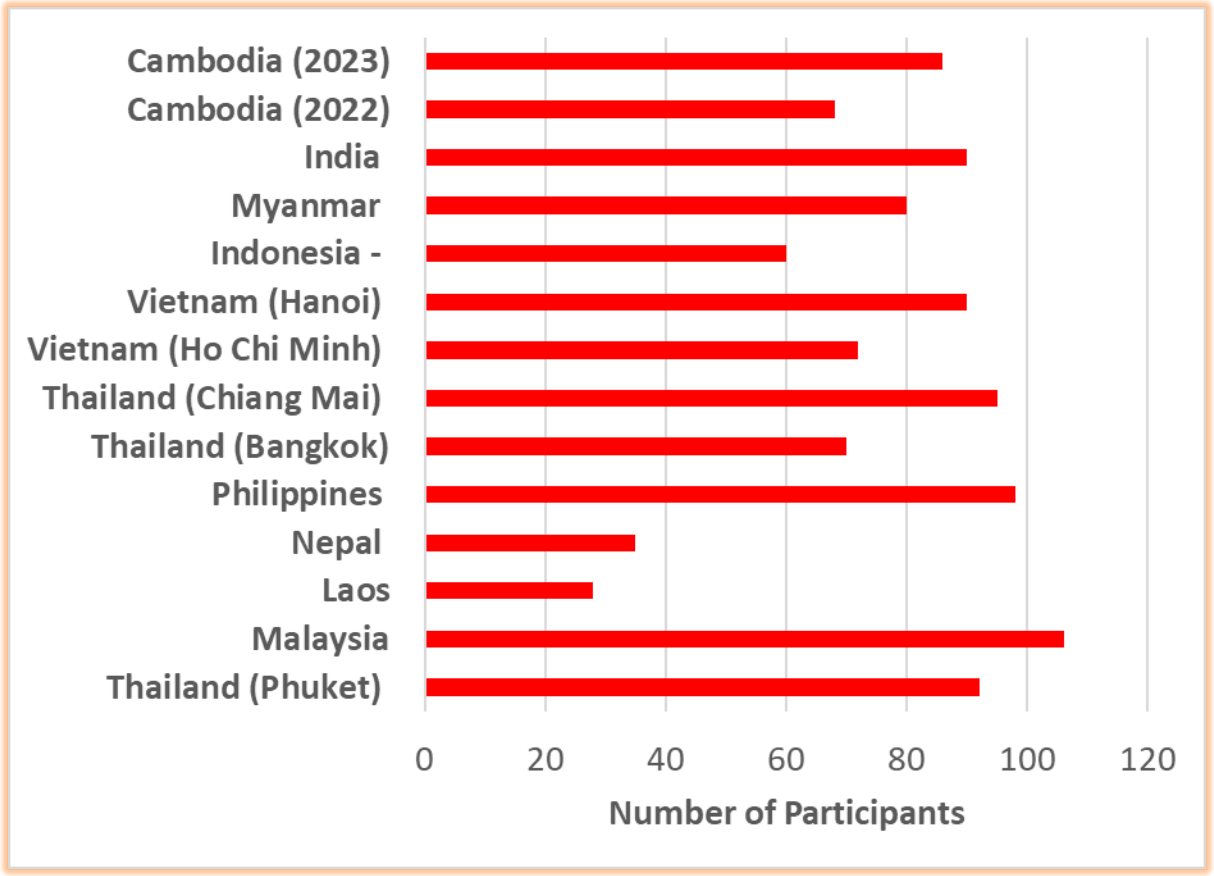
Springer, 2023

2 Additional Books in Progress

-LCLUC in Asia – 2-volume book, CRC Press. 2024

-AFOLU Emissions in Asia, Springer, 2025

SARI – LCLUC Training Events



Training Workshop, Royal Agriculture University, Cambodia, 2023

Certificate of Participation

This is to certify that

has participated in the

NASA Land Cover/Land Use Change Program and SARI Training on Fundamentals of Remote Sensing and Applications
8-10th February, 2023

Royal University of Agriculture, Cambodia

Prof. Wataru Takeuchi, University of Tokyo, Japan
Dr. Krishna Prasad Vadrevu, NASA MSFC, SARI Program Scientist
Dr.Thuy Le Toan, CESBIO, CNES, France
Dr.Kim Soben, Royal University of Agriculture

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

- SARI PI’s documented several LCLUC involving past and Recent changes.

