Intl. Conf. on 25 years of Community Forestry:
Mapping Tree Dynamics in Nepal
Kathmandu, Nepal, Nov 29-30, 2018

Dynamics and Drivers of Land Use & Land Cover Changes – Country Scale to Global Scale

Atul K Jain

University of Illinois, Urbana, IL 61801, USA

Email: jain1@illinois.edu

Acknowledgements

Xiaoming Xu and Regional and US CO-Is & Collaborators

NASA LCLUC Program

Overall Objective

- Improve our understanding of the dynamics and drivers of LCLUC

Why?

  - Improve the understanding of the impacts of LCLUC dynamics on the quantities and pathways of land carbon and nitrogen fluxes at various scales
  - Improve the projection of the impacts of climate change on agriculture and land use

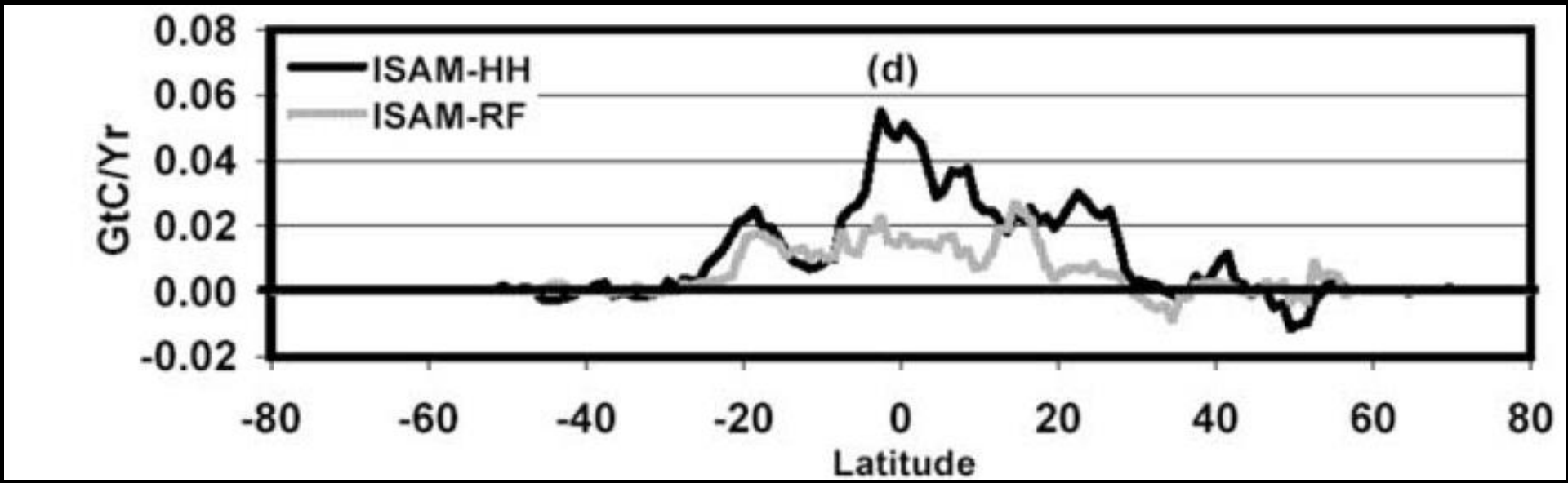
GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 19, GB2015, doi:10.1029/2004GB002349, 2005

Modeling the effects of two different land cover change data sets on the carbon stocks of plants and soils in concert with CO_2 and climate change

Atul K. Jain and Xiaojuan Yang

Department of Atmospheric Science, University of Illinois, Urbana, Illinois, USA

Received 2 August 2004; revised 5 January 2005; accepted 9 March 2005; published 5 May 2005.



Estimates of Net Carbon Fluxes (+ release to the atmosphere) for the 1980s due to two different land data sets

Global Change Biology (2016), doi: 10.1111/gcb.13447

Assessing uncertainties in land cover projections

PETER ALEXANDER[1,2], REINHARD PRESTELE[3], PETER H. VERBURG[3], ALMUT ARNETH[4], CLAUDIA BARANZELLI[5], FILIPE BATISTA E SILVA[5], CALUM BROWN[1], ADAM BUTLER[6], KATHERINE CALVIN[7], NICOLAS DENDONCKER[8], JONATHAN C. DOELMAN[9], ROBERT DUNFORD[10,11], KERSTIN ENGSTRÖM[12], DAVID EITELBERG[3], SHINICHIRO FUJIMORI[13], PAULA A. HARRISON[11], TOMOKO HASEGAWA[13], PETR HAVLIK[14], SASCHA HOLZHAUER[1], FLORIAN HUMPENÖDER[15], CHRIS JACOBS-CRISIONI[5], ATUL K. JAIN[16], TAMÁS KRISZTIN[14], PAGE KYLE[7], CARLO LAVALLE[5], TIM LENTON[17], JIAYI LIU[6], PRASANTH MEIYAPPAN[16], ALEXANDER POPP[15], TOM POWELL[17], RONALD D. SANDS[18], RÜDIGER SCHALDACH[19], ELKE STEHFEST[9], JEVGENIJS STEINBUKS[20], ANDRZEJ TABEAU[21], HANS VAN MEIJL[21], MARSHALL A. WISE[7] and MARK D. A. ROUNSEVELL[1]

Global Change Biology (2016), doi: 10.1111/gcb.13447

Assessing uncertainties in land cover projections

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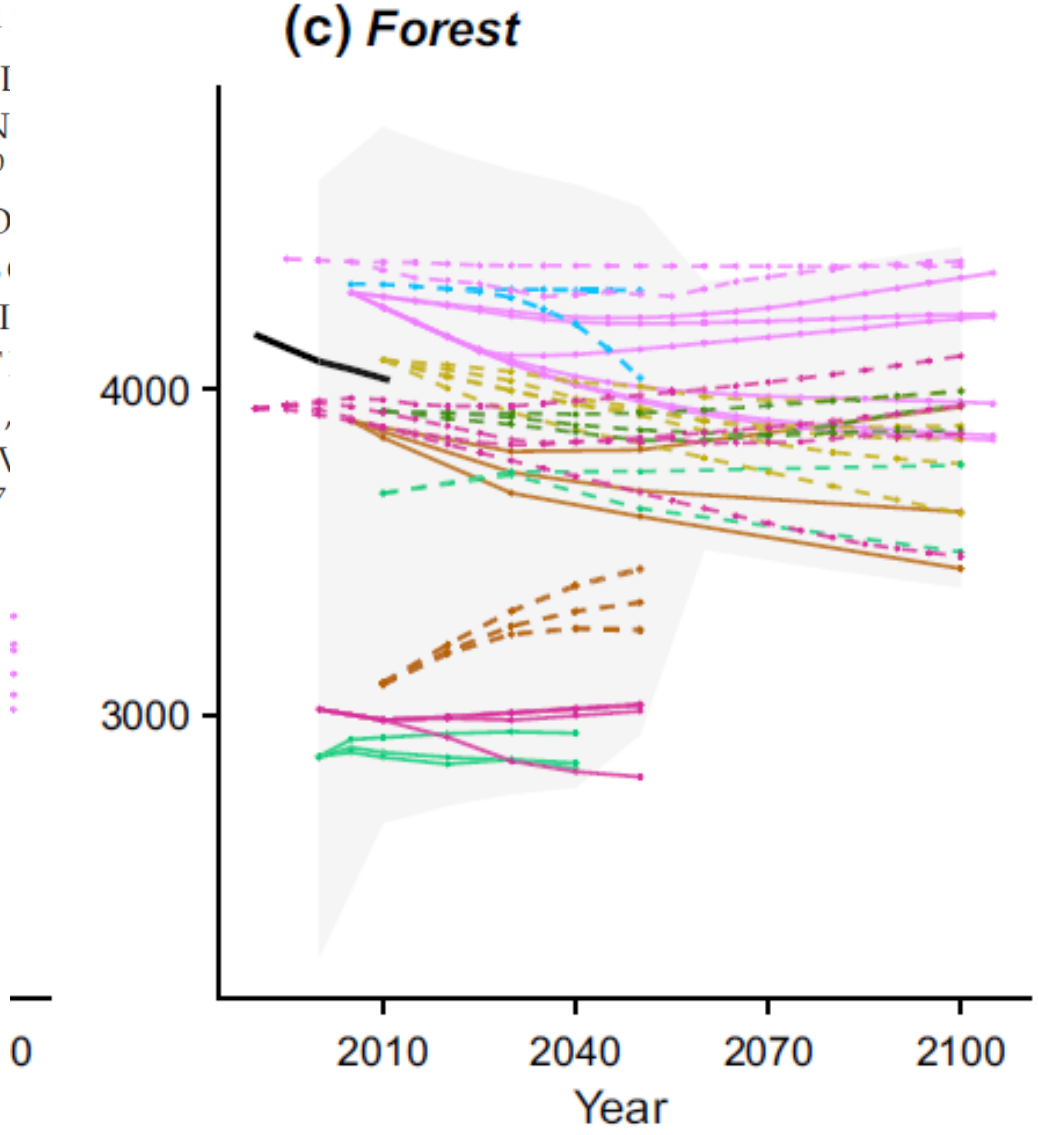
AM BUTLER[6],
N[9],
[3],
E[7],
ALDACH[19],
AN MEIJL[21],



