

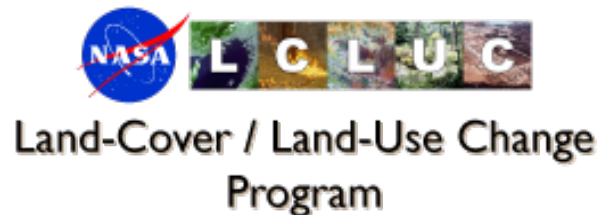
Land Cover/Land Use Change in South/Southeast Asian Countries

Krishna Prasad Vadrevu

SARI Lead

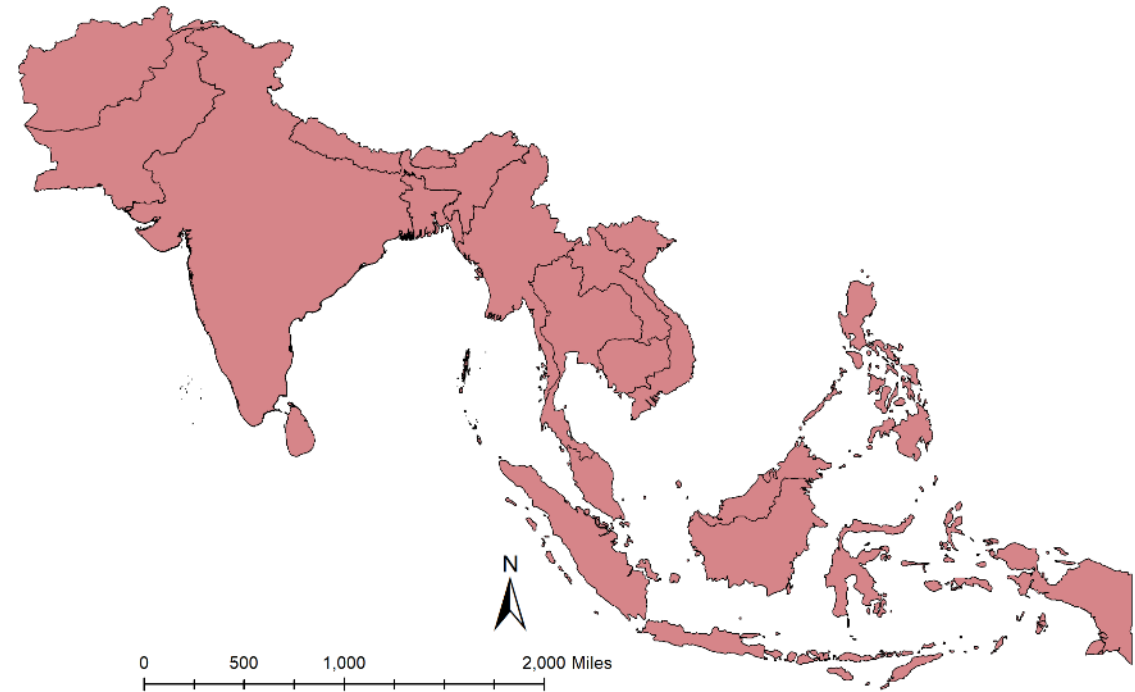
NASA Marshall Space Flight Center

Huntsville, Alabama



Outline

- Background to the South/Southeast Asia Research Initiative(SARI)
- SARI Projects and Updates
- SARI outputs to date
- Objectives



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

24

meeting/workshop summaries

The Earth Observer March - April 2013 Volume 25, Issue 2

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@terracore.gsfc.nasa.gov
 Prasad Thirukosail, United States Geological Survey, pthirukosail@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);

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



Water resource-focused workshop participants. Image Credits: 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.

The Earth Observer March - April 2013 Volume 25, Issue 2

25

meeting/workshop summaries



Rhizophora mangroves, known as the "red mangrove," near Kadalamudi 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.



Coconuts, mangoes, bananas, and yam plantations, Kozhikode, Kerala.



Smoke from forest fires, Piddikad, Wintersham, Kerala.

March/April 2013

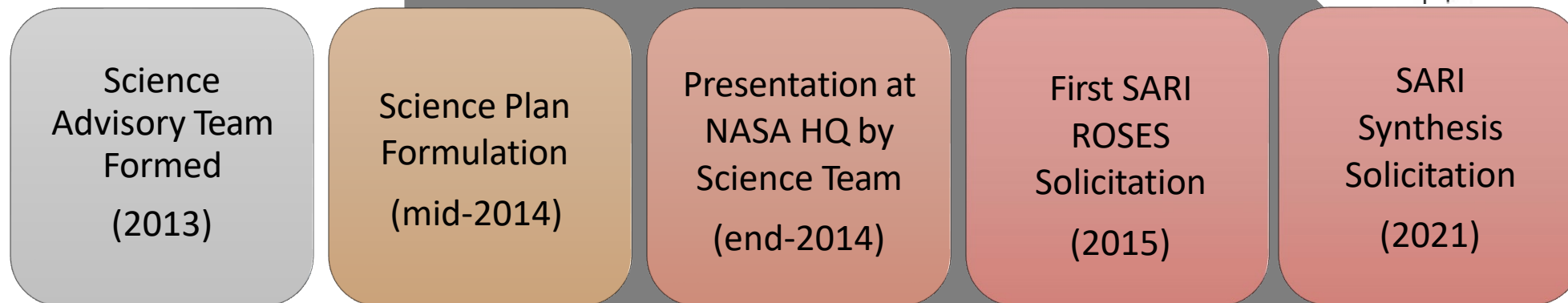
http://eospsso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php



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



-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 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; 3 more in 2019)



S.No	2020	PI	Theme
23	Where are the Missing Burned Areas? Global Hotspots of Burned Area - A Multiresolution Analysis	David Roy, Michigan State U	Burned area mapping
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 – not selected yet.**

SARI FOCUS – NASA LCLUC

SARI

SARI focuses on building research projects between the US and regional scientists

Regional meetings/workshops help in identifying the needs and priorities for the region and provide inputs to the NASA LCLUC calls

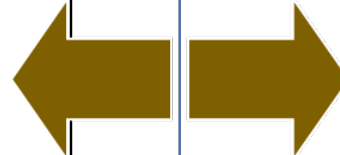
Capacity building training events are integral to SARI

NASA LCLUC

Map and monitor LCLUC

Interpret LCLUC changes and impacts

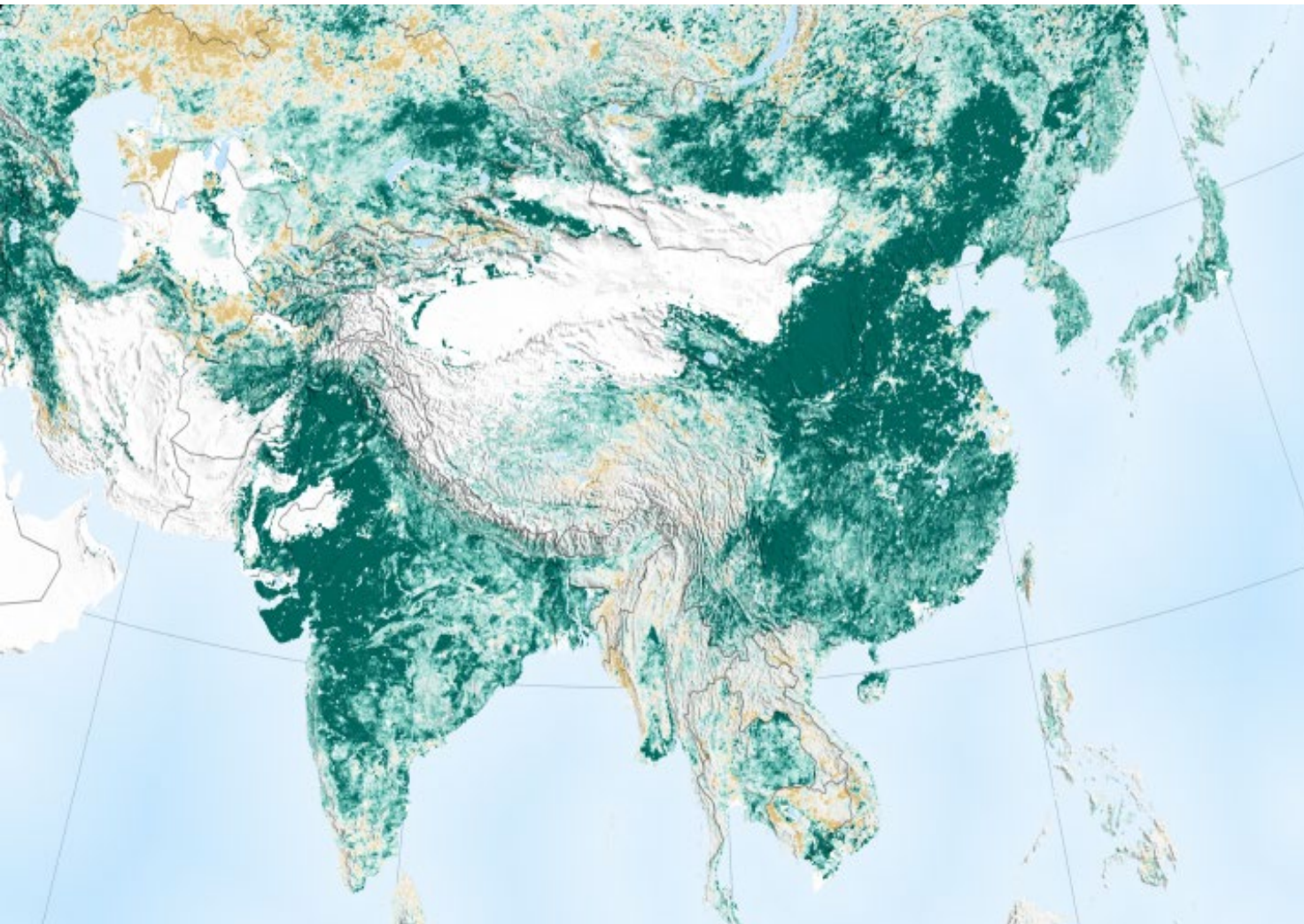
Develop models to address future LCLUC consequences