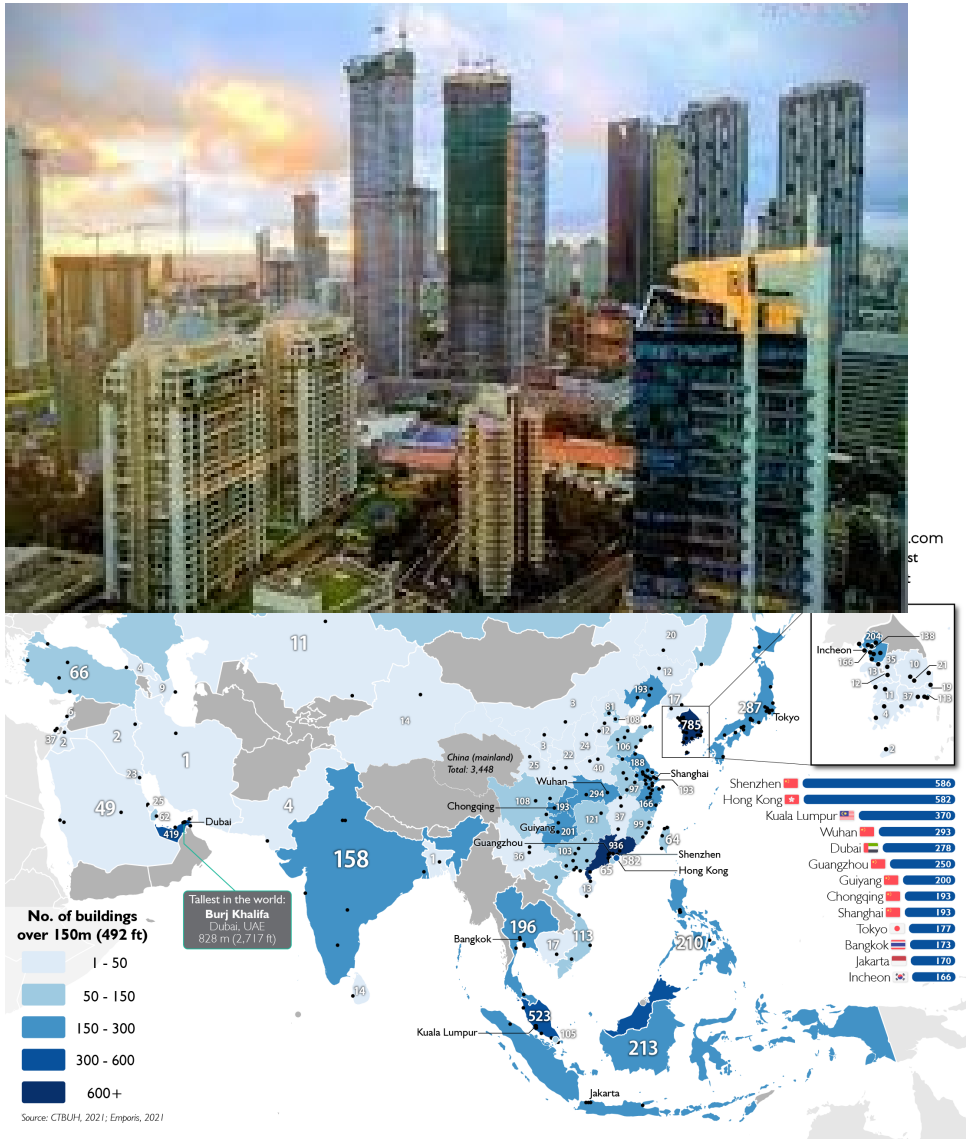
Land Conversions- Past 50 or more years ago versus Recent 20 years

Land Conversion for Subsistence Agriculture through Slash and Burn

Land Conversion for Industrial Plantations (Oil Palm and Rubber in Southeast Asian countries

Urbanization - Past 50 or more years ago versus Recent 20 years

Horizontal expansion



Vertical Expansion

Agriculture - Past 50 or more years ago versus Recent 20 years

Smallholder farms

Large scale industrial farms

- Need for Synthesizing these studies!

- What is Synthesis ?
  - The current meeting objectives

Synthesis in LCLUC Solicitation

Synthesize the accumulated knowledge from previous studies in the SARI domain

Assess the current state and trends of land-use change in the SARI region

Provide a conceptual framework or generalized theory appropriate to land transformations in the region useful for Policy interventions

The synthesis should include research findings, methods, theories, practices or applications of different projects in the region

Synthesis of not just funded under earlier SARI focused solicitations and other international, regional and local agencies.