nature COMMUNICATIONS

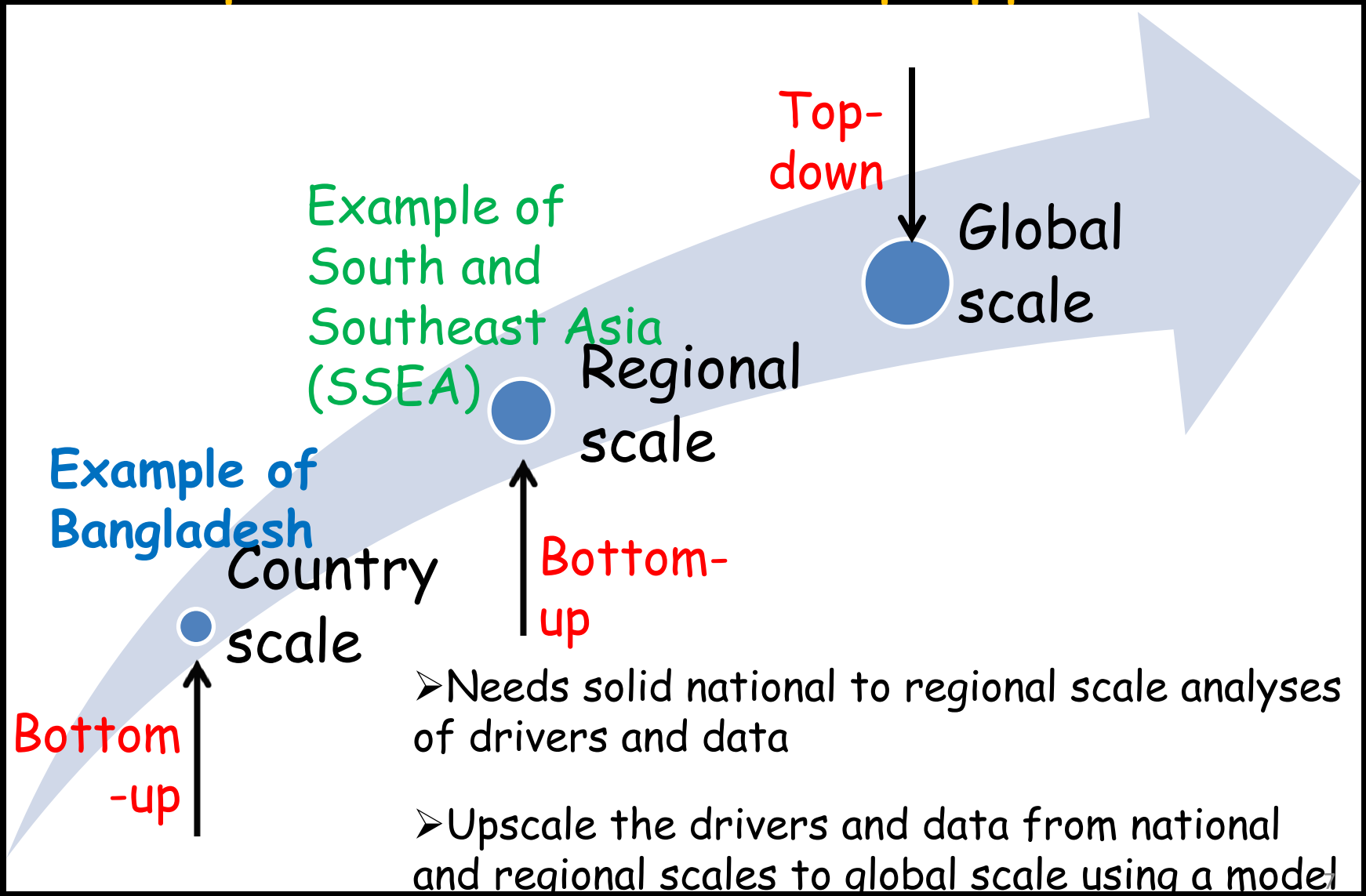
ARTICLE

DOI: 10.1038/s41467-018-05340-z OPEN

Land-use emissions play a critical role in land-based mitigation for Paris climate targets

Anna B. Harper[1], Tom Powell[2], Peter M. Cox[1], Joanna House[3], Chris Huntingford[4], Timothy M. Lenton[2], Stephen Sitch[2], Eleanor Burke[5], Sarah E. Chadburn[1,6], William J. Collins[7], Edward Comyn-Platt[4], Vassilis Daioglou[8,9], Jonathan C. Doelman[8], Garry Hayman[4], Eddy Robertson[5], Detlef van Vuuren[8,9], Andy Wiltshire[5], Christopher P. Webber[7], Ana Bastos[10,11], Lena Boysen[12], Philippe Ciais[11], Narayanappa Devaraju[11], Atul K. Jain[13], Andreas Krause[14], Ben Poulter[15] & Shijie Shu[13]

LCLUC Drivers and Data at Global Scale - Mix of top-down and bottom-up approaches



- Needs solid national to regional scale analyses of drivers and data
- Upscale the drivers and data from national and regional scales to global scale using a model

Xu and Jain (2019)

Top-Down - Global Scale

Top-down Approach: Global Scale Modeling of LCLUC

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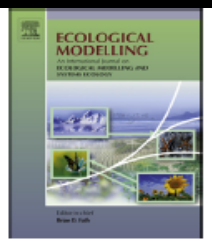
Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



Spatial modeling of agricultural land use change at global scale

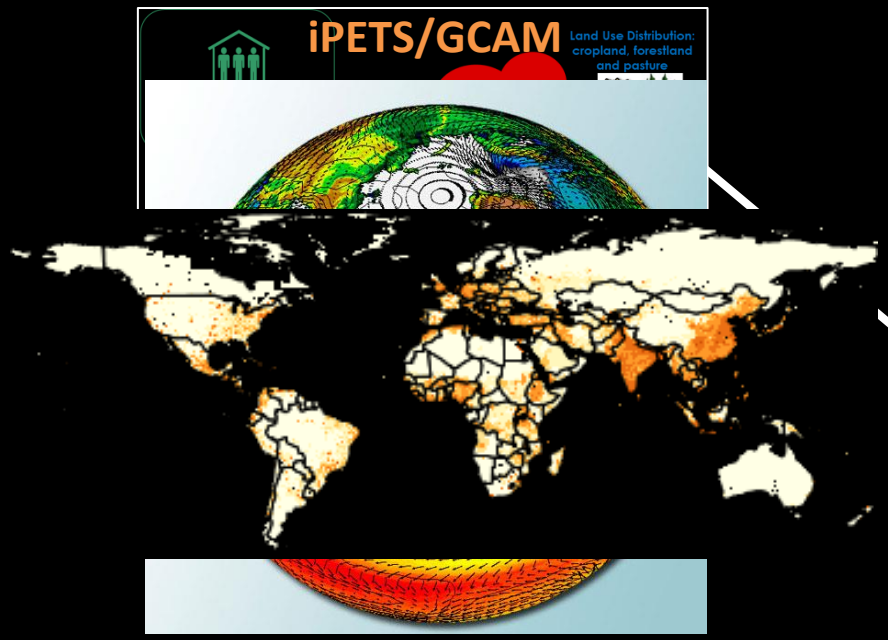
Prasanth Meiyappan[a,*], Michael Dalton[b], Brian C. O'Neill[c], Atul K. Jain[a,**]

Implementation of Global-Scale Spatial Dynamic Allocation Model (SDAM) in a Coupled Modeling Framework

- Land use competition
- Spatial and temporal autocorrelation in land use patterns
- Spatial heterogeneity of the biophysical and socioeconomic drivers across geographic regions
- It can reproduce the broad spatial features of the past 100 years of cropland and pastureland patterns

Meiyappan *et al*, 2014

LULCC Spatial Downscaling Model Projections



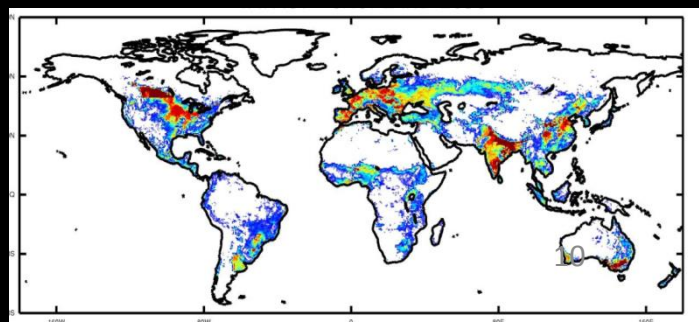
Aggregate regional land use (iPETS/GCAM model scenario)

Projected climate change (CESM/ACME)

Projected population, GDP, market access

LULCC Spatial Downscaling Model (SDAM)

Projected LULCC

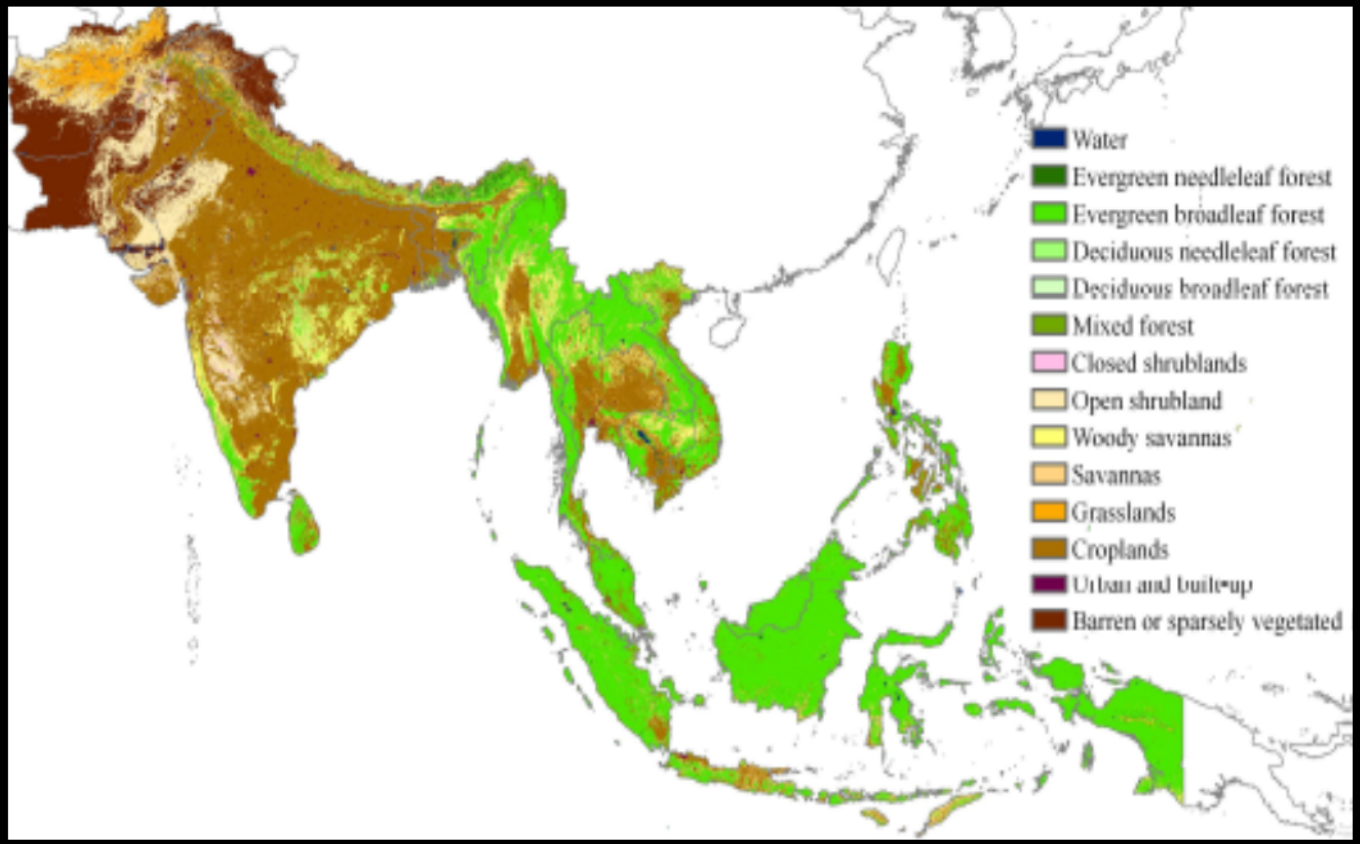


Meiyappan *et al* (2014)

Bottom-up – Regional Scale
Example: SSEA

Xu *et al.* (2018a)

Bottom-up approach: Regional scale study of LCLUC drivers for (SSEA) NASA LCLUC Project

