

**THE ROLE OF LAND-COVER
CHANGE IN MMSEA IN ALTERING
REGIONAL HYDROLOGICAL
PROCESSES UNDER A CHANGING
CLIMATE**

Participants, Affiliations & Project Roles

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Land Cover / Land Use

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Hydrological Field Observations

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Watershed-scale Modeling

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Regional-scale Climate Modeling



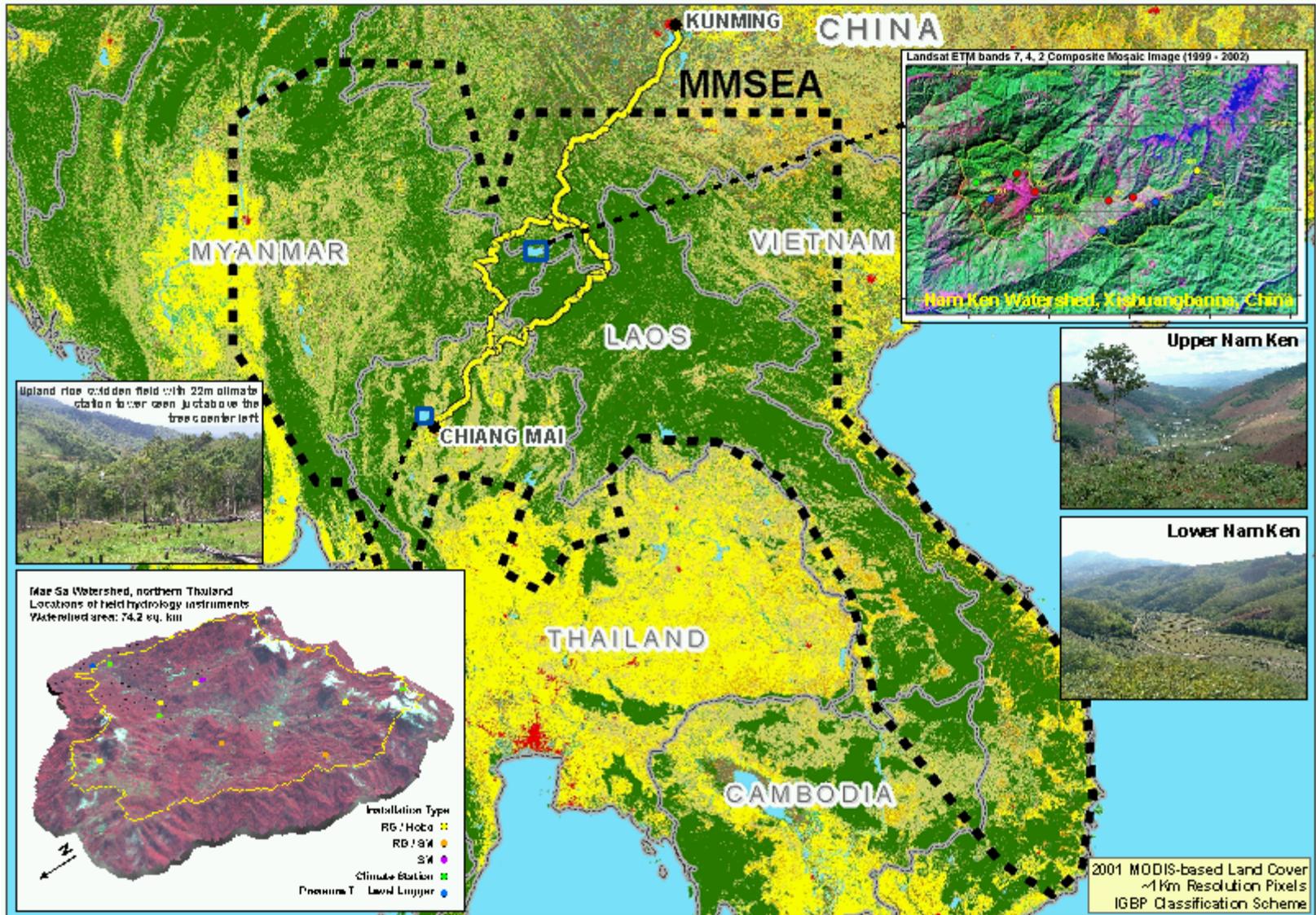
Istanbul Technical University 
since 1773 pioneer through the ages

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<http://research.eastwestcenter.org/mmsea/>