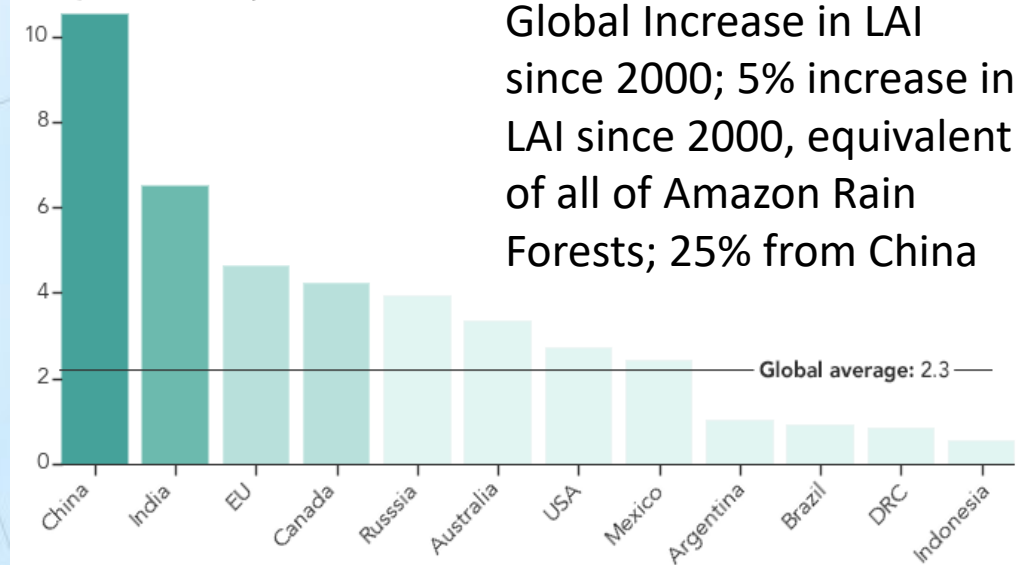
- Some on-going LCLUC issues in South/Southeast Asia



China and India Lead in Greening



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



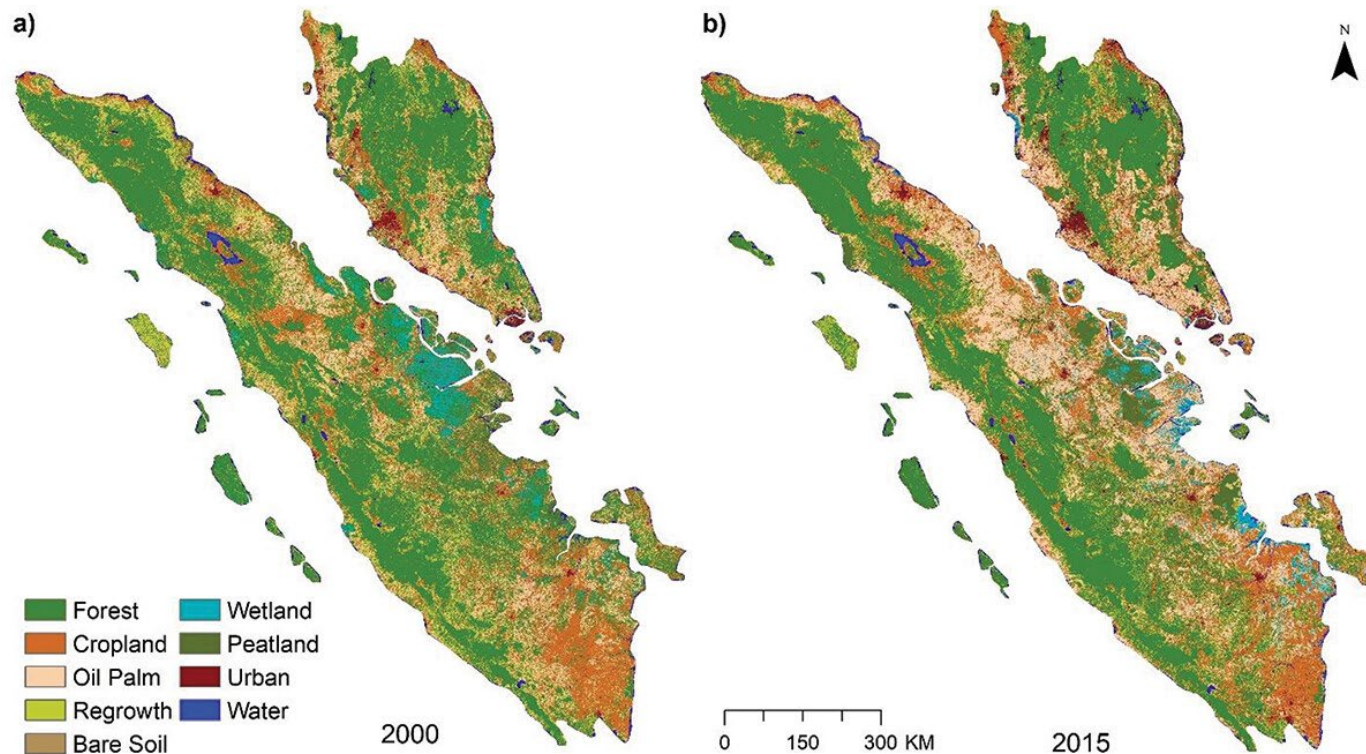
Global Increase in LAI since 2000; 5% increase in LAI since 2000, equivalent of all of Amazon Rain Forests; 25% from China

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)

Oil Palm Plantations are the biggest driver of LCLUC in SEA

Indonesia, Malaysia, and Thailand are home to 80% of the world's oil palm plantations, which is driven by global demand for oil palm-derived products, such as renewable energy, food-based, and health/beauty product



- Forest cover became less fragmented in part due to the rise of large-scale monoculture plantations
- The mean size of oil palm patches almost doubled from 2000-2015
- Patches of forests were replaced by oil palm mostly in the eastern part of Sumatra

Land cover classification for Sumatra and Western Malaysia for the years of **a)** 2000 and **b)** 2015.

More than half of net deforestation resulted from agricultural expansion (i.e. oil palm and cropland) with total gross forest losses in 2000 attributed to the conversion to cropland, oil palm, and regrowth – less due to Urbanization.

Table 1. Forest cover and change statistics for SE Asia, 1992–2018. Losses and gains are reported as gross statistics. Annual change rate is the percentage of 1992 forest that underwent change by 2018, divided by 26 years. Areas were calculated using projected ESA data.

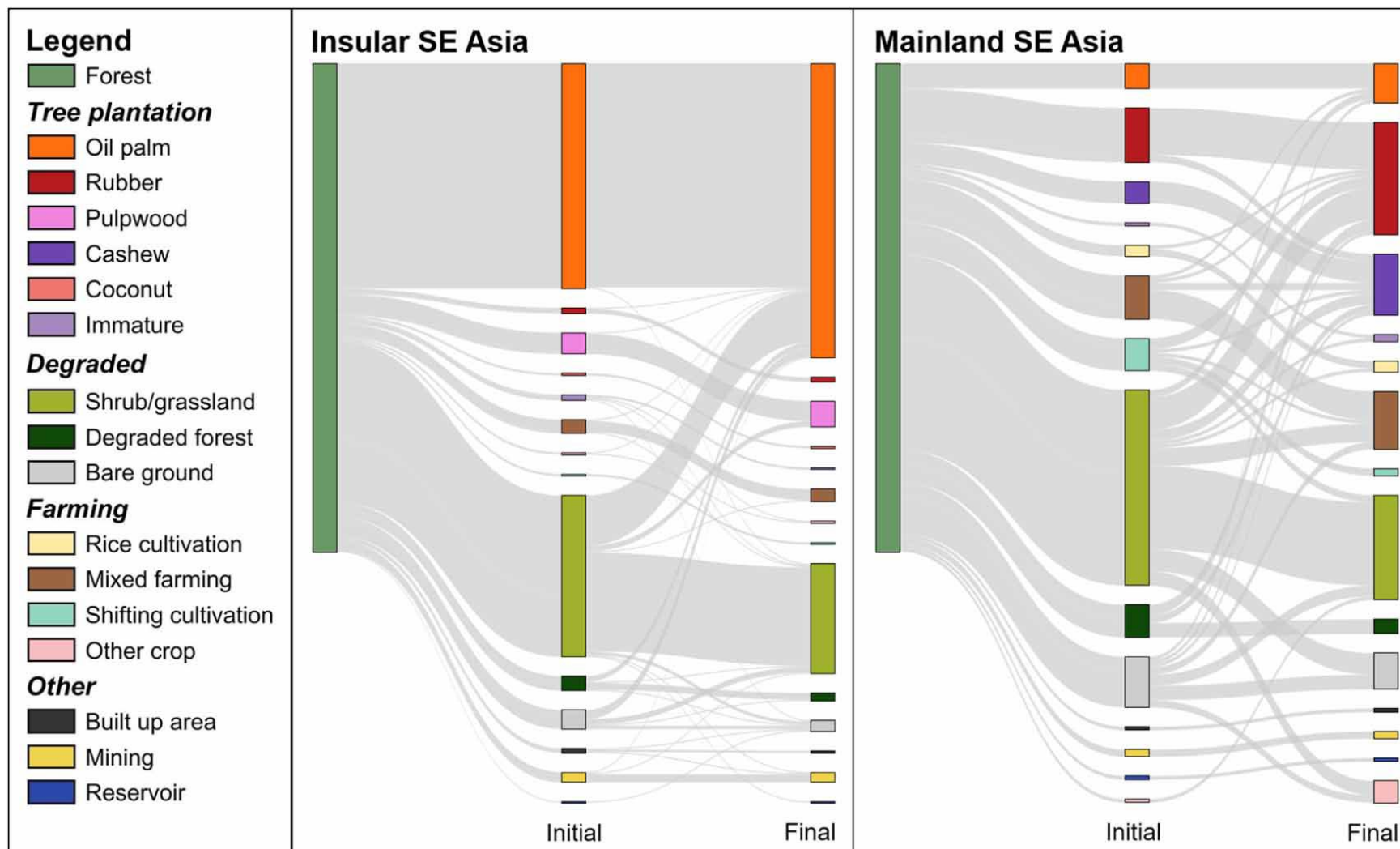
Region	Area (km ²)	Forest area (km ²)		Forest change (km ²)			Annual change rate (%)		
		1992	2018	Loss	Gain	Net	Loss	Gain	Net
<i>Insular SE Asia</i>									
Kalimantan	533 937	367 983	333 019	49 977	15 013	−34 964	0.52	0.16	−0.37
Sumatra	475 383	231 265	197 146	48 485	14 366	−34 118	0.81	0.24	−0.57
East Malaysia	197 607	156 833	145 925	20 810	9903	−10 907	0.51	0.24	−0.27
Sulawesi and Maluku	264 240	187 858	184 016	11 585	7743	−3842	0.24	0.16	−0.08
West Malaysia	131 776	66 649	64 420	8449	6221	−2228	0.49	0.36	−0.13
Papua	412 305	373 968	372 331	5629	3992	−1637	0.06	0.04	−0.02
Singapore	697	128	90	53	15	−38	1.60	0.46	−1.14
Brunei	5778	4868	4952	79	164	85	0.06	0.13	0.07
Timor Leste	14 915	2055	2255	87	288	201	0.16	0.54	0.38
Philippines	295 857	100 877	103 717	8679	11 519	2840	0.33	0.44	0.11
Java and Nusa Tenggara	204 379	46 723	55 688	2344	11 310	8965	0.19	0.93	0.74
Subtotal	2536 875	1539 206	1463 562	156 177	80 533	−75 644	0.39	0.20	−0.19
<i>Mainland SE Asia</i>									
Cambodia	181 360	99 459	83 862	16 402	804	−15 598	0.63	0.03	−0.60
Vietnam	329 276	127 329	116 555	16 631	5857	−10 774	0.50	0.18	−0.33
Thailand	514 055	129 553	131 460	7222	9130	1908	0.21	0.27	0.06
Laos	230 002	125 365	128 993	7073	10 702	3628	0.22	0.33	0.11
Myanmar	669 297	322 861	342 723	16 327	36 189	19 862	0.19	0.43	0.24
Subtotal	1923 989	804 567	803 592	63 655	62 681	−974	0.30	0.30	0.00
Total SE Asia	4460 865	2343 773	2267 154	219 833	143 215	−76 618	0.36	0.24	−0.13