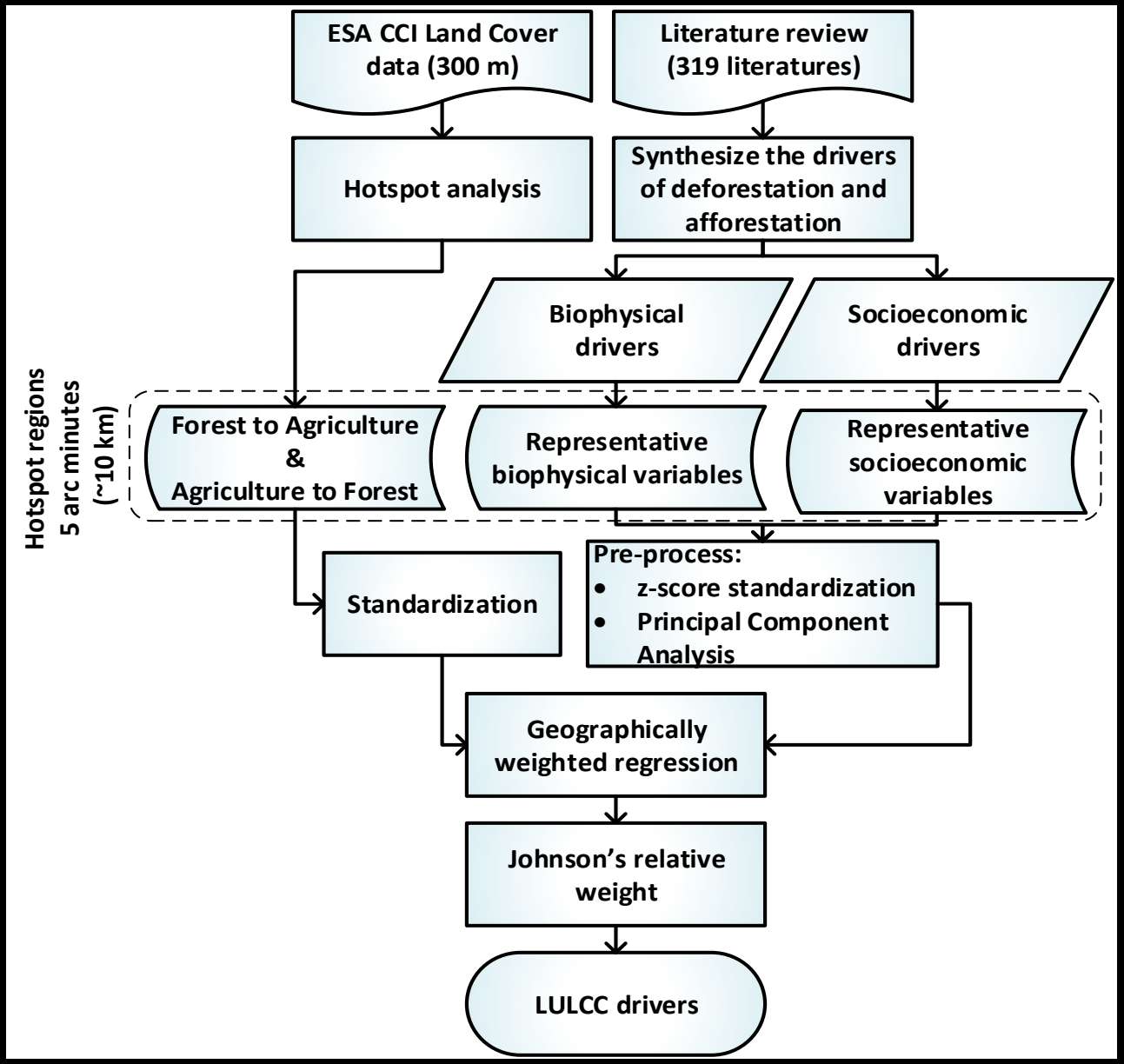


LULC distribution in the study region

- *Study LCLUC drivers on a country-by-country basis*

Xu *et al.* (2018a)

Material and Methods



Xu *et al.* (2018a)

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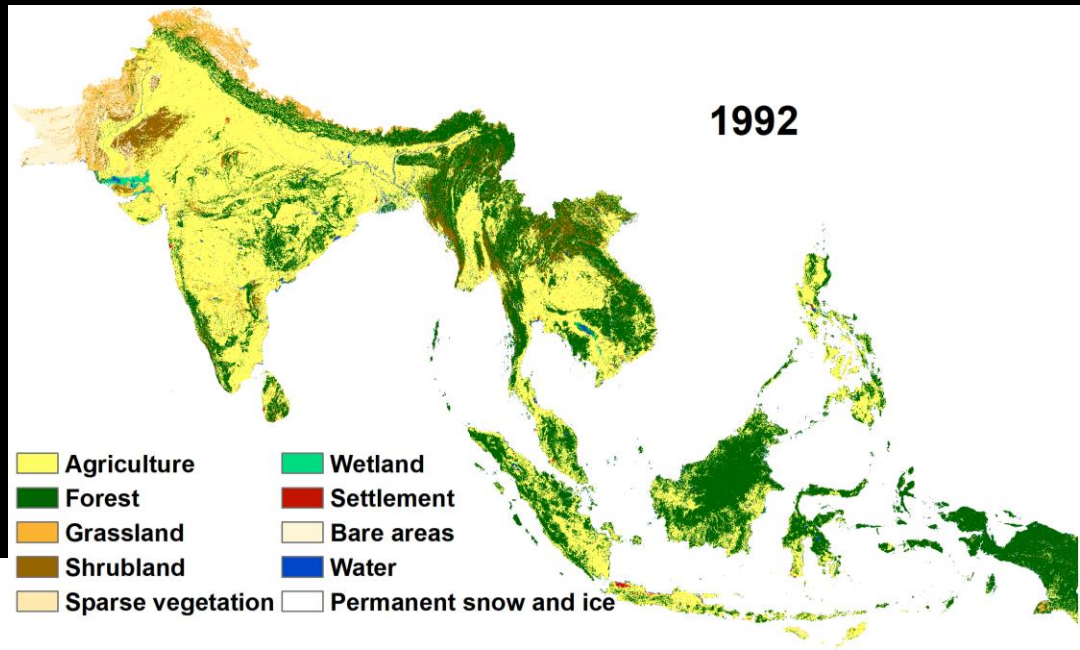
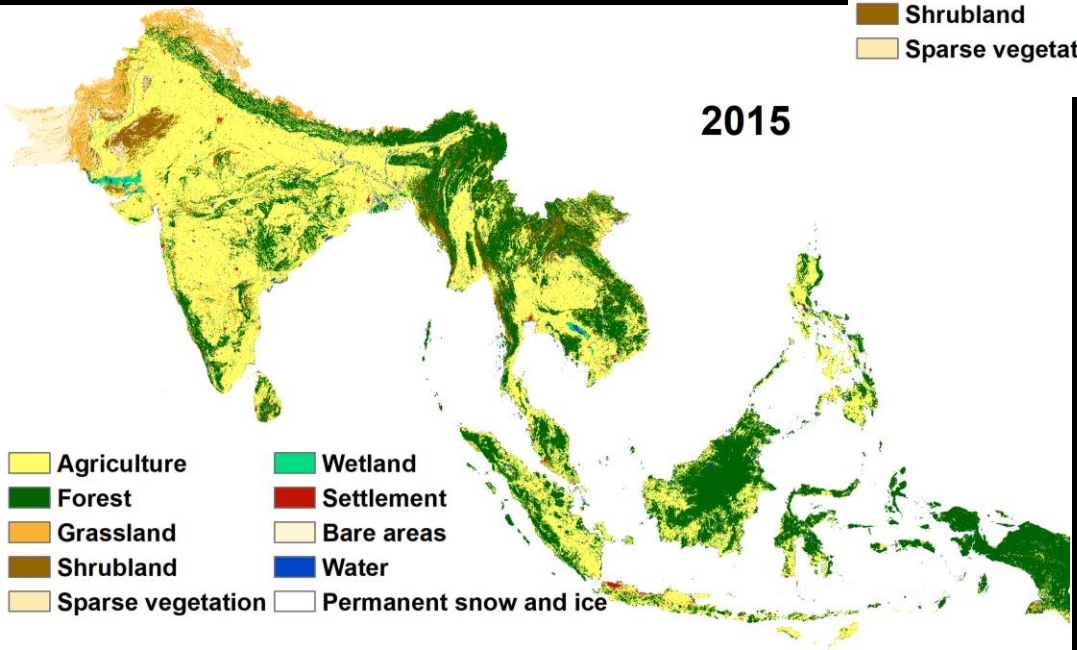
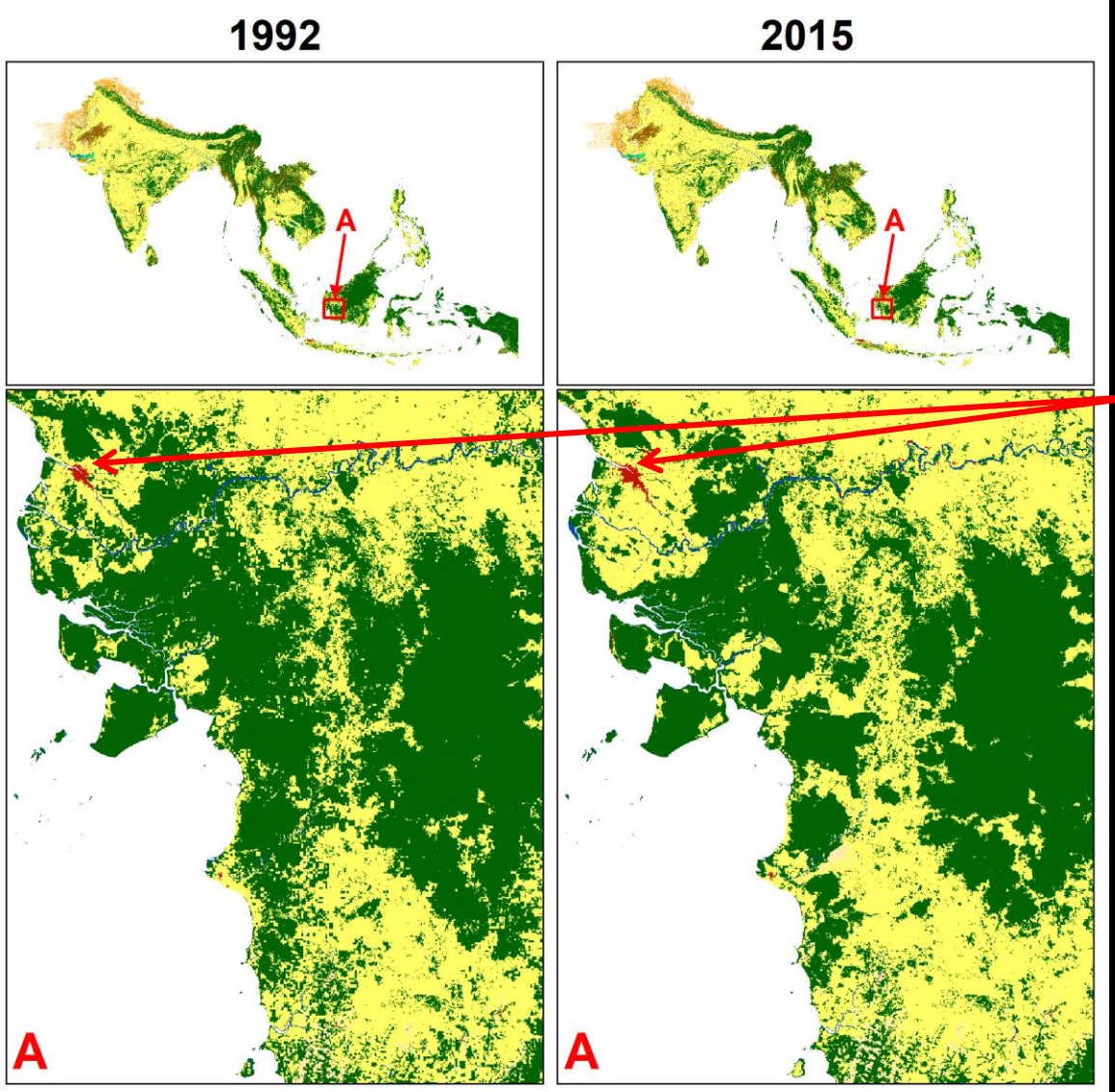
ESA CCI Data