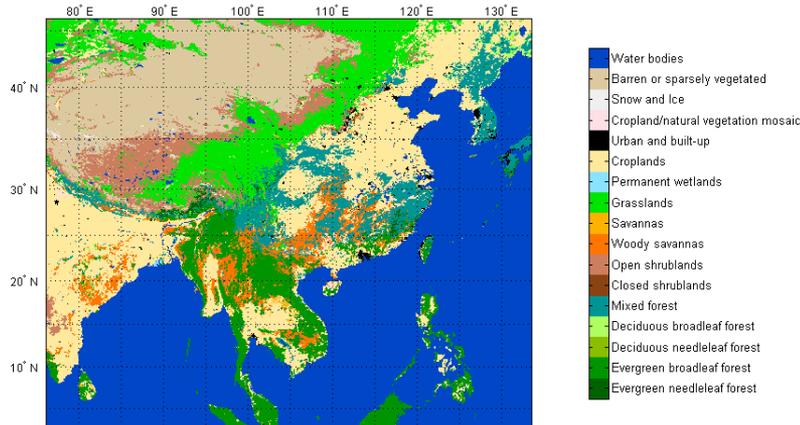
Major Project Goals and Progress (Research components are color-coded here and elsewhere on poster)

- 1) To **develop a comprehensive, high-resolution database** of recent and current land cover in MMSEA and to **develop scenarios and simulations of LCLUC** in the region to 2025 and 2050 to be used as data layers in a regional climate change model;
- 2) To make **field measurements** of key hydrological variables within **two representative watersheds** for the purposes of calibrating and validating hydrological and climatological models for the region;
- 3) To **model hydrological processes** within each study watershed to establish the role of land-cover change in altering watershed function.
- 4) To **simulate the climate and hydrology** of the greater East and SE Asia region under scenarios of land-cover and climatic change.
- 5) To use climate model output to drive simulations of the watershed model to **predict the effects of both land-cover and climatic change**, including feedbacks, on MMSEA hydrology.

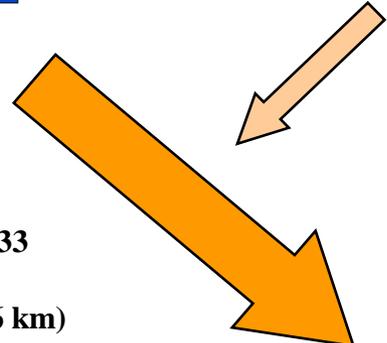
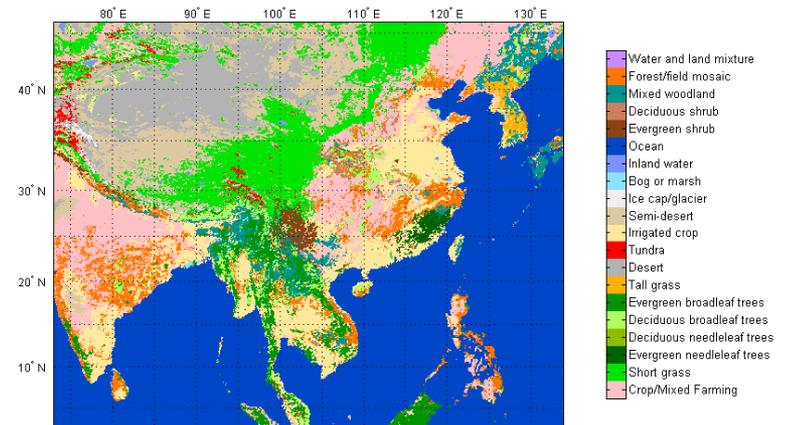


Land cover/vegetation map

MODIS-IGBP



AVHRR-BATS



- MODIS-IGBP obtained at 0.008333 degree
- Upscaled to 0.08333 degree (~9.26 km) using dominant landscape approach
- IGBP vegetation classes were then translated to corresponding BATS classes
 - Incorporated some attributes from AVHRR-BATS when MODIS-IGBP class was too broad (“Grassland” in IGBP could be translated to “Short grass” or “Tall grass” in BATS)