1992-2018

Most forest cover loss in Insular SE Asia

In Mainland, Cambodia and Vietnam had a net loss of forest cover

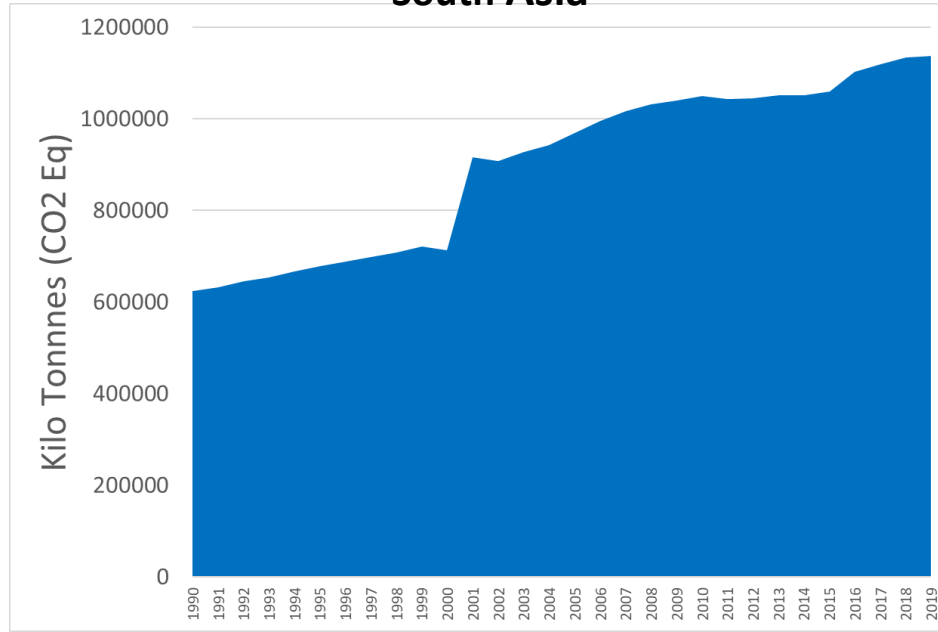
Land Cover Trajectories (Johannes et al., 2022)



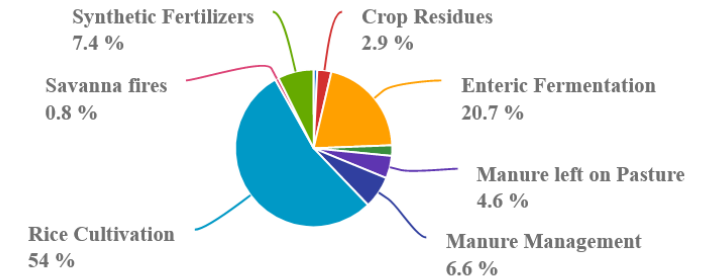
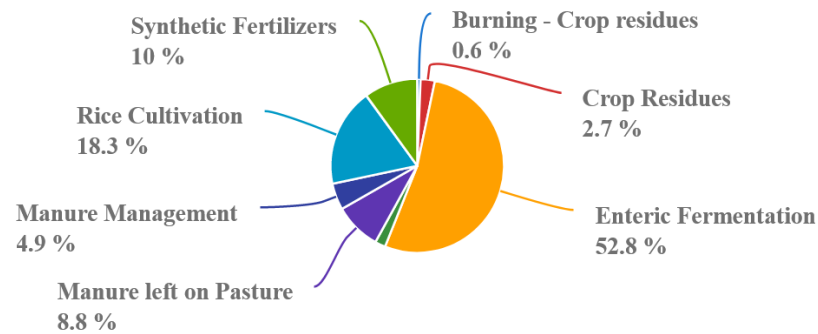
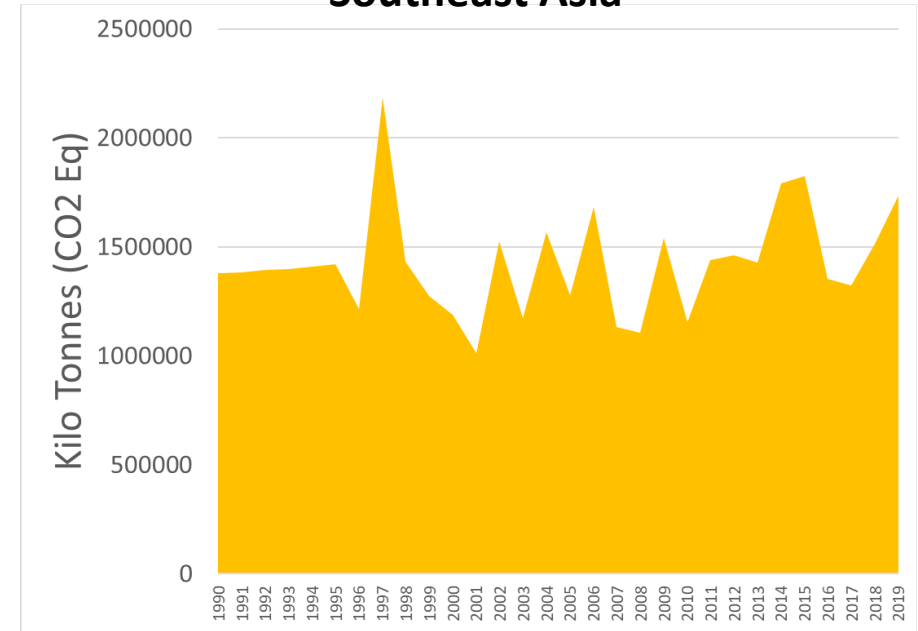
Land cover trajectories of deforestation in emergent hot spots of insular and mainland SE Asia. Sankey diagrams depict the initial (five-year post-deforestation (2017)) and final (2021) land cover outcomes of forest loss. In both insular and mainland SE Asia, degraded habitat served as a major intermediate land cover, prior to conversion to the final land cover outcome.

AFOLU (Total CO2 Eq.), Average (1990-2019) (FAOSTAT, 2020)

South Asia



Southeast Asia



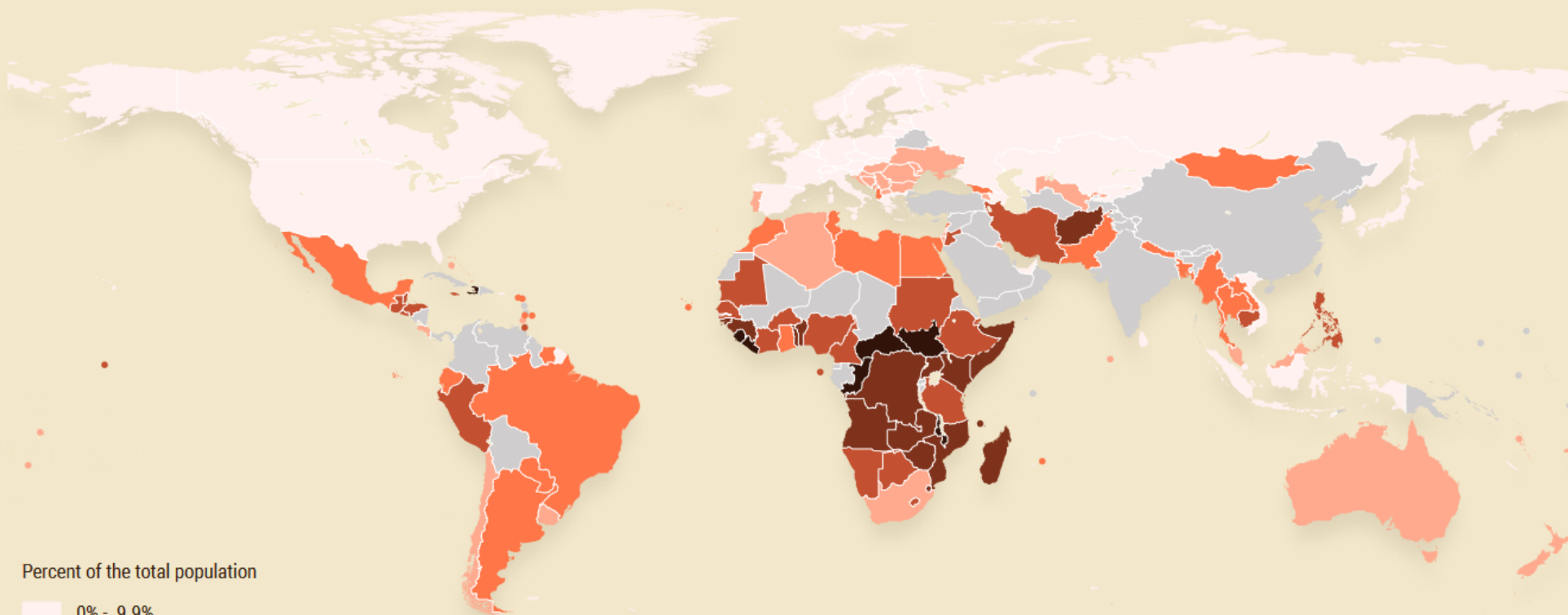
- Burning - Crop residues
- Crop Residues
- Enteric Fermentation
- Manure applied to Soils
- Manure left on Pasture
- Manure Management
- Rice Cultivation
- Savanna fires
- Synthetic Fertilizers