Plummer *et al.* (2017)

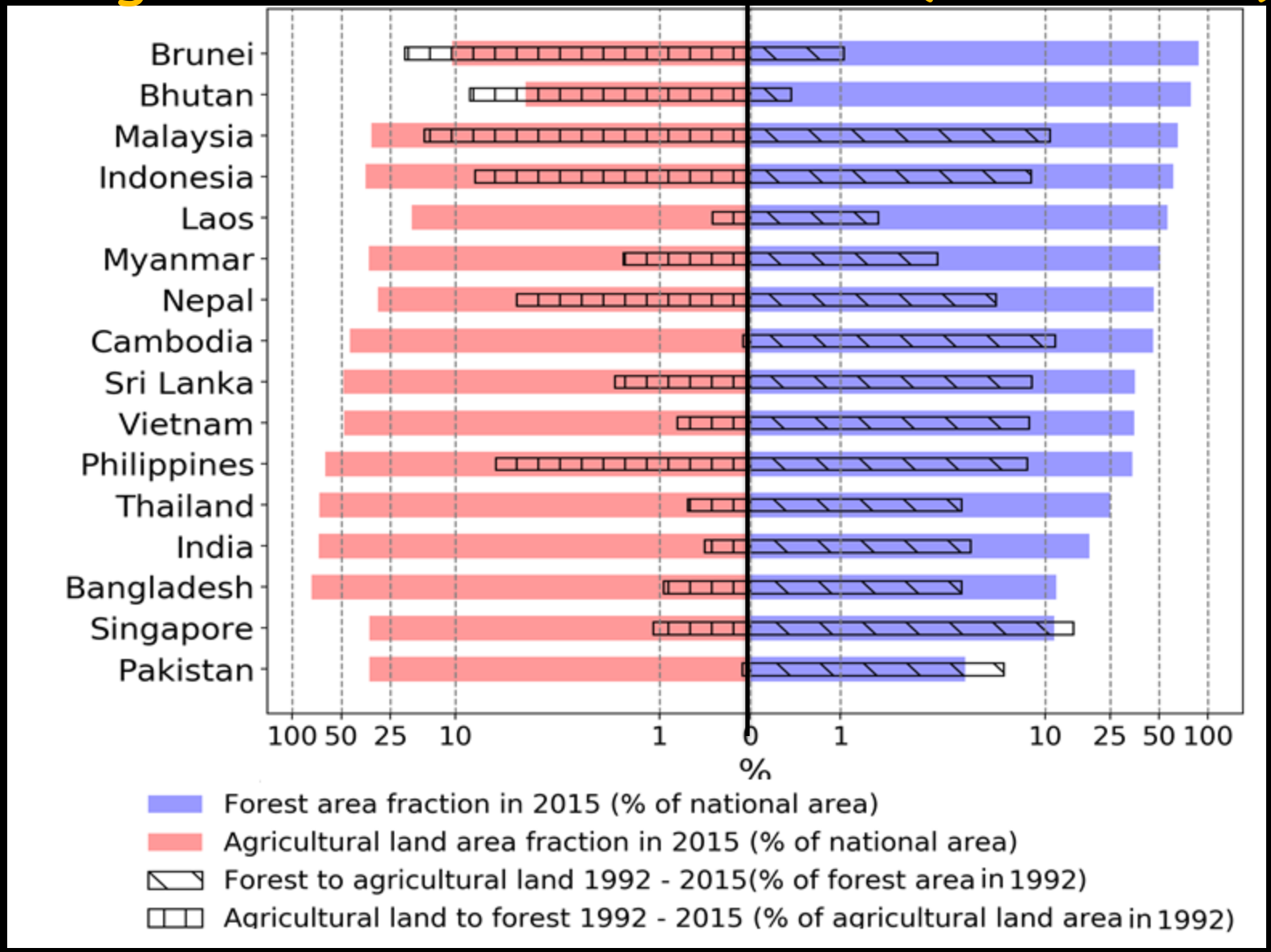


Pontianak, capital of the Indonesian province of West Kalimantan

Forest to agriculture

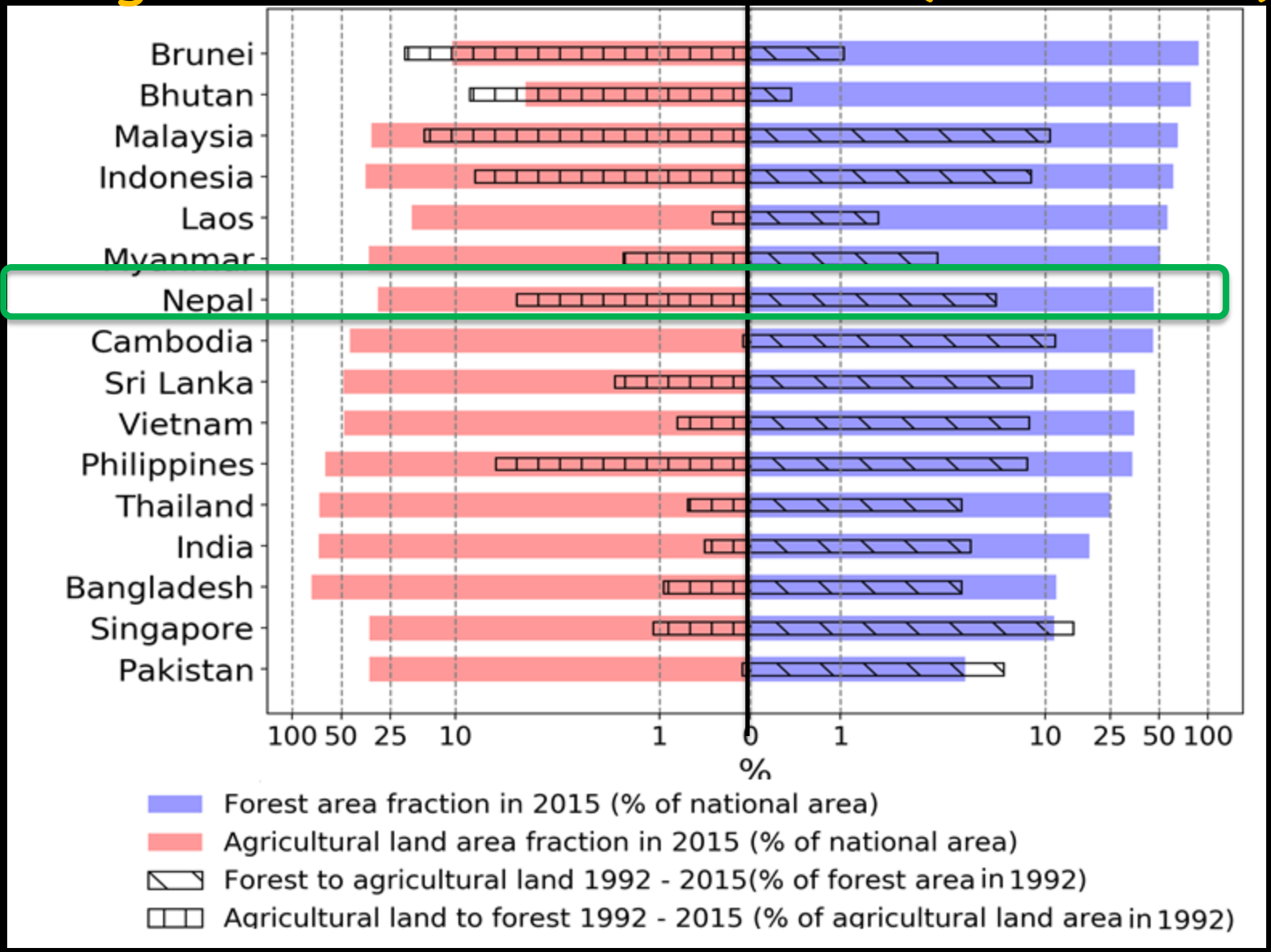
Plummer *et al.* (2017)

Country Specific Dynamics of Forest and Agricultural Land in SSEA (1992-2015)



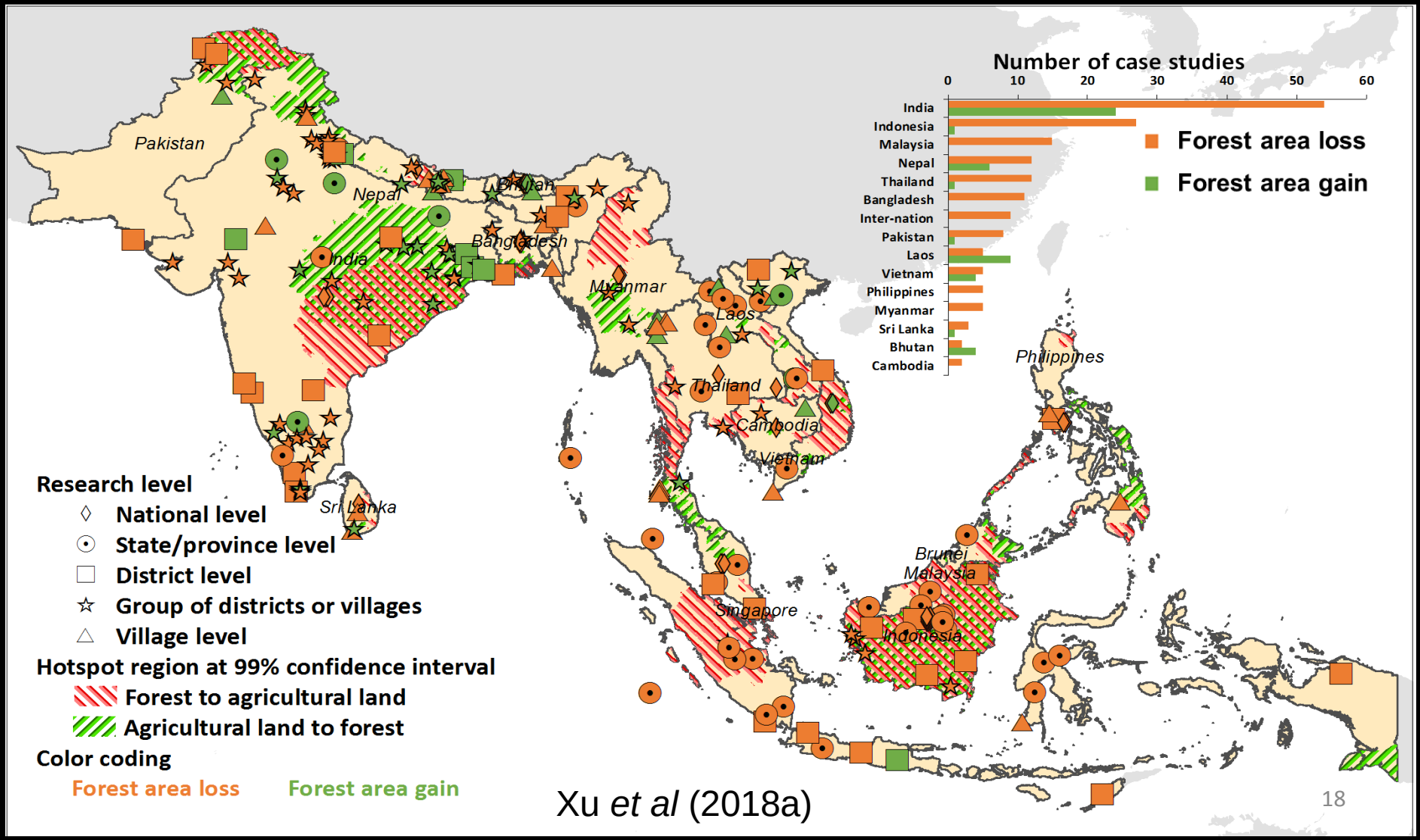
Xu *et al.* (2018a)