MODIS-BATS

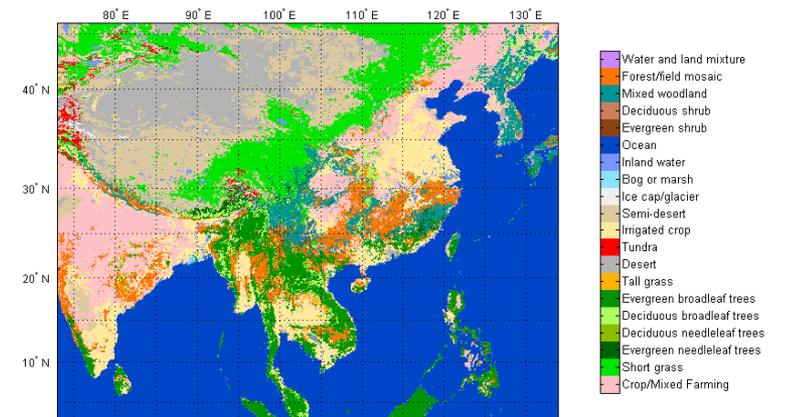




Figure 3. Baseline (2001), 16-class land-cover map for the MMSEA simulation region.

Spatial policies & restrictions

- Parks & protected areas
- Restricted areas
- Agricultural development zones

CHANGING LAND USE AND ITS EFFECTS

LCLU type-specific conversion settings

- Transition sequences (From-to matrix)
- Conversion elasticity (min and max t)

CLUE

LCLU change
allocation

LCLU requirements (demand)