- Burning - Crop residues
- Crop Residues
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AFOLU still is a significant source of net CO2 Emissions in Asia

FAO FOOD INSECURITY MAP

Prevalence of Moderate or Severe Food Insecurity
SDG Indicator 2.1.2



Percent of the total population

0% - 9.9%

10% - 24.9%

25% - 39.9%

40% - 59.9%

60% - 79.9%

80% - 100%

Data not available or not country validated

Source: FAO, IFAD, UNICEF, WFP and WHO. 2022. *The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable*. Data are available on FAOSTAT (<https://www.fao.org/faostat/en/#data/FS>)

The boundaries and names shown and the designations used on these map(s) do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

COVID-19 impacts yet to be understood

Negative Impacts

- COVID Tsunami (daily rise of 300,000 cases)
- 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

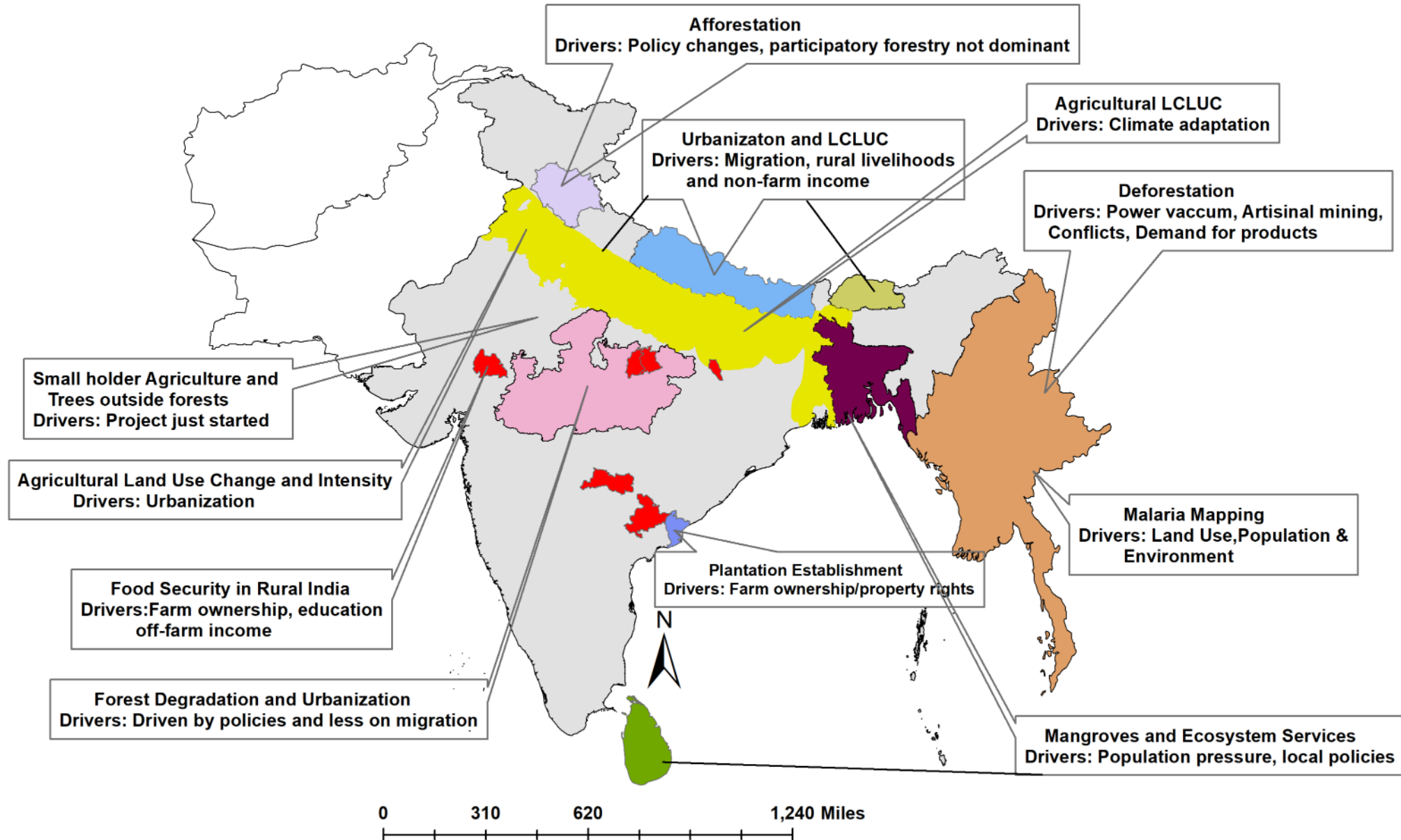
- Decreased fossil fuel dependence
- Decreased urban pollution
- Decreased water pollution
- Favored local foods
- Decreased construction activities
- Adverse impacts of tourism on environment reduced (eg: clean beaches)
- Reduced urban footprint



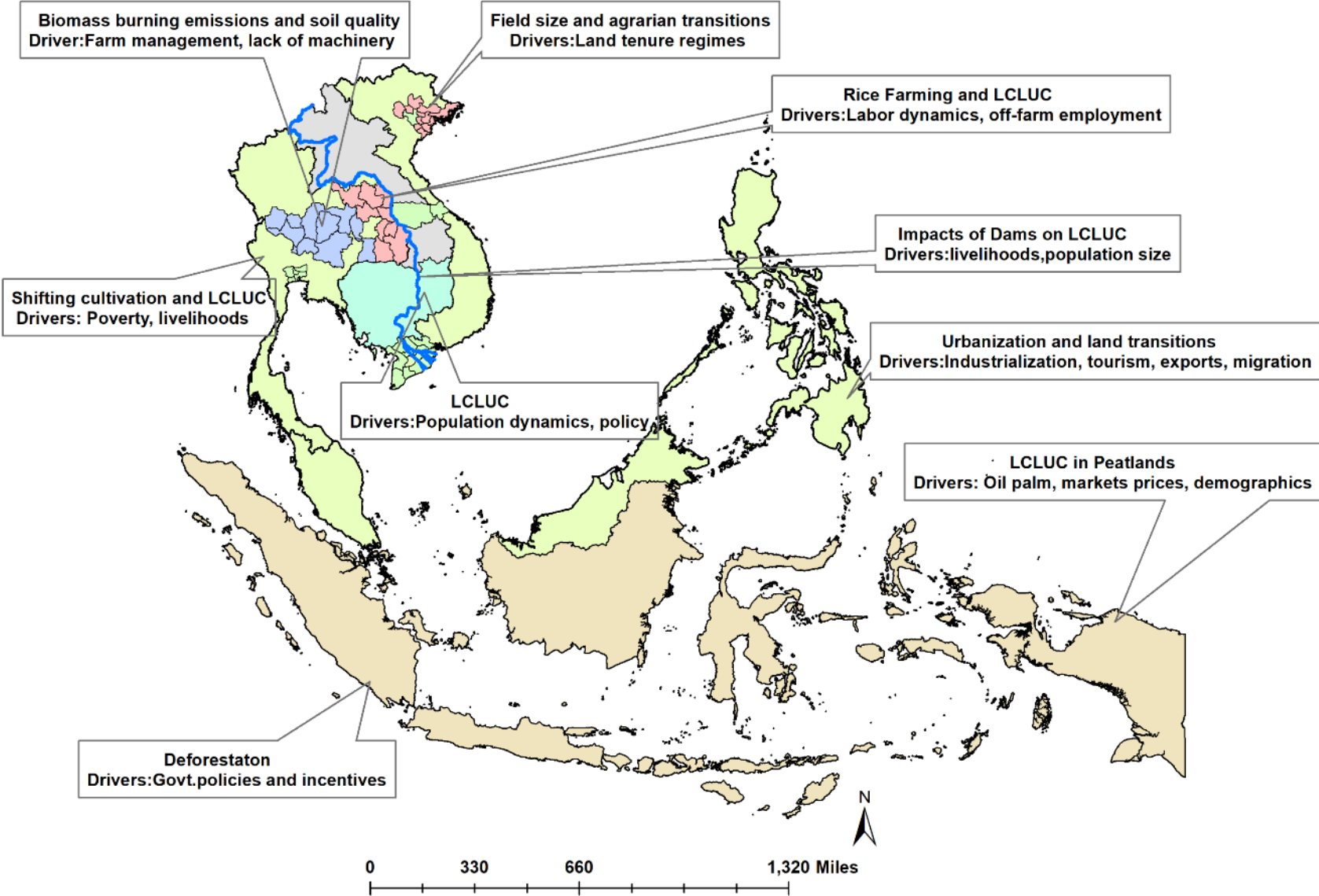
- What are the major drivers of LCLUC in South and Southeast Asian countries?



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 and SARI

- Several PI's integrate biophysical and socioeconomic datasets to address LCLUC questions.
- Focus is on analyzing economic, social and environmental impacts to address sustainability issues.