Country Specific Dynamics of Forest and Agricultural Land in SSEA (1992-2015)



Xu *et al.* (2018a)

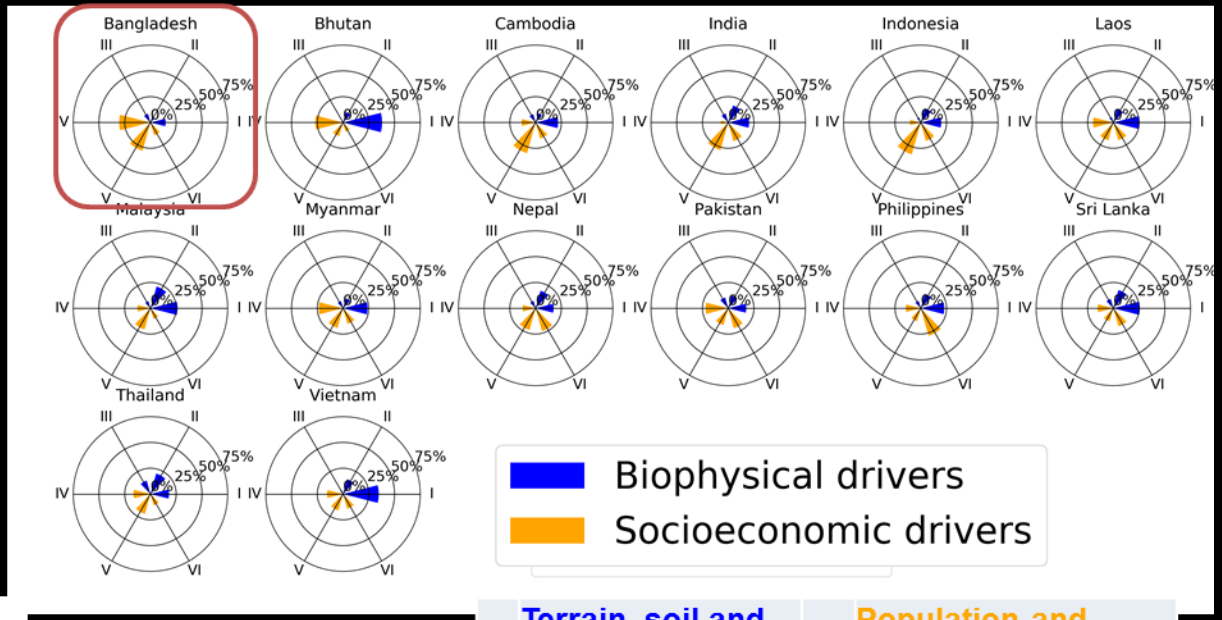
Synthesis of case studies & hotspot regions
Example: Forest areas gain and loss



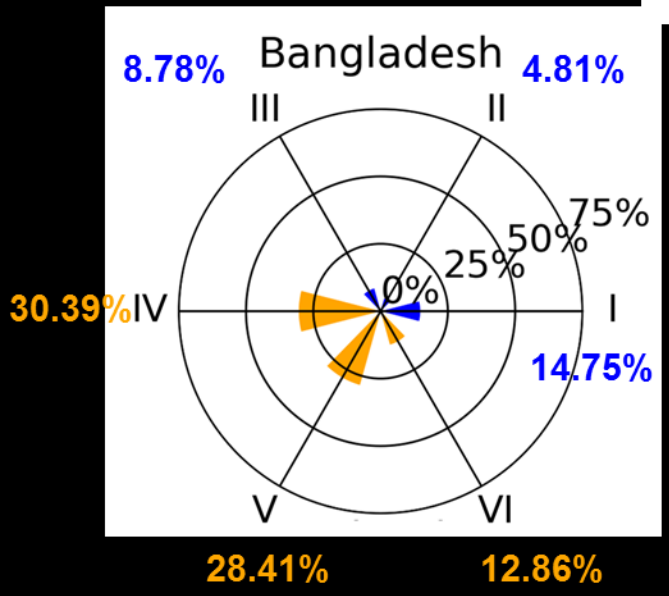
Xu *et al* (2018a)

Country-specific relative importance of each driver category

Forest → Agriculture



I.	Terrain, soil and water	IV.	Population and urbanization
II.	Climate	V.	Livestock
III.	Natural disaster	VI.	Economy



Biophysical drivers: 28%

Socioeconomic drivers: 72%

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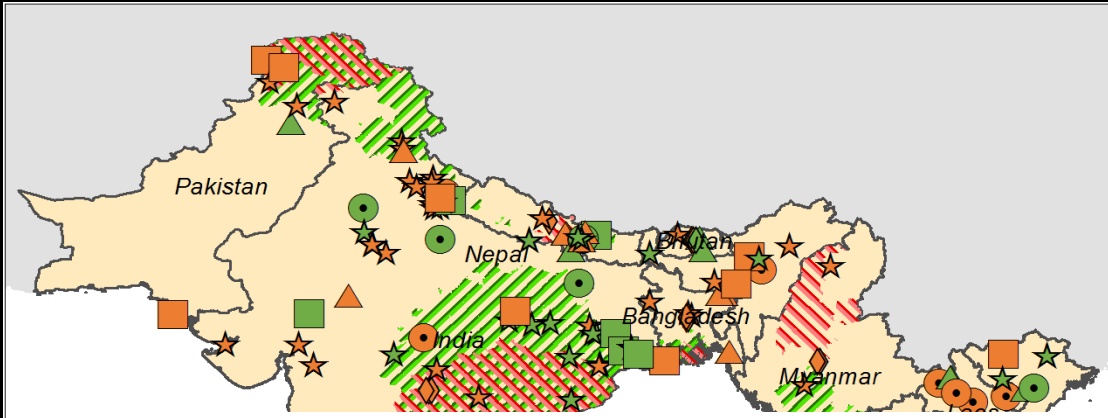
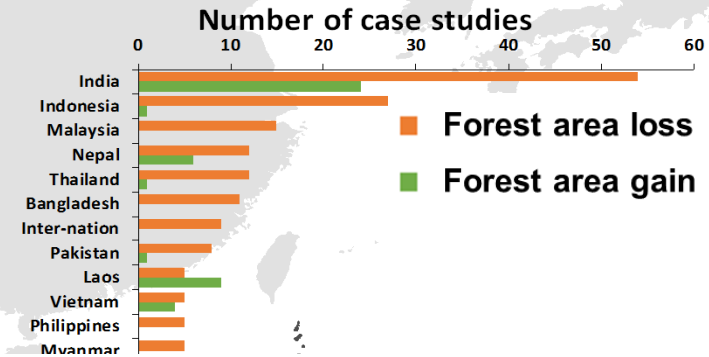
Xu *et al* (2018a)

Synthesis of case studies & hotspot regions
Example: Forest areas gain and loss

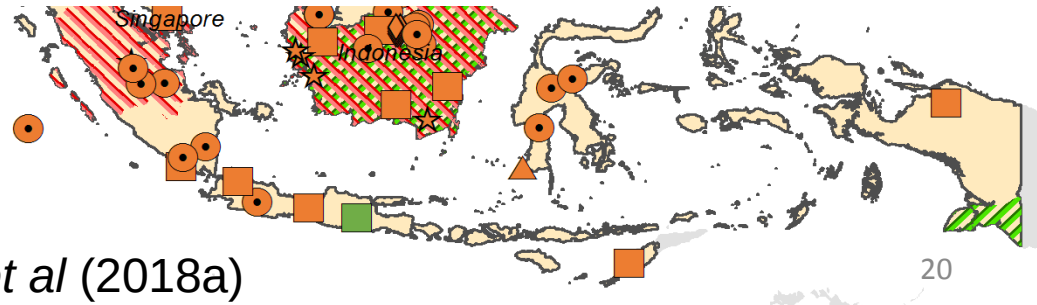




The driving processes for LCLUC vary with regions and countries, indicating the needs for further understanding of LCLUC dynamics at country and local scales.