scenarios

trends

advanced models

aggregate
lclu
demand

MMSEA REGIONAL LCLUC MODELING FRAMEWORK

Location characteristics

Lclu
specific
location
suitability

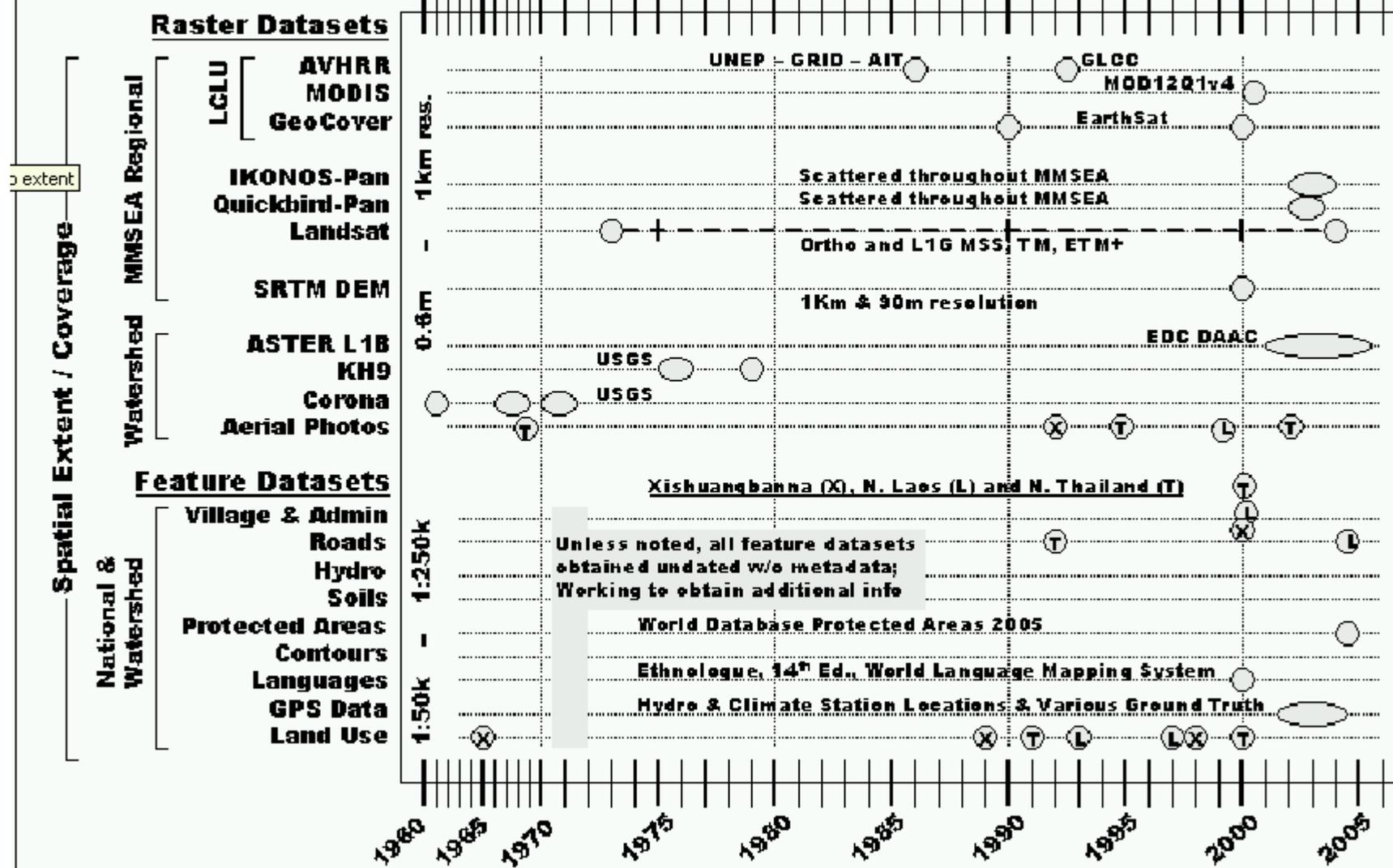
Logistic
regression

Location
factors :

soil, access,
topography,
bioclimate,
demography,
socio-economic,
etc.

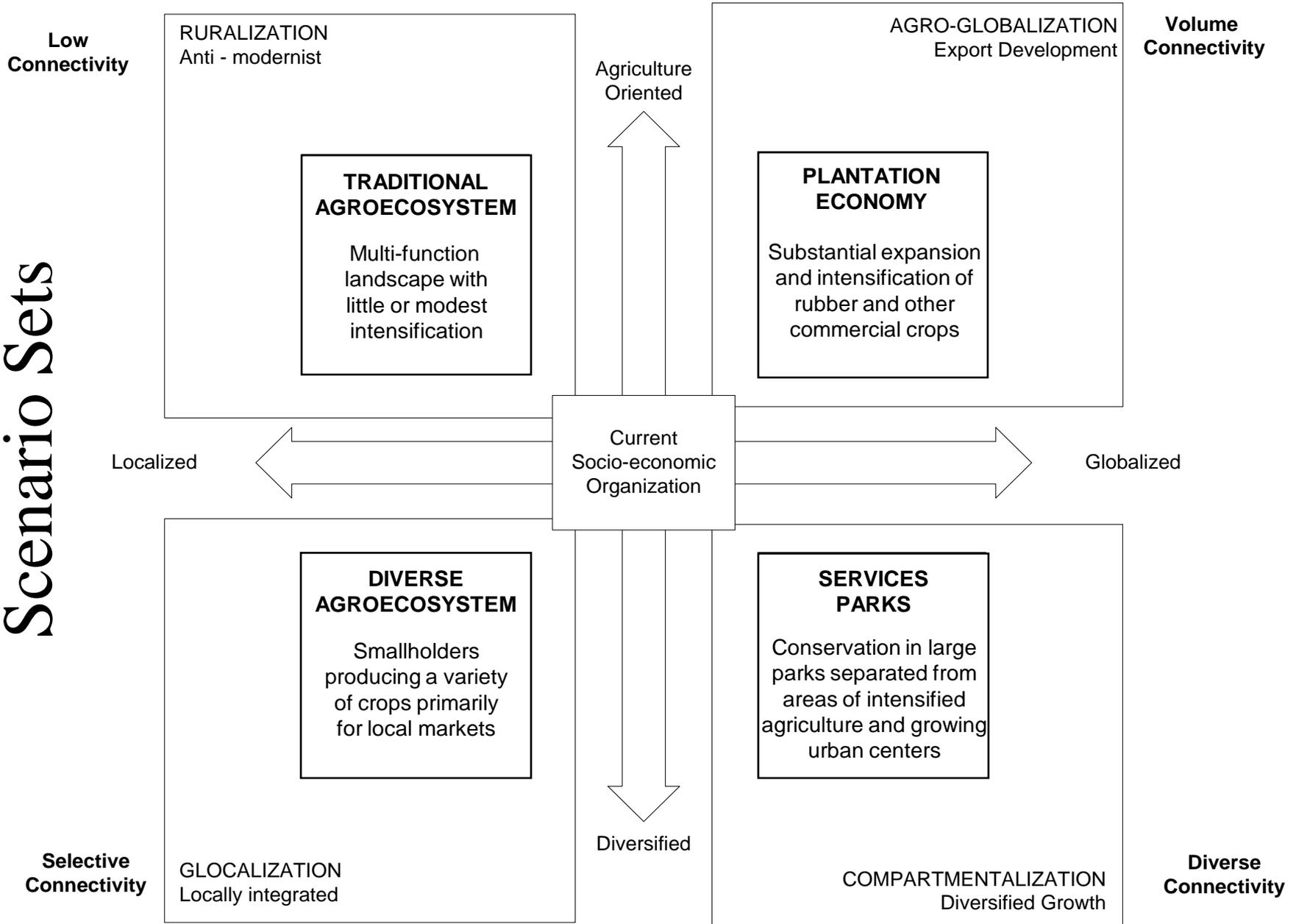
Source: The CLUE Group, Wageningen University, Netherlands, website: <http://www.dow.wageningen-ur.nl/clue/>