Extent & Impact of Government Tree Plantations on Livelihoods in Himachal Pradesh, India

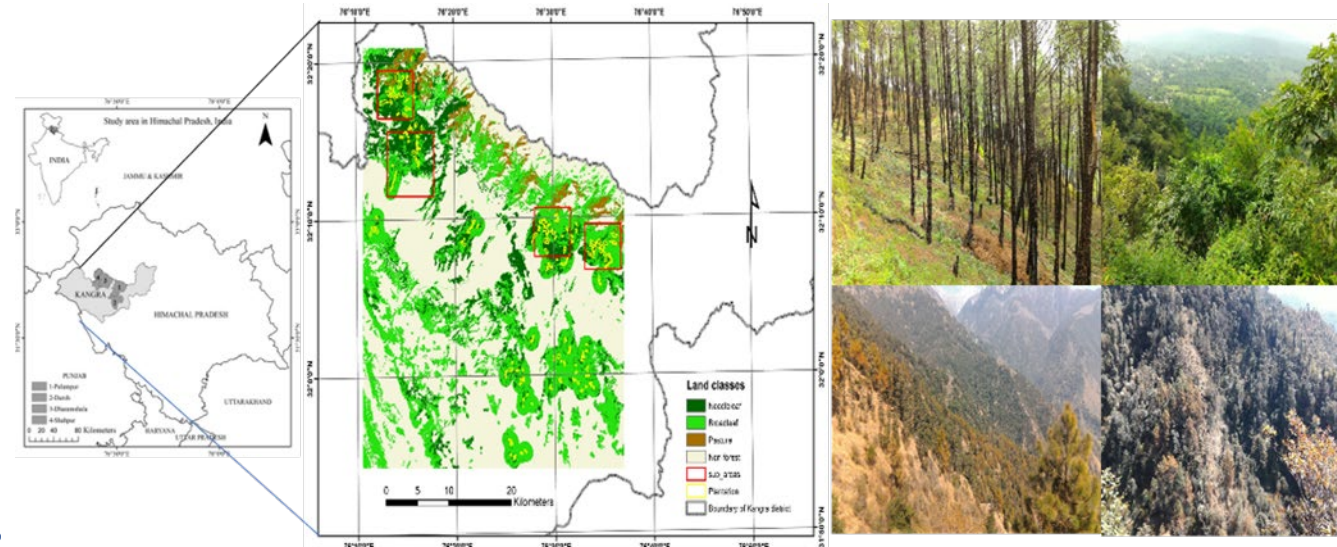
Fleischman, F, Univ. Of Minnesota

Background:

- In India, massive afforestation programs are on-going on public forest lands.
- It is not clear if the afforestation programs increased in Himachal Pradesh, India and if they benefitted local people and had positive impacts on rural livelihoods.

Analysis:

- As a case study, we focused on Kangra, Himachal Pradesh. Quantified the land cover/land use change and plantation growth using Landsat data. Results were integrated with socio-economic surveys to address afforestation impacts on local livelihoods.



Left: Landsat data is used to map Land Use/Cover and extent of tree plantations in Himachal Pradesh, India. Results suggest significant decline in plantations and degraded nature of forests. Deep convolutional network algorithm yielded >85% map accuracy.

Findings:

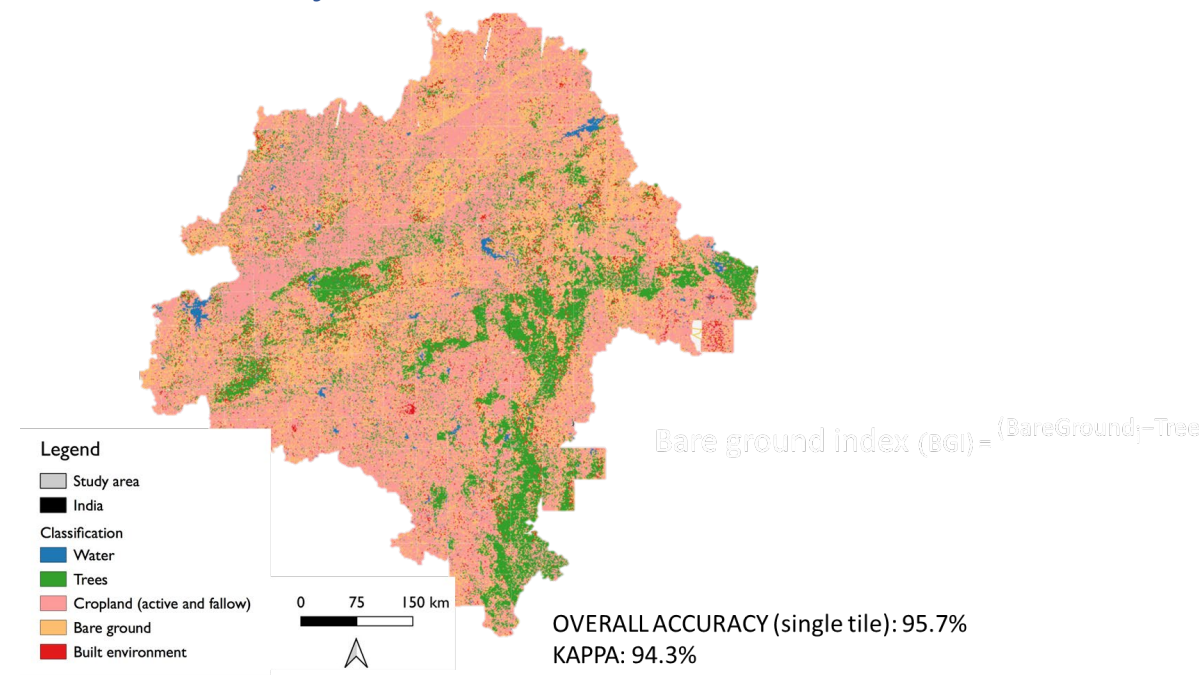
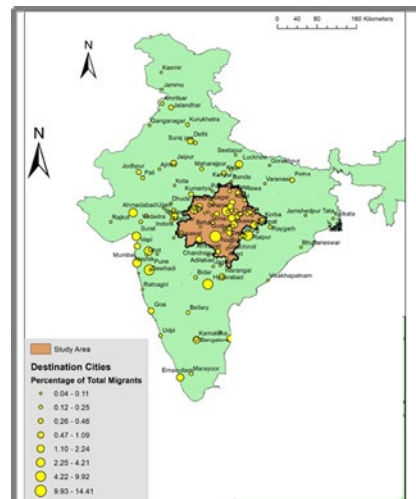
- Quantified the Plantation extent using LANDSAT data. Classification accuracy using 2dcnn-deep learning suggested greater than 85% in mapping efforts.
- Contrary to belief that afforestation increased in Himachal Pradesh, it decreased significantly since the 1990s (from ~35K ha to 10Kha/year).
- Locals depend on forests mostly for fuel and fodder. However, Government afforestation programs are not participatory involving locals, thus, not helping locals or livelihoods.
- Local households find broad leafed plantations more desirable than needle leaf plantations for livelihoods. However, Government has been promoting commercial needle-leaf plantations that are less useful to locals.

Does Migration Enhance or Reduce Forest Degradation in Central India?

Ruth DeFries, Columbia University

Approach

Very High Resolution
Planetscope Data (3m) was
used to map degradation.
5000 household
socioeconomic surveys
conducted to address the
migration and degradation.

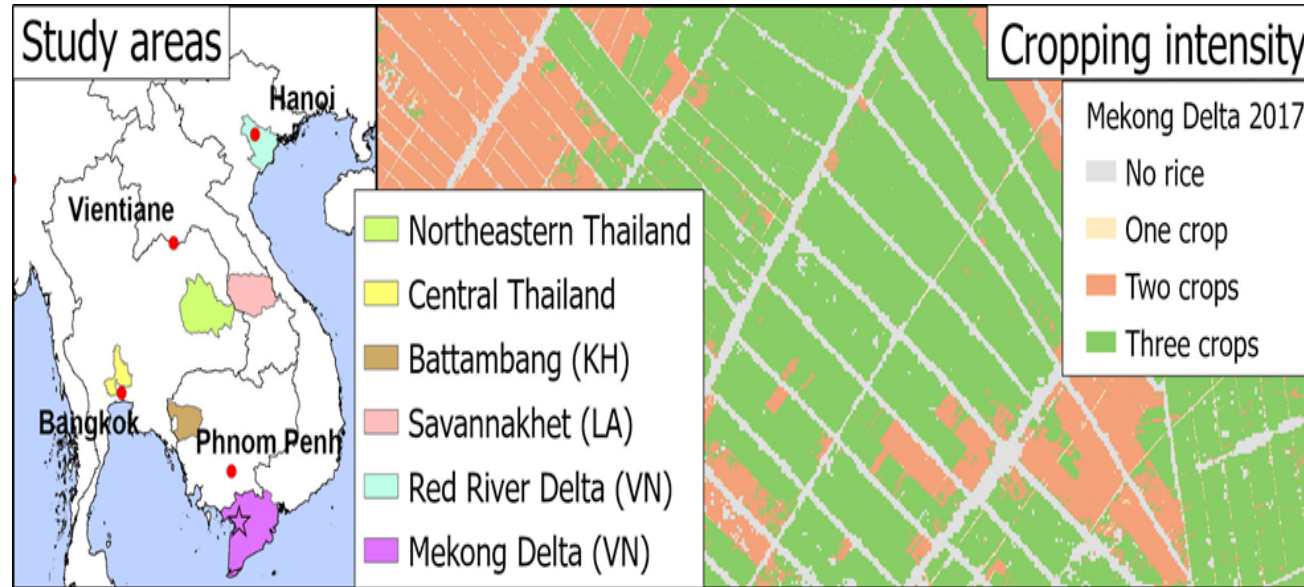


Results

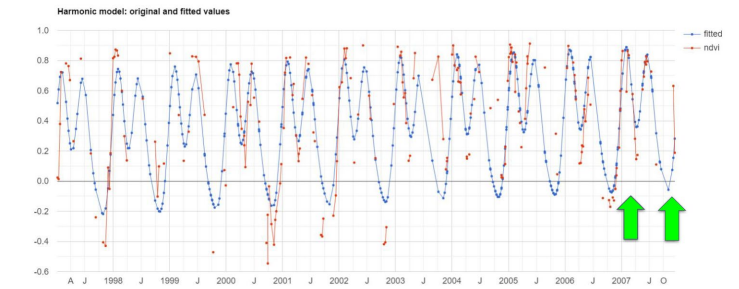
- Planetscope data was useful to map land cover classes with 93% accuracy and in developing a “bare ground index” to capture degradation.
- Households with migrants are poorer and own less land than non-migrant holders. Forest degradation is slightly associated with migration, however, changes in forest use is not associated strongly with migration.