Re

☆ Group of districts or villages
△ Village level
Hotspot region at 99% confidence interval
Forest to agricultural land
Agricultural land to forest
Color coding
Forest area loss Forest area gain



Xu *et al* (2018a)

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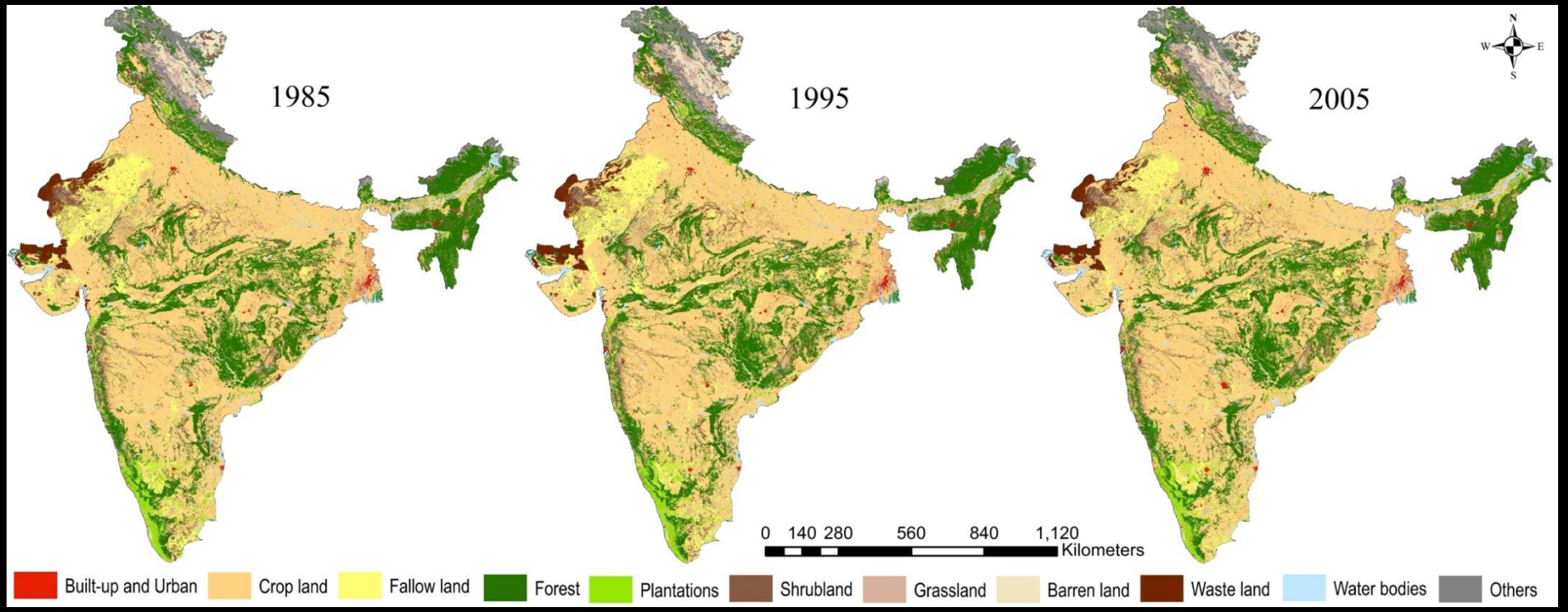
Country to Local Scale Analysis – Example of India

Xu *et al* (2018b)

Wall-to-wall Landsat Analysis (30m)

- Covers Longer Time Period: Decadal (1985-1995-2005)
- Uniform Classification Scheme: IGBP
- Patch to Patch Land Dynamics
- Ground Validation (>12000 points)



Roy et al. (*Remote Sensing*, 2015)

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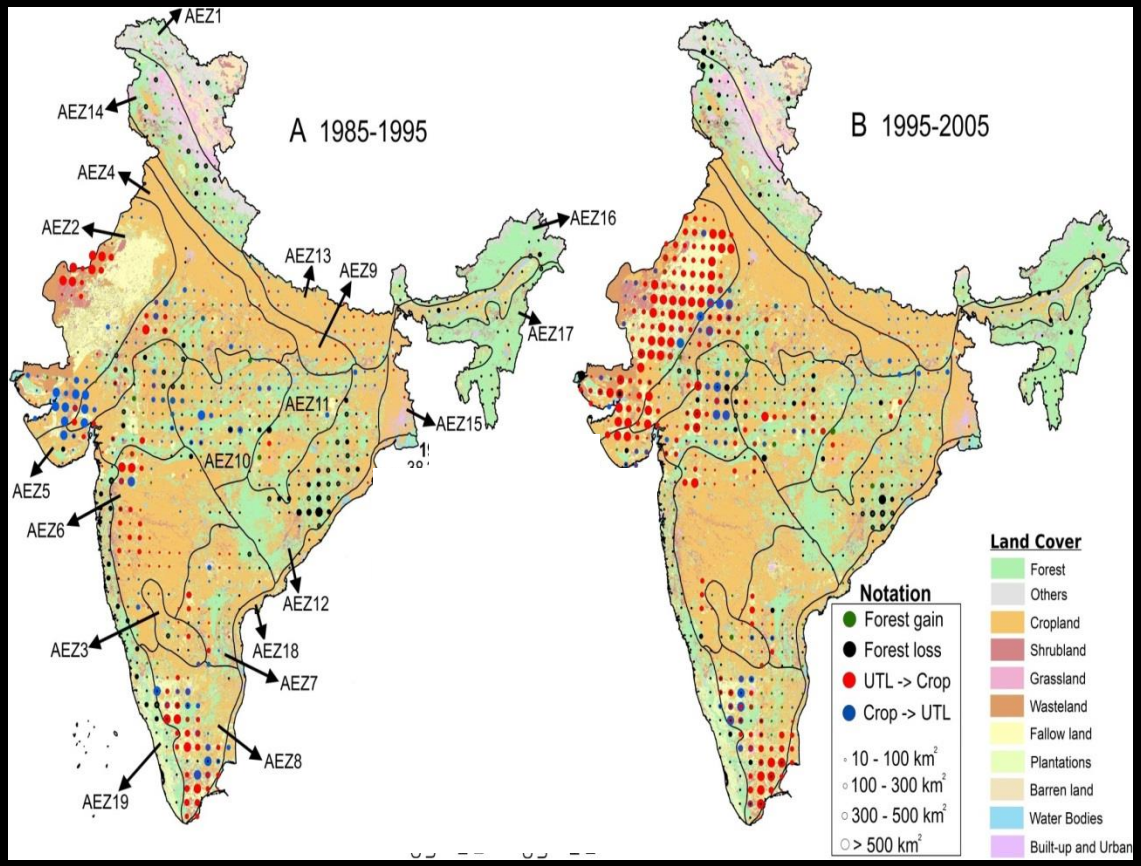
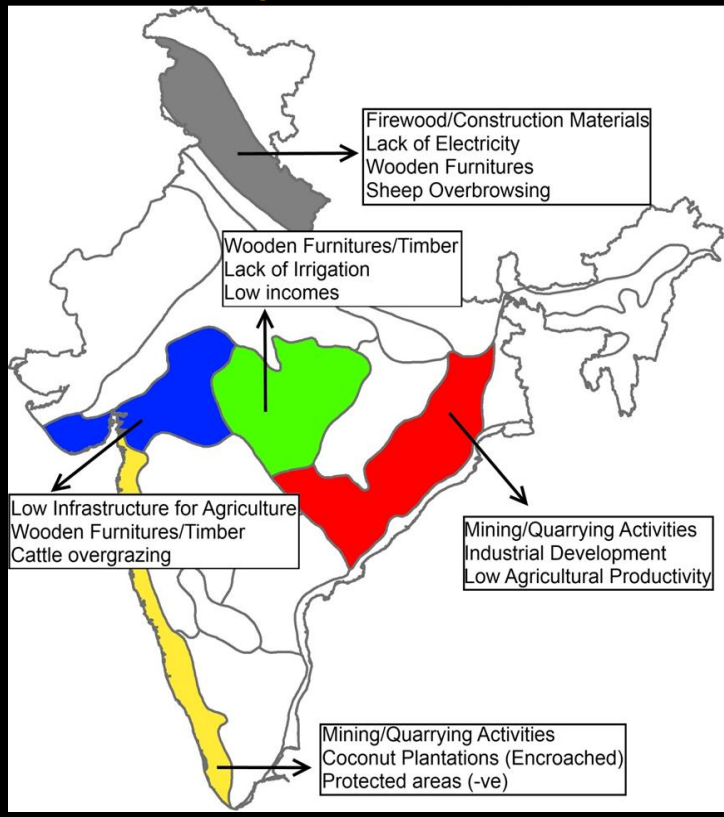
Dynamics and determinants of land change in India: integrating satellite data with village socioeconomics

Reg Environ Change
DOI 10.1007/s10113-016-1068-2

Prasanth Meiyappan[1] · Parth S. Roy[2] · Yeshu Sharma[3] · Reshma M. Ramachandran[2] · Pawan K. Joshi[4] · Ruth S. DeFries[5] · Atul K. Jain[1]



Major findings



Meiyappan *et al* (2016)

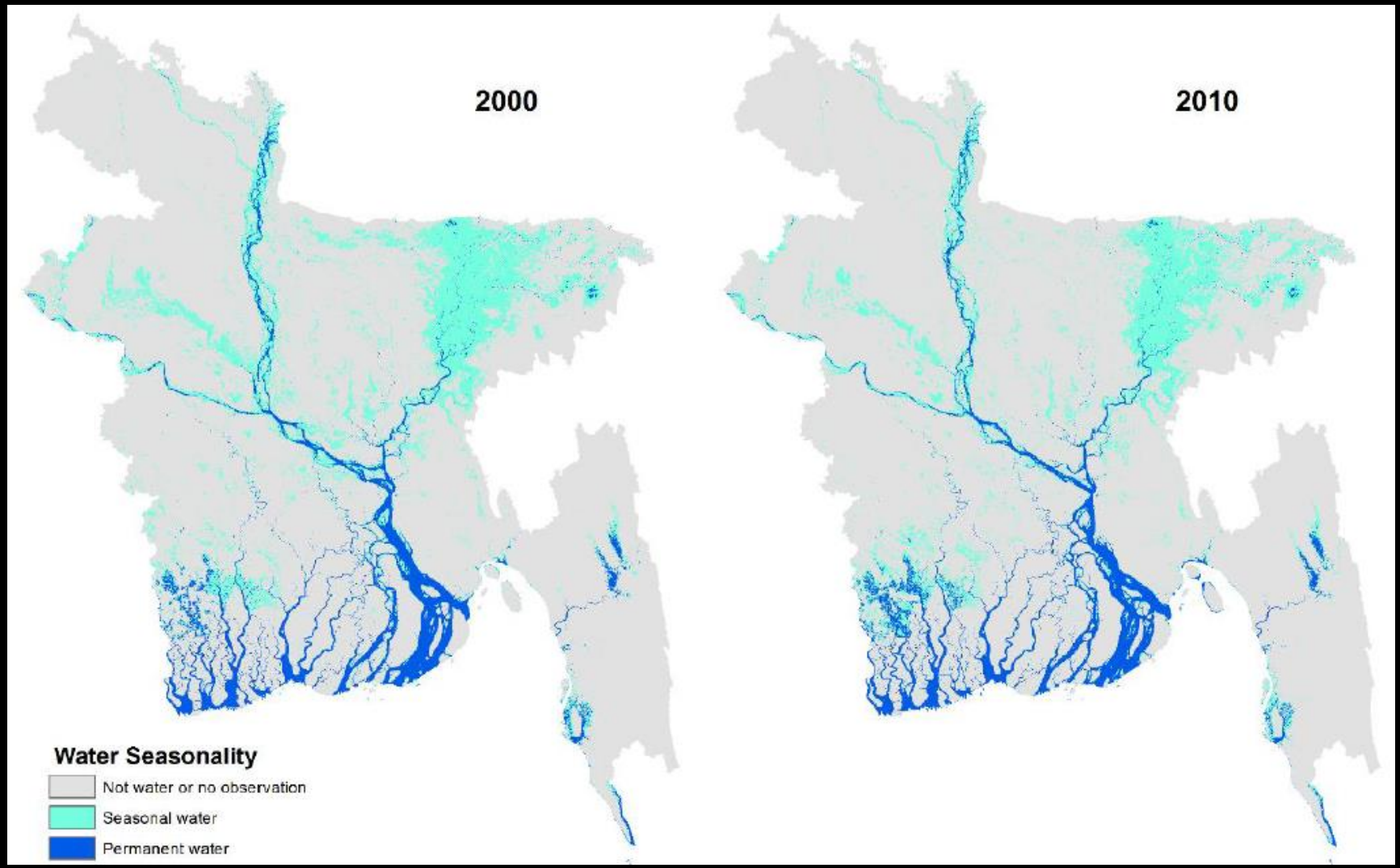
Country to Local Scale Analysis - Bangladesh