NASA / NSF Projects Geospatial Database



<http://research.eastwestcenter.org/mmsea/data.htm>

Scenario Sets



Scenario sets can be logically defined by combination of key axes of uncertainties



Lowland Zone: Khon Muang (Northern Thai)

Paddy Rice



Home Gardens



Upland
Field Crops



Paddy
Field Crops



Paddy
Vegetables



Number of experts interviewed and areas of expertise

Country	No. of experts	Areas of expertise
Cambodia	1	International academic
Laos	3	Local academic (2), international academic (1)
Myanmar	1	International academic
Thailand	13	Local academic (3), international academic (4), politician (2), land-use manager (1), farmer (1)
Vietnam	3	Local academic (2), international academic (1)
Yunnan	5	Local academic (3), international academic (2)

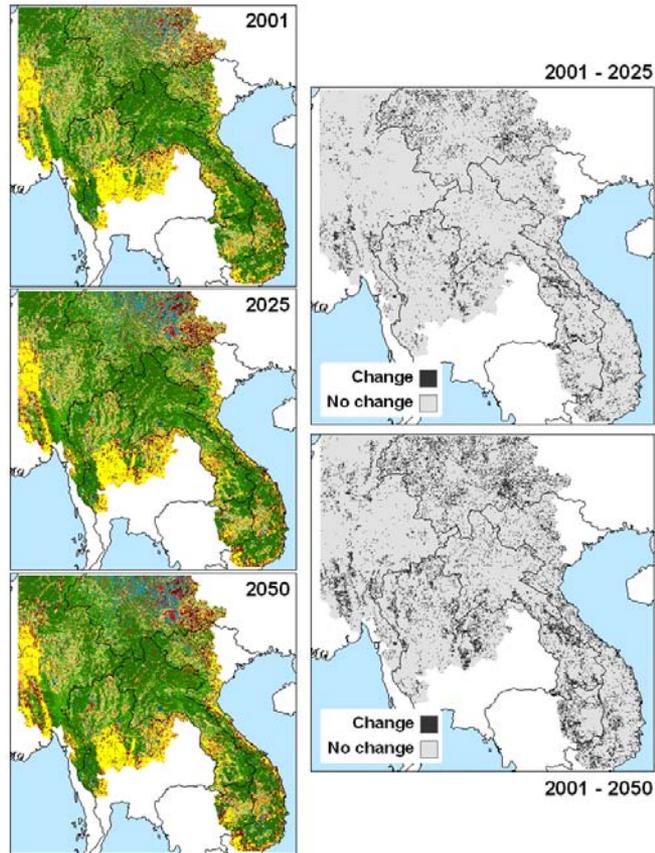
Cumulative land-cover change in terms of area (sq. km.) and percent calculated in 5 year increments over the 25 and 50 year periods.

Country	Total upland area (sq. km)	2001-2025		2001-2050	
		Cumulative area change (sq. km)	Cumulative % change	Cumulative area change (sq. km)	Cumulative % change
Cambodia	59,579	6,142	10.31	14,963	25.11
Laos	283,363	26,589	9.38	40,982	14.46
Myanmar	462,495	27,096	5.86	44,819	9.69
Thailand	303,093	28,583	9.43	50,032	16.51
Vietnam	285,271	33,954	11.90	54,694	19.17
Yunnan	337,532	49,189	14.57	78,560	23.27
MMSEA	1,731,333	171,553	9.91	284,050	16.41

MMSEA Land Cover / Land Use Simulations

- Overall MMSEA Results Increase Decrease

Model Land Cover	% 2000	% 2050	% Change
Crops + Grass	12.38	14.81	2.43
Irrigated Crops	9.5	10.11	0.61
Shrubs	2.91	4.6	1.69
Deciduous Forest	12.82	15.28	2.46
Evergreen Forest	36.58	32.85	-3.73
Mixed Forest/ Mosaic	22.99	18.19	-4.8



Baseline land-cover map (2001), simulation output maps for years 2025 and 2050, and maps showing areas of change/no change for 2001-2025 and 2001-2050 time periods.



Tea