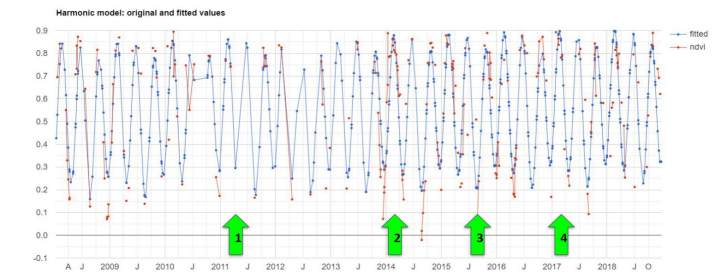
The agrarian transition in Mainland Southeast Asia: Changes in Rice farming – PI: Jeff Fox, East West Center, Hawaii



10-year period from 1997-2007: 2 crops per year



10-year period from 2008-2018: 3 crops per year



Approach: Cropping intensity and timing of land management of paddy rice are mapped using harmonics and a fusion of Landsat and MODIS time-series. We conducted socioeconomic interviews in 240 households in each of the six basins to address changes in farming methods and farm size.

Results: Small farmers are modernizing rapidly through changes in farming methods, Policy makers need to be aware of these changes and assist small farmers to become more economically productive.

LCLUC Products and Metadata Efforts

- All data/products are 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



Inventories: Modeling and Climatic Impacts of Carbon and Greenhouse Gas Emissions from Economic Activities in the Asian Region

June 24th-26th, 2014



Logos for NIES JAPAN, GOF-C-GOLD (Global Observing Facility for Carbon and Greenhouse Gas Emissions), UNIVERSITY OF MARYLAND, and START (Sustainable Technology and Innovation Research Team). Below the logos, it says "Local Host" and "VNU UNIVERSITY OF ENGINEERING AND TECHNOLOGY".



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



Documenting Regional Research Needs and Priorities - Meeting Summaries

Summary of the 2019 South/Southeast Asia Research Initiative Land Cover Land Use Change Regional Science Meeting

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Introduction

As a result of growth in South and Southeast Asia (S/SEA), land use/cover change (LUCC) is occurring at a rapid rate, moving from forest to agriculture and from agricultural areas to residential and urban use, with concomitant disruption of water and forest resources, biodiversity, regional climate, biogeochemical cycles, and the atmosphere. To address these issues, NASA's Land Cover/Land Use Change (LCLUC) Program—South/Southeast Asia Research Initiative (SARI, www.sari.usm.edu) in collaboration with other partners organized a meeting, titled *Land-Use/Cover Changes, Environment and Emissions in South/Southeast Asia*, held July 22–24, 2019, at the Hilton Hotel in Johor Bahru, Malaysia. The University of Technology, Malaysia (UTM) hosted the meeting. Collaborators included the National Institute for Environmental Studies (NIES), Japan; the international Global Observations of Forest and Land-Use Dynamics (GOFC-GOLD) program; START, U.S.; and the international Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative, in addition to fourteen other national and international partners. The meeting aimed to review the availability, potential, and limitations of different satellite data sources and methodologies for monitoring LUCC, and its impact on the environment. Another objective was to strengthen GOFC-GOLD/SSEA regional networks on the latest LUCC science.

*START (not an acronym) is a core international partner of the U.S. Global Change Research Program that seeks to realize a sustainable future through science (<https://start.org>).



Photo 1. SARI LCLUC regional science meeting participants in Johor Bahru, Malaysia. Photo credit: University of Technology Malaysia (UTM) team

The three-day meeting was attended by 170 participants from 16 countries—see Photo 1 below.

After several opening presentations, the bulk of the meeting was organized into five sessions, including:

- Updates on Regional Programs and Space Agency Activities;
- Agricultural LUCC;
- Land-Atmosphere Interactions and Emissions;
- Forest LUCC; and
- Urban LUCC.

In addition, on the final day of the meeting there were three discussion sessions that focused on regional research and priorities for agriculture, atmosphere, and LUCC capacity-building themes.

The remainder of this article is organized by day and presents highlights from each of the sessions and the discussions. It also includes a brief description of a press conference held on the afternoon of the first day, to introduce the local media to the practical applications of LUCC science, and a three-day, hands-on training event that took place immediately after the SARI LCLUC meeting, which focused on the use of remote sensing and geographic information systems for LUCC applications. The reader is directed to <https://gea.nasa.gov/3a4nuk> to find more information about the meeting, including the full presentations.

meeting summaries

meeting/workshop summaries

Summary of the 2019 NASA Land Cover/Land Use Change Regional Science Meeting, South India

2019 NASA Land Cover/Land Use Change Regional Science Meeting, South India

Meeting Goals:
 • Update on regional programs and space agency activities
 • Agricultural LUCC
 • Land-Atmosphere Interactions and Emissions
 • Forest LUCC
 • Urban LUCC
 • Regional research and capacity building



Photo 2. Meeting participants at the South India meeting, 2019. Photo credit: NASA Marshall Space Flight Center

meeting/workshop summaries

SARI International



Photo 3. SARI International meeting participants, 2019. Photo credit: NASA Marshall Space Flight Center

meeting summaries

Land-Use Change

Land-Use Change: A session focusing on the latest research and applications in land-use change, including agricultural, forest, and urban LUCC.



Photo 4. Land-Use Change session participants, 2019. Photo credit: NASA Marshall Space Flight Center

meeting summaries

Meeting on Land Use and Atmosphere

Meeting on Land Use and Atmosphere: A session focusing on the interactions between land use and atmospheric processes, including emissions and climate change.



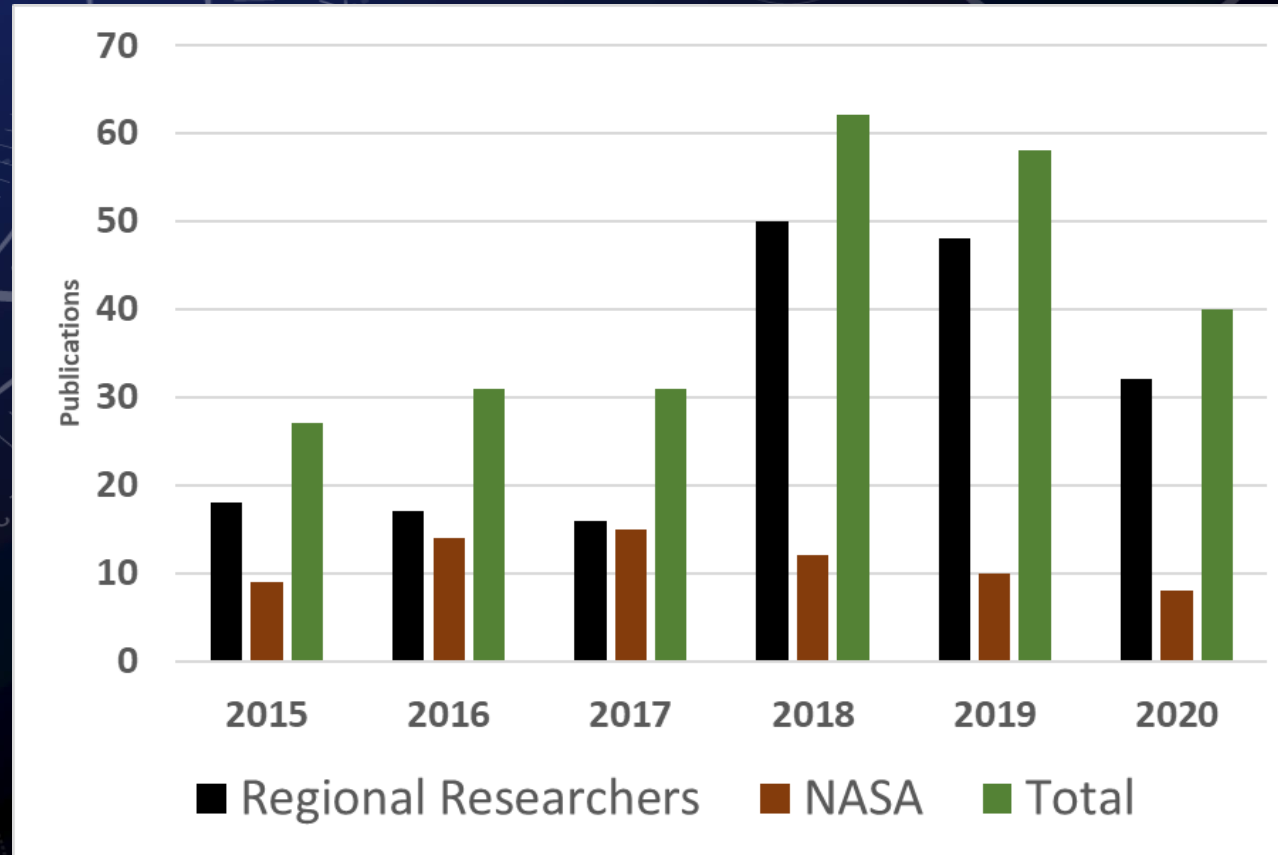
Photo 5. Meeting on Land Use and Atmosphere session participants, 2019. Photo credit: NASA Marshall Space Flight Center

Bottom-Up Approach
 Inputs to NASA ROSES LCLUC calls



SARI 5 YEARS OF SCIENCE

-23 projects and more being added
>250 scientists
>150 institutions
12-different
Special
Issues in
Journals



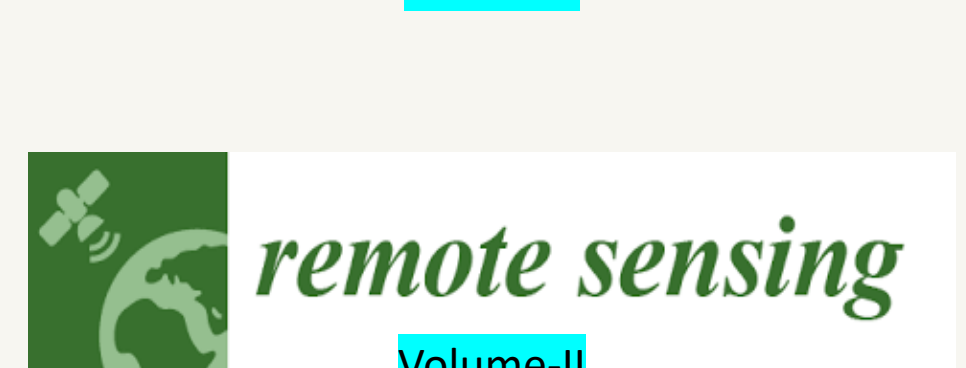
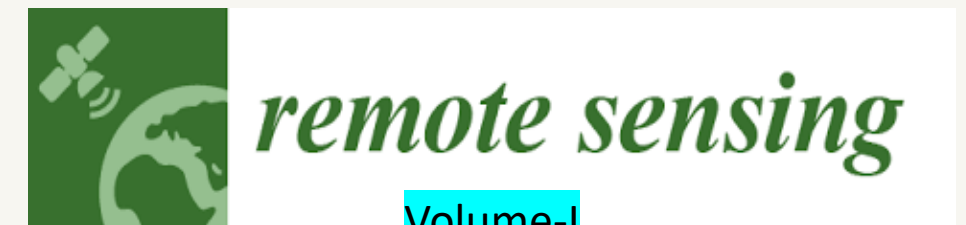
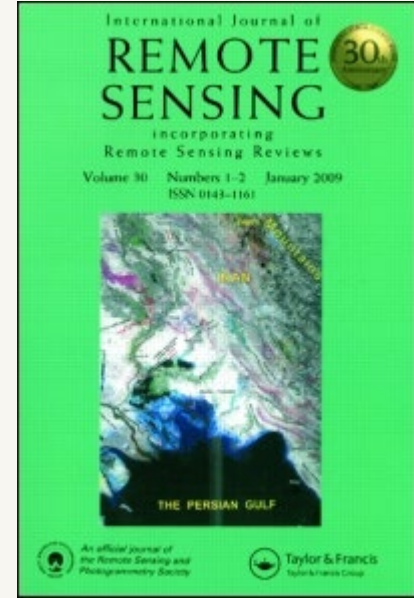
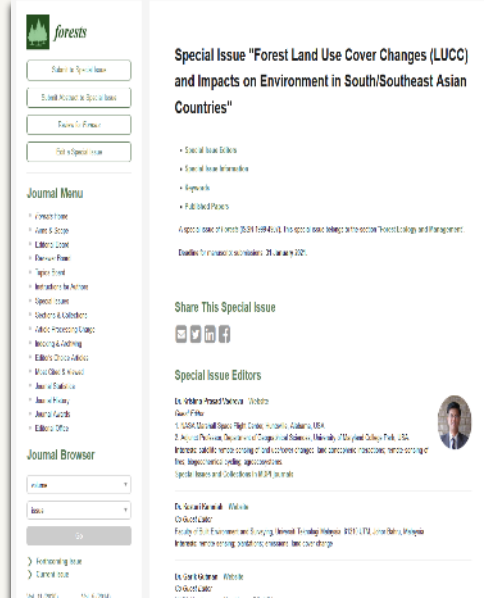
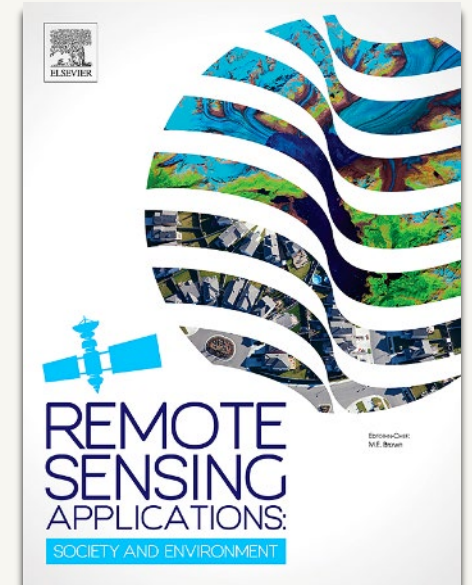
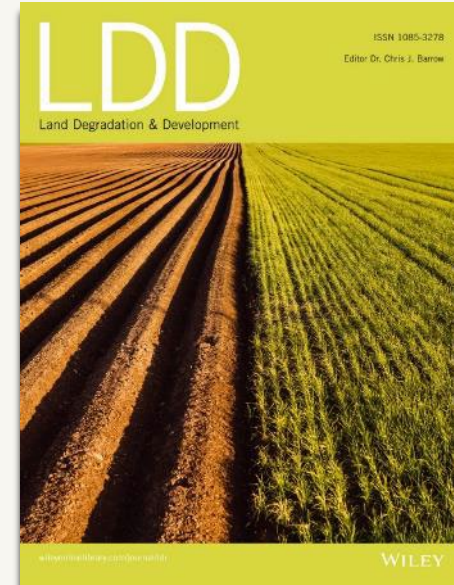
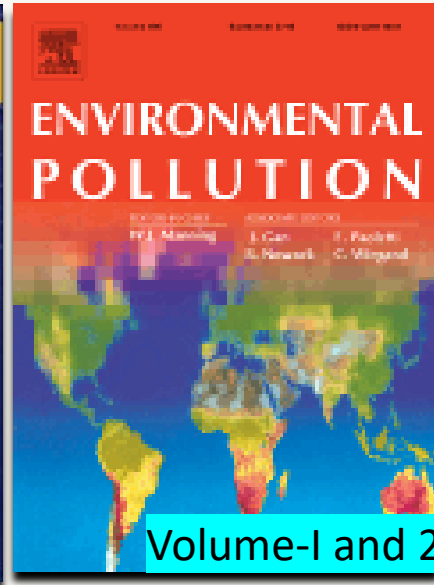
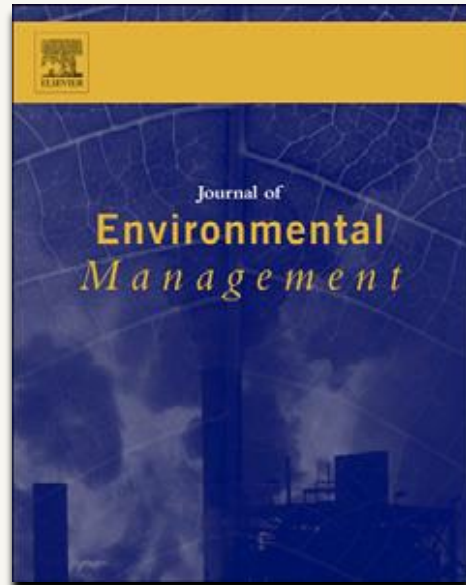
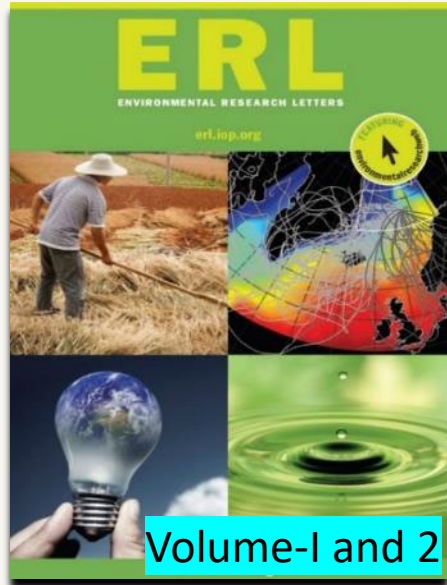
Nearly 350
publications
in Peer
reviewed
journals
and Books

South-Southeast Asia

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

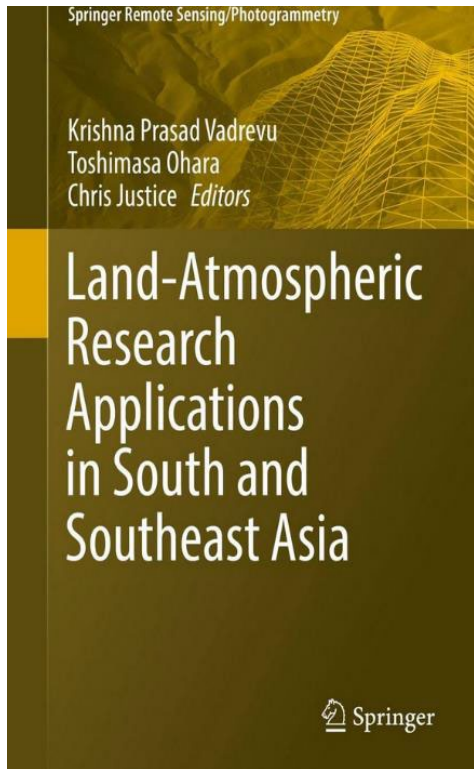


SARI Special Issues Published in Multiple Journals

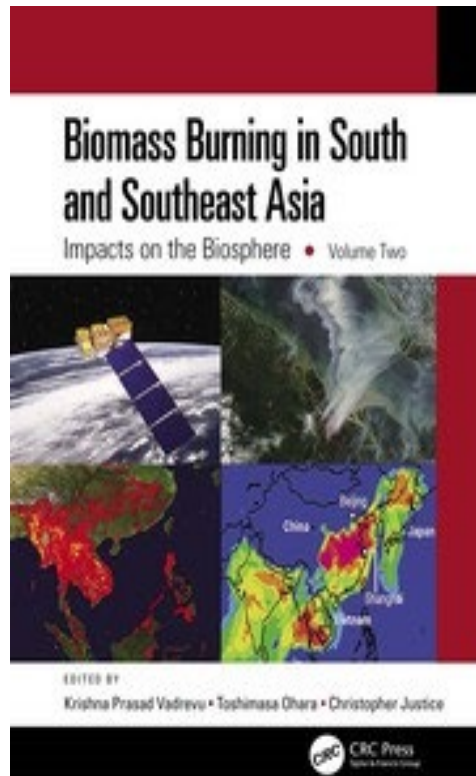


~200 peer reviewed publications in 5-years

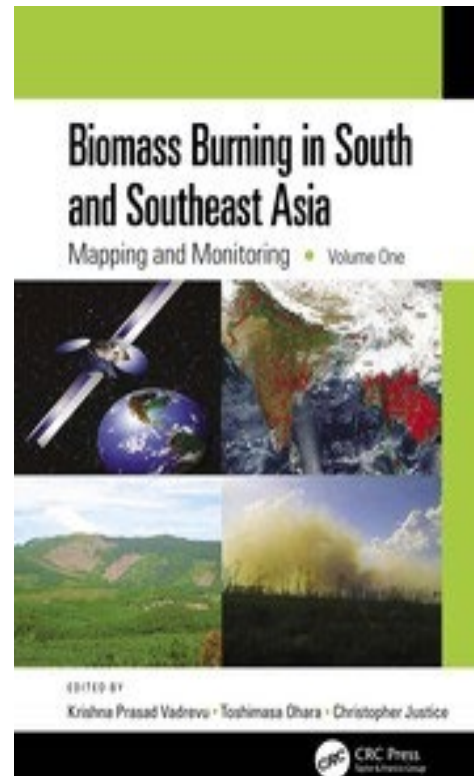
LCLUC/SARI Books



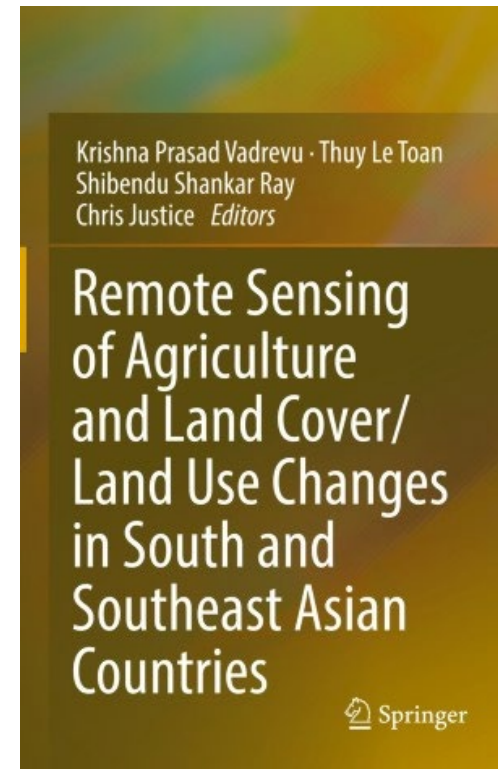
Springer 2018



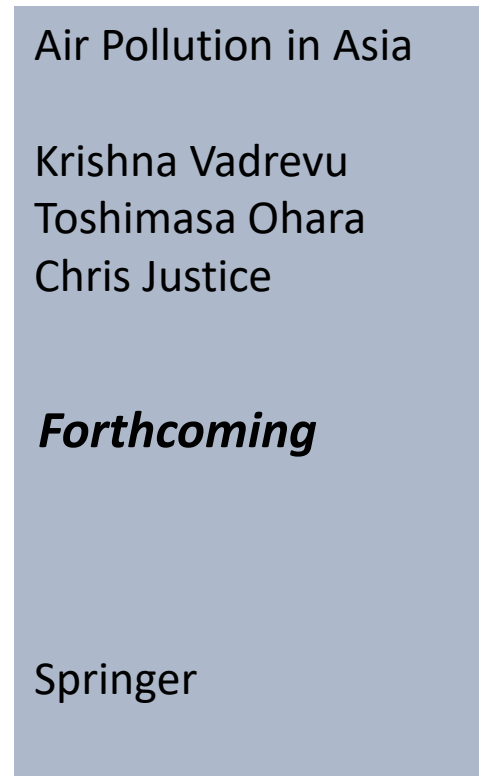
CRC Press, 2021



CRC Press, 2021

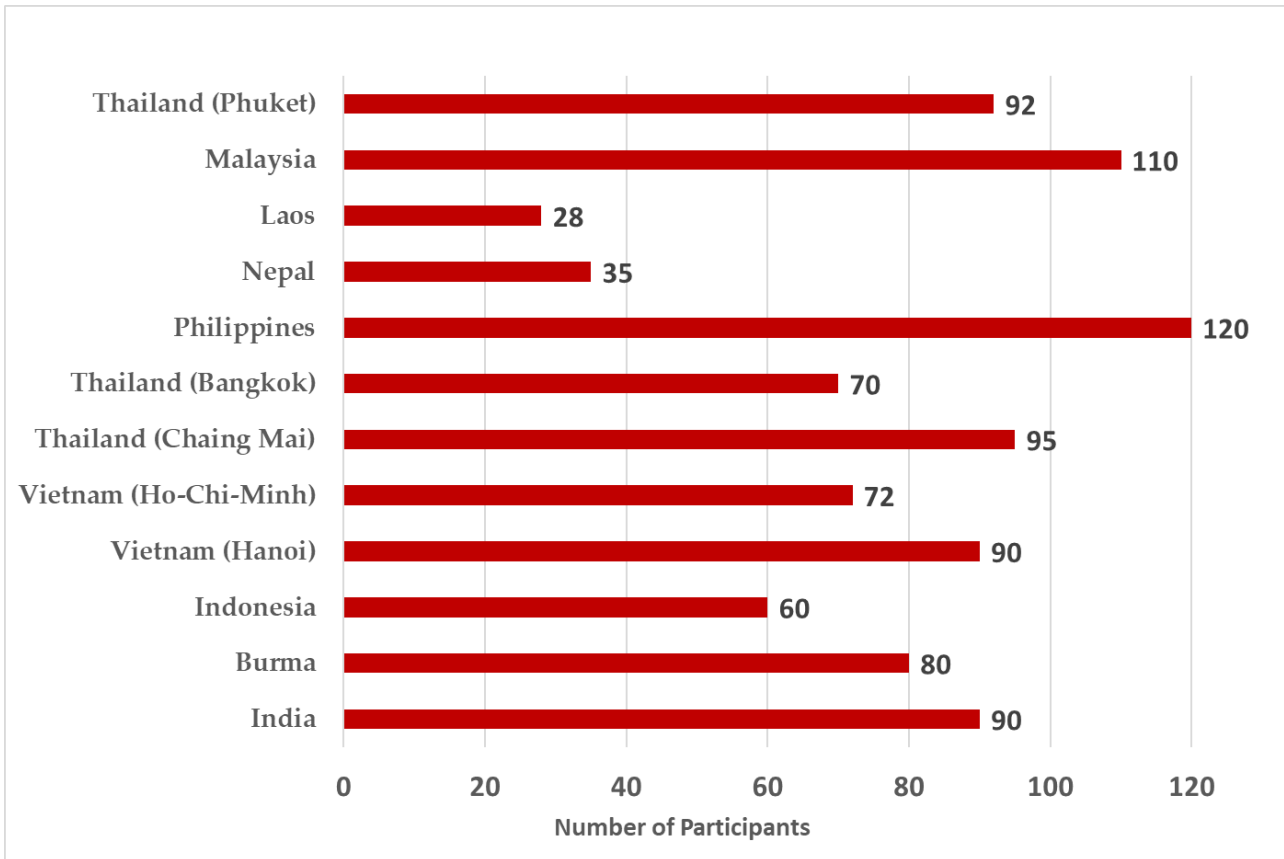


Springer, 2022



Springer, 2022

SARI – LCLUC Training Events



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



A certificate of participation from Prince of Songkla University. The certificate is awarded to a participant for attending an international regional science training event. The event is titled "Remote Sensing of Land-use/Cover Change and Climate Impacts In Coastal Zone", held from 17-19th December, 2020, in Phuket, Thailand. The certificate is signed by Garik Gutman (NASA LCLUC Program Manager, USA), Werapong Koedsin (Dean, Faculty of Technology and Environment, Prince of Songkla University, Thailand), and Krishna Vadrevu (NASA MSFC, SARI Program Scientist, USA). The certificate features logos for SARI, GOFCC-GOLD, LCLUC, SARI, and GISTDA.

PSU PRINCE OF SONGKLA UNIVERSITY PHUKET CAMPUS

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

SARI GOFCC-GOLD LCLUC SARI GISTDA

Example on the Integrated SARI Training Event

Remote Sensing of Land-Use/Cover Change and Climate Impacts In Coastal Zone
17-19th December, 2019, 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.



COVID Crisis – 2020-2021



Virtual Meetings and Training Events



WELCOME TO LCLUC

Welcome to the NASA Land-Cover and Land-Use Change (LCLUC) Program website. LCLUC is an interdisciplinary science program in the Earth Science Division of the Science Mission Directorate. LCLUC is part of the Carbon Cycle and Ecosystems Focus Area with links to some programs in other Focus Areas.

Search LCLUC Website

Enter terms then hit Search...

LCLUC Science Team Meeting Schedule

DATE	LOCATION
10/19/2021	Bethesda, MD
10/19/2020	Online
07/22/2019	Johor Bahru, Malaysia
04/09/2019	Rockville, MD

1 of 10 next >

[LCLUC - Related Meetings](#)

[LCLUC - Related Calendar](#)

NASA LCLUC SARI Webinar Series 2019-2020



[LCLUC E-Newsletter](#)

[LCLUC Webinar Series](#)

April

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Featured Project

"Land Use Status, Change and Impacts in Vietnam, Cambodia and Laos"
Principal Investigator: Son Nghiem

The overall science objective of this research is to quantitatively document the current status and rate of change of

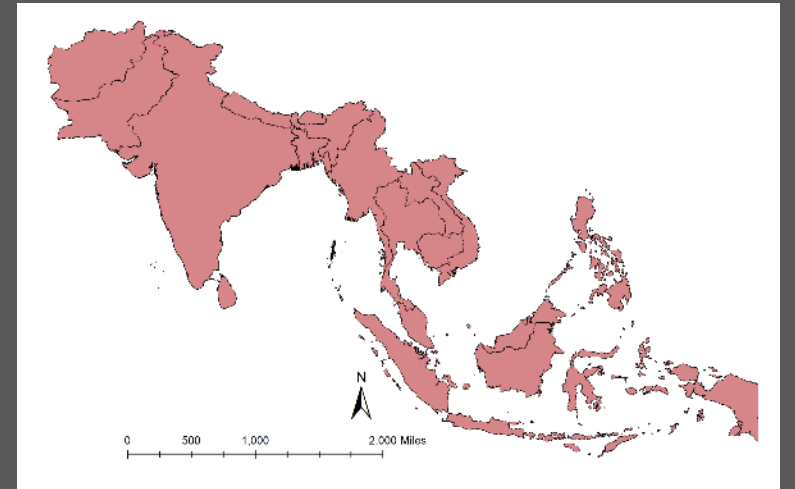
Objectives

- Review the causes and impacts of LCLUC specific to agriculture and forests in S/SEA (Day-1 and Day-2);
- Review latest research specific to GHG inventories, aerosols; biomass burning pollutants and emissions (Day-3).
- Identify important regional research, capacity building and training needs and priorities in S/SEA.
- Facilitate regional collaborations

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



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



Thank you for your
attention

Questions?