Xu *et al* (2018b)

Bangladesh Study - Background

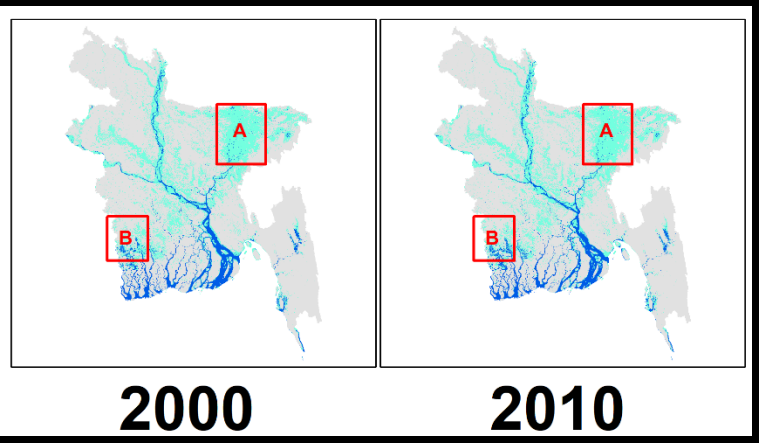
- Rapid change between various land cover types and agricultural land over the years
  - growing population and economy, expanding infrastructure use, and climate change.
- It is becoming challenging for Bangladesh to ensure enough agricultural land for the growing population
- Shrinking agricultural land, because of the expansion of the aquaculture farms due to its extensive water resources in the form of natural ponds and lakes (Haors and Baors)
  - These changes are influenced by the seasonal water dynamics, such as flooding. So, it is difficulty to detect the changes in waterbodies due to human activities

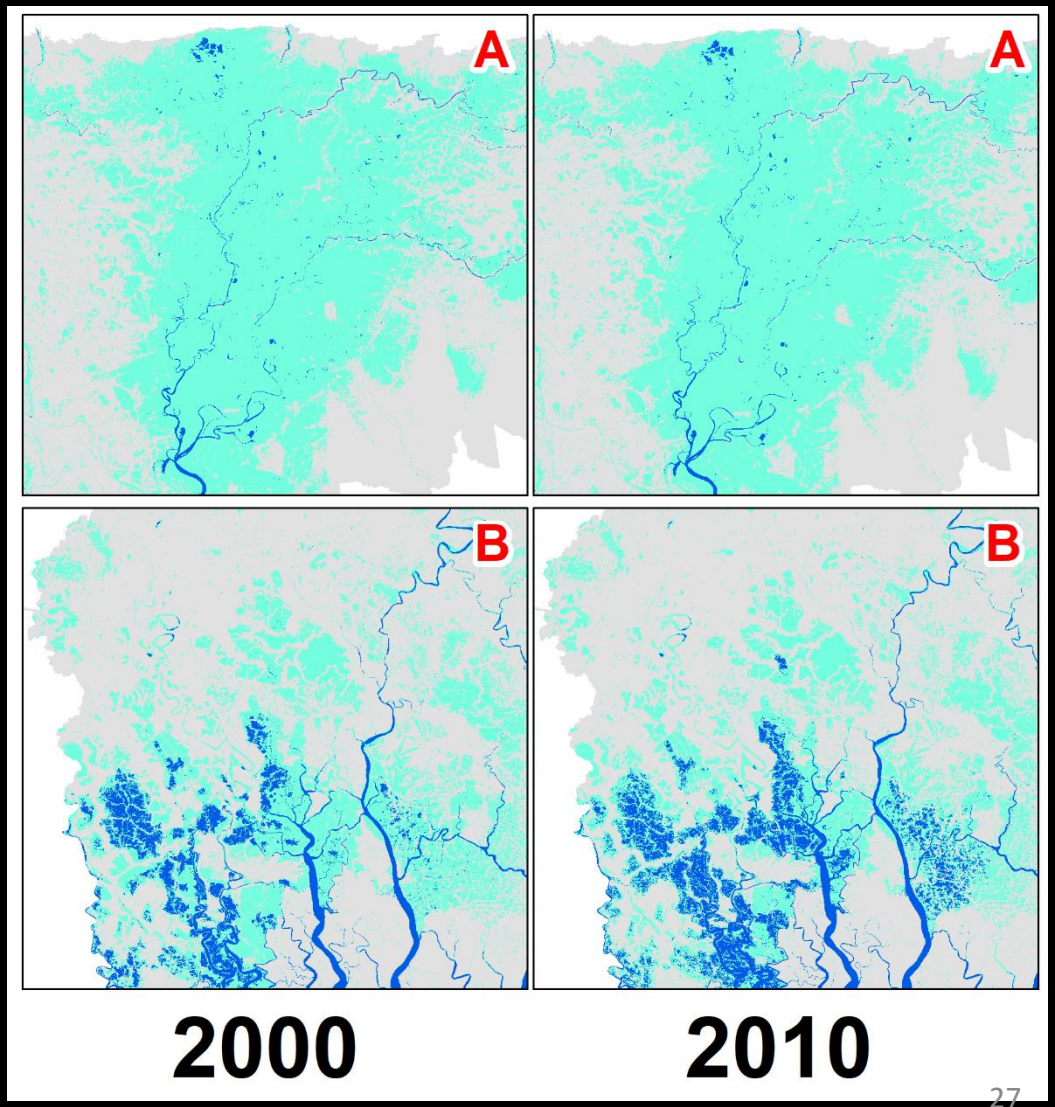
Water Seasonality in 2000 and 2010 Based on Global Surface Water Dataset



(Source: EC JRC/Google; Pekel *et al*, 2016)

Water Seasonality in 2000 and 2010 Based on Global Surface Water Dataset





(Source: EC JRC/Google; Pekel *et al*, 2016)

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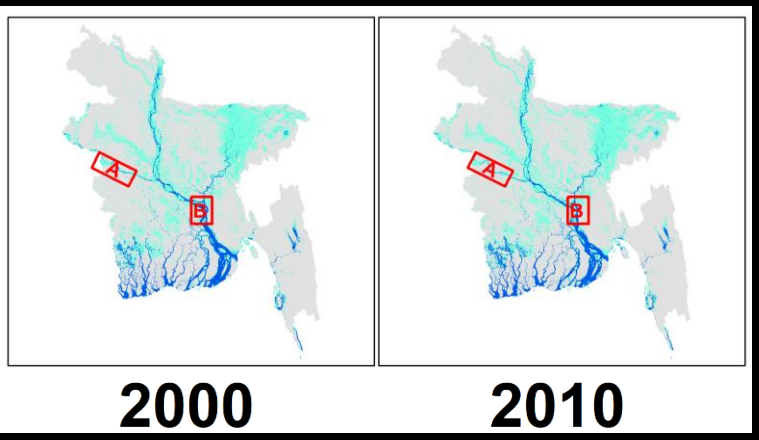
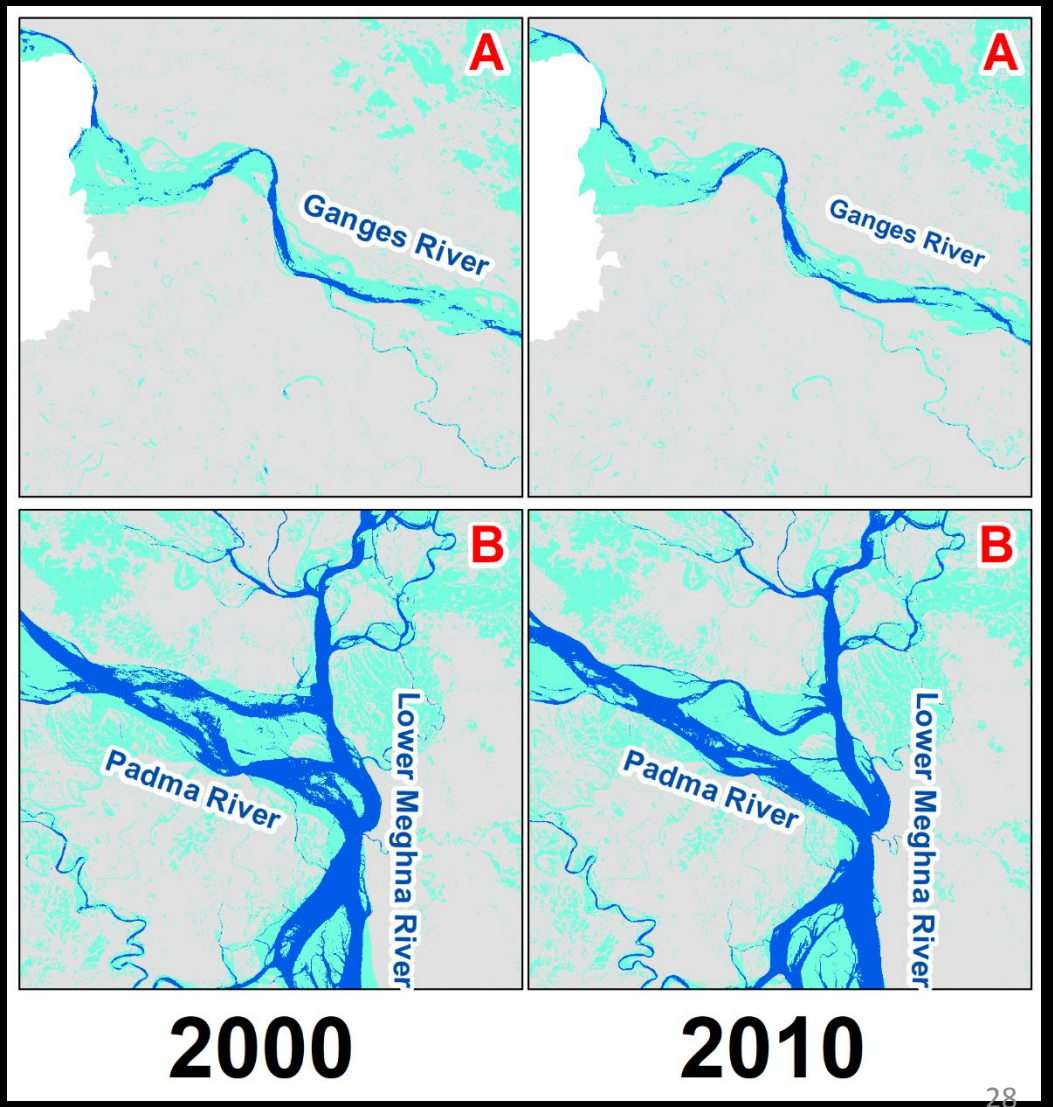
Water Seasonality in 2000 and 2010 Based on Global Surface Water Dataset





(Source: EC JRC/Google; Pekel *et al*, 2016)