Land Cover/Land Use Change

Mapping

Monitoring

Drivers

Impacts

SYNTHESIS

Case Studies

Urbanization in Coastal Areas

- **Loss of habitat**
- **Increased vulnerability to natural disasters such as storms.**
- **Pressure on freshwater resources due to population influx.**

Agricultural Expansion in Forested Regions

- **Deforestation leading to loss of biodiversity and disruption of ecosystem services.**
- **Soil degradation and loss of carbon sinks.**
- **Conflict between traditional land use practices and modern agricultural techniques.**

Mining Activities in Indigenous Territories

- **Extraction of minerals from indigenous territories without proper consultation.**
- **Destruction of sacred sites and cultural heritage.**
- **Pollution of water sources and land degradation.**

Synthesis

Synthesis

- Diverse case studies; however, they highlight common themes such as **environmental degradation, loss of biodiversity, and socio-economic conflicts.**
- They highlight the need for integrated approaches that consider environmental, social, and economic dimensions of land use.
- Need for development of holistic and sustainable land use policies that balance conservation with development goals.
- Encouraging the adoption of sustainable practices through incentives, regulations, and capacity-building initiatives.

Synthesizing the case studies allows for a comprehensive understanding of the challenges and opportunities in managing land use sustainably, guiding the formulation of evidence-based policies and practices.

Rapid development in Mapping Algorithms in the recent 20-years

1.Supervised Classification Algorithms:
1. Maximum Likelihood Classification (MLC)
2. Support Vector Machines (SVM)
3. Random Forest (RF)
4. Decision Trees (DT)
5. Neural Networks (NN)
6. k-Nearest Neighbors (k-NN)
7. Gaussian Mixture Models (GMM)

2.Unsupervised Classification Algorithms:
1. K-means clustering
2. ISODATA (Iterative Self-Organizing Data Analysis Technique)
3. Self-Organizing Maps (SOM)
4. Hierarchical Clustering

3.Object-Based Image Analysis (OBIA):
1. Segmentation algorithms (e.g., Mean Shift, Watershed, Graph-based segmentation)
2. Classification algorithms applied to segments (e.g., SVM, RF)

4.Fuzzy Logic and Expert Systems:
1. Fuzzy classifiers
2. Expert systems combining rules and knowledge

5.Feature Selection and Dimensionality Reduction:
1. Principal Component Analysis (PCA)
2. Linear Discriminant Analysis (LDA)
3. Independent Component Analysis (ICA)

Development of Novel Algorithms

1.Deep Learning Algorithms:
1. Convolutional Neural Networks (CNN)
2. Recurrent Neural Networks (RNN) for temporal analysis
3. Fully Convolutional Networks (FCN)
4. U-Net
5. Deep Belief Networks (DBN)