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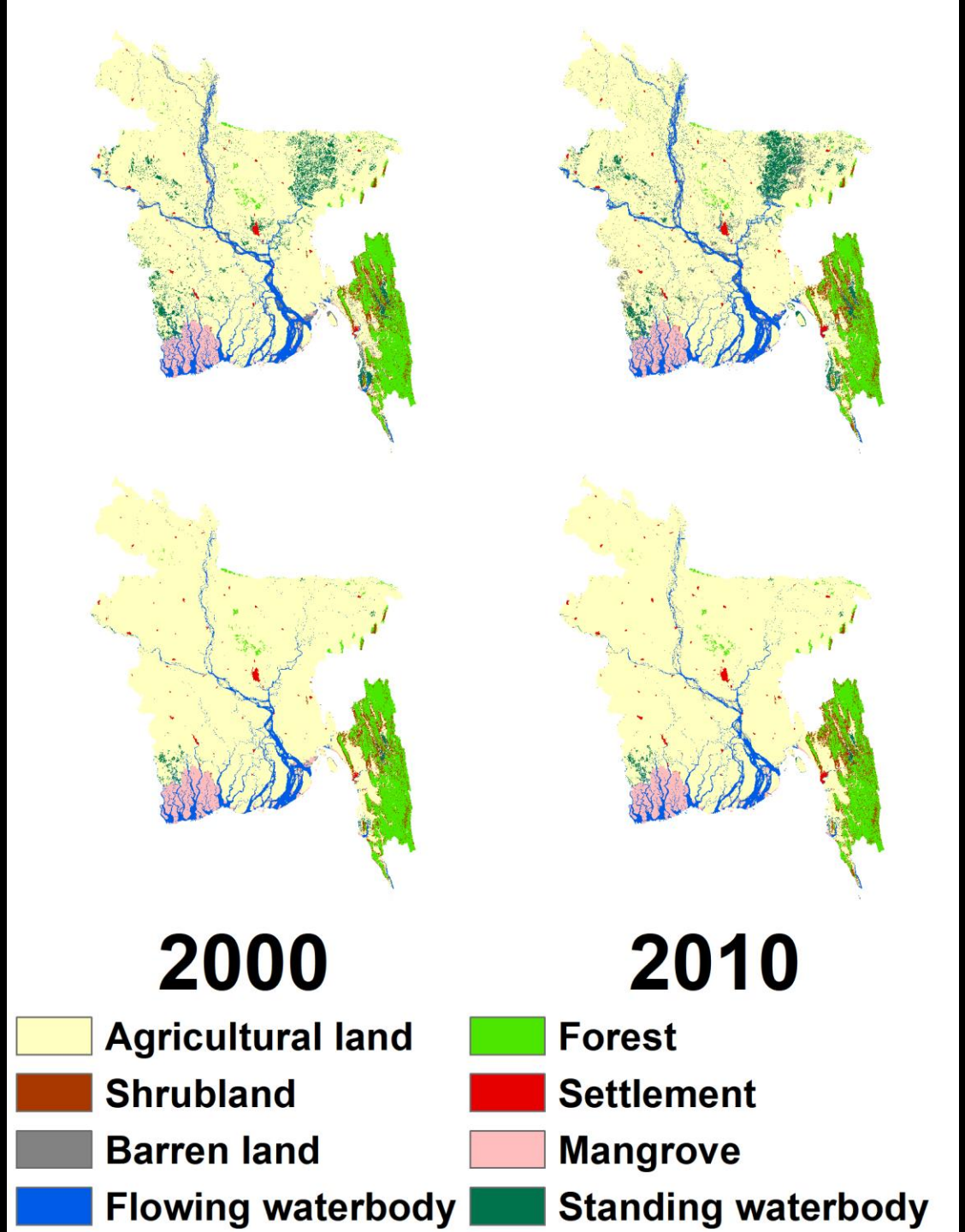
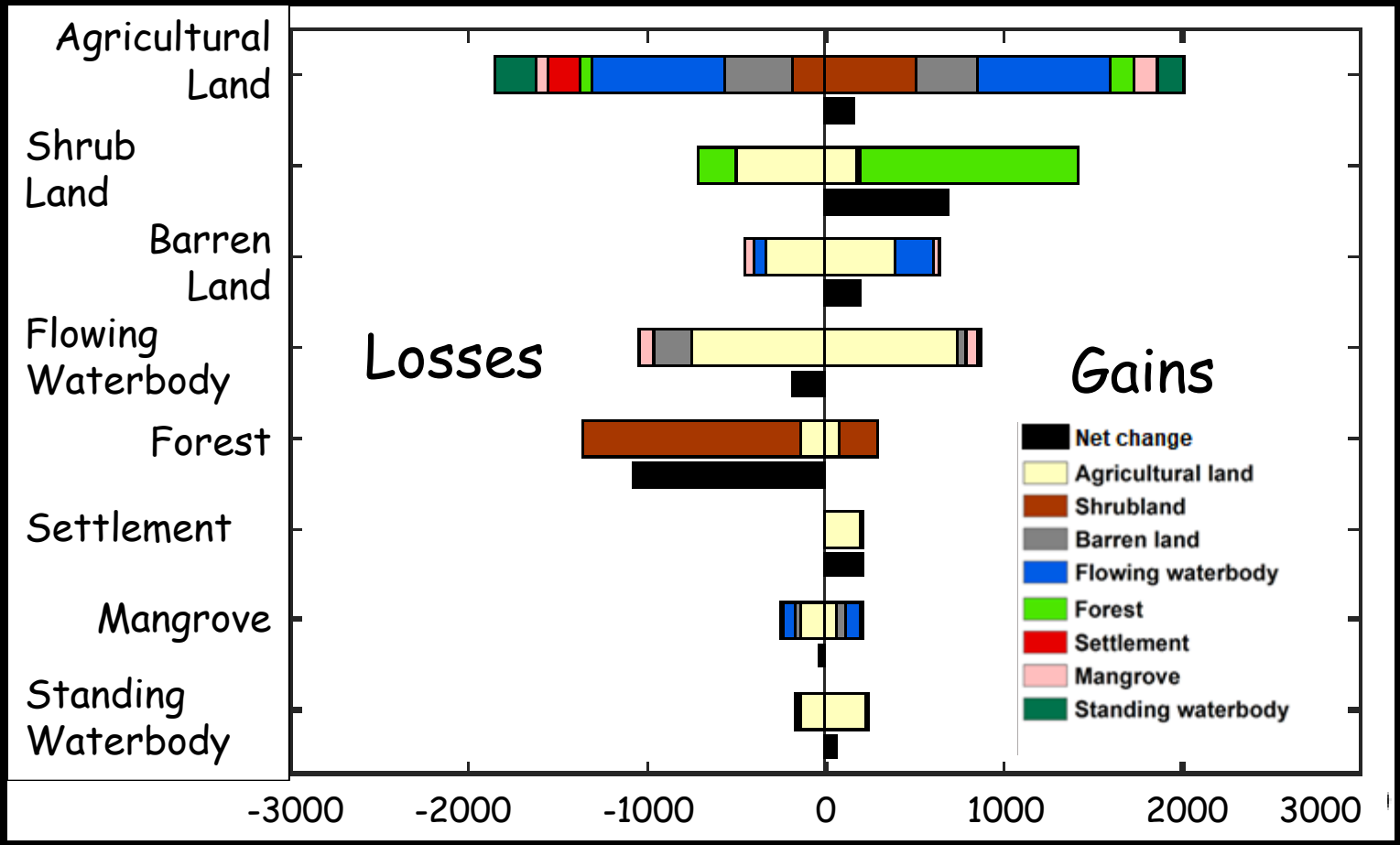


LULCC -
before accounting for
the Water Seasonality

LULCC -
after accounting for
the Water Seasonality

Xu *et al* (2018b)

LCLUC Change Area (km^2) between 2000 and 2010



Xu *et al* (2018b)

Drivers of LCLUC

From Agricultural Land to Standing Waterbodies

Distance to rivers

Urban household numbers

Distance to major cities

Increasing rate of urban household size

Populations

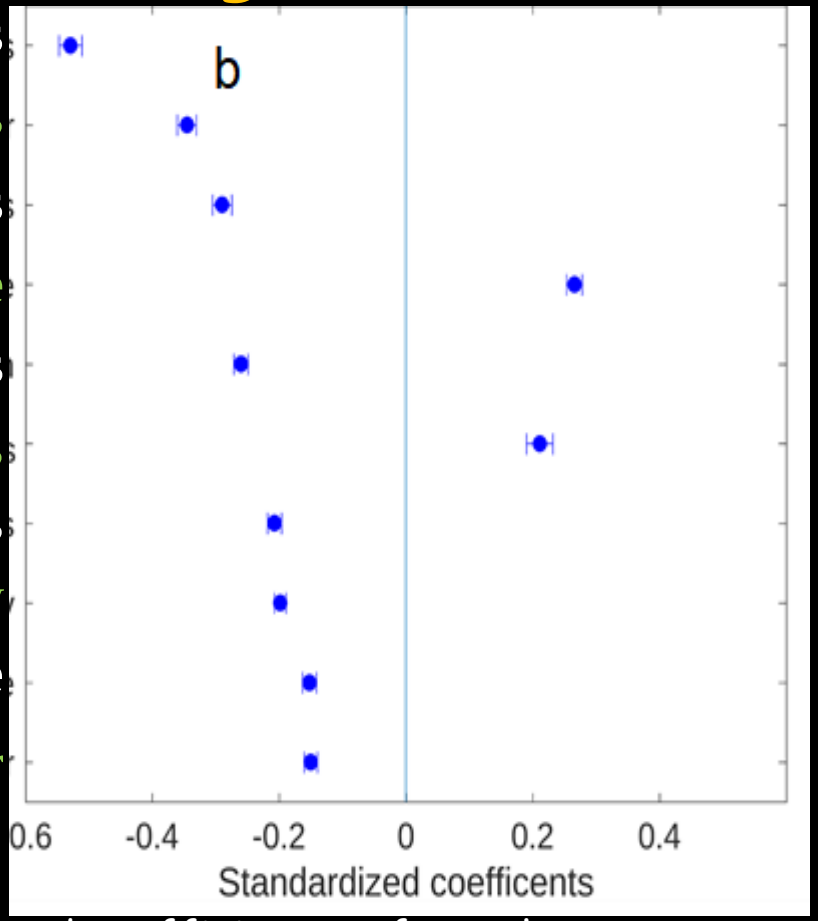
Distance to major highways and other major roads

Increasing rate of precipitation in monsoon months

Connection ratio of electricity

Increasing rate of rural household size

Rural household number



Standardized coefficients refer to how many standard deviations of dependent variable (LCLUC area) will change, per standard deviation change in the independent variable (drivers)

Xu *et al* (2018b)

Current and Future Directions

Objectives

- Improve the understanding of the impacts of LCLUC dynamics on the quantities and pathways of terrestrial carbon and nitrogen fluxes at various scales

Next Step Improve the projection of the impacts of climate change on agriculture and land use

How to link socio-economic and Earth System Model (ESM)?

Thank You