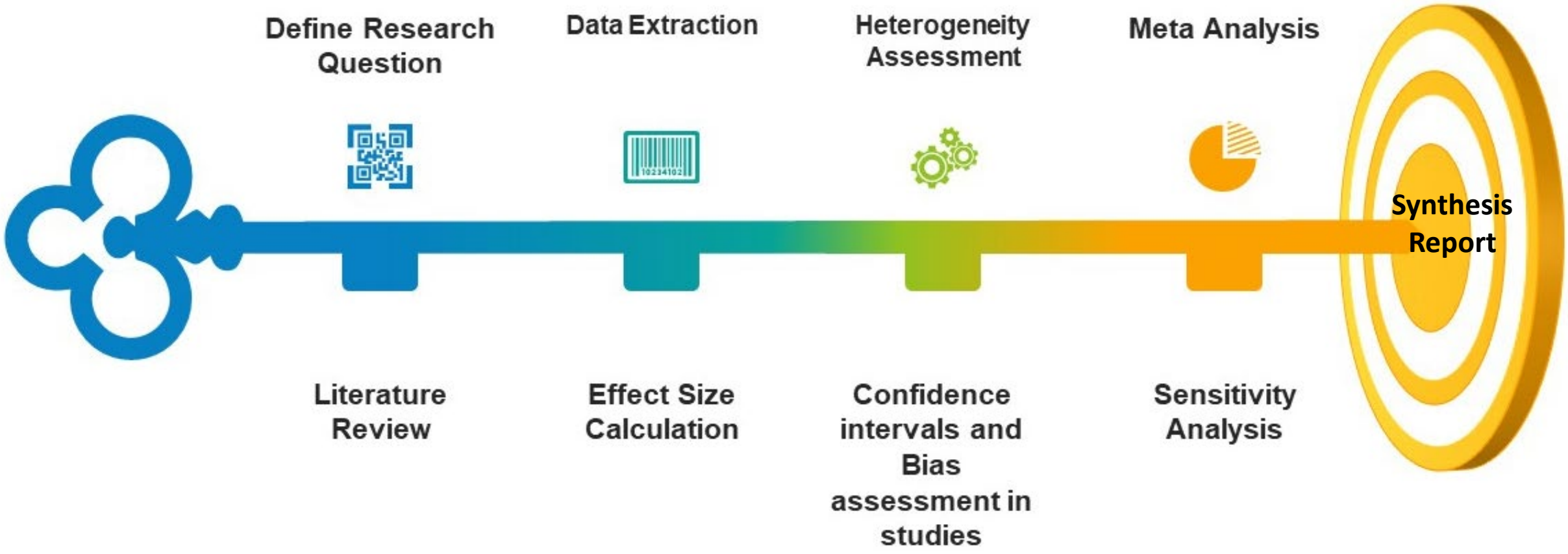
2.Ensemble Methods:
1. Bagging
2. Boosting
3. Stacking

3.Semantic Segmentation:
1. Algorithms designed for pixel-wise classification while considering spatial context
2. Deep learning-based methods such as FCN, U-Net

4.Transfer Learning:
1. Leveraging pre-trained models on large datasets and fine-tuning for land cover mapping tasks

5.Data Fusion Techniques:
1. Combining information from multiple sensors (e.g., optical, radar, LiDAR) using fusion algorithms.

Synthesis Studies – Quantitative Framework



Meeting Themes

Day-1 - January 31st (Wednesday)

- Session-I: Opening Session
- Session-II: Programmatic and Space Agency Presentations
- Session-III: Land Cover/Land Use Change
- Panel Discussion

Day-2 - February 1st (Thursday)

- Session-IV: Urban Land Cover/Land Use Change
- Panel Discussion
- Session-V: LCLUC, Agriculture and Water Resources
- Panel Discussion

Day-3 - February 2nd (Friday)

- Session VI. Fires, Greenhouse Gas Emissions, and Pollution
- Session VII. Discussion Session on Synthesis

Purpose of the Panels

- In each of the SEA countries, there are similarities and differences in the trajectories of change in Land Cover/Land Use practices (LCLUC).

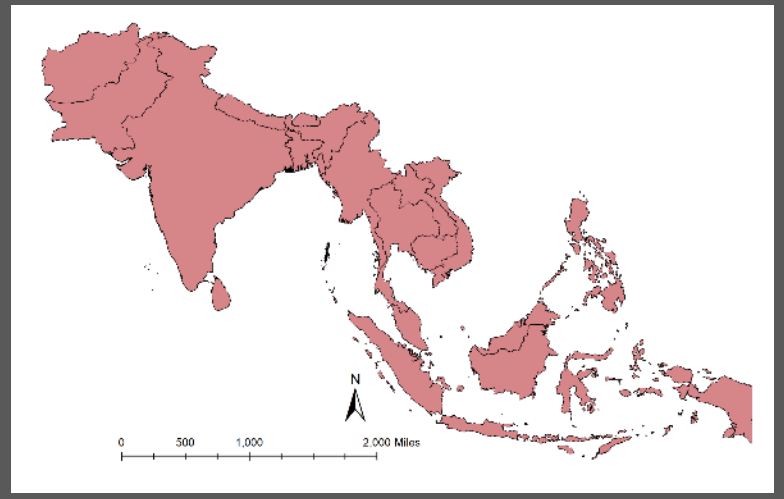
- These are a result of the role of Govt., Policies, Economics and National Priorities.

- The four panels (LCLUC, Urban, Agriculture and Atmospheric pollutants) *are intended to provide regional insights in terms of these LCLUC changes at the National level which can be integrated into a regional Synthesis.*

- Each panelist is asked to identify important LCLUC trends, projections, implications including *how research help inform more sustainable land use policies.*

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

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



Wishing all of us a productive meeting and an enriching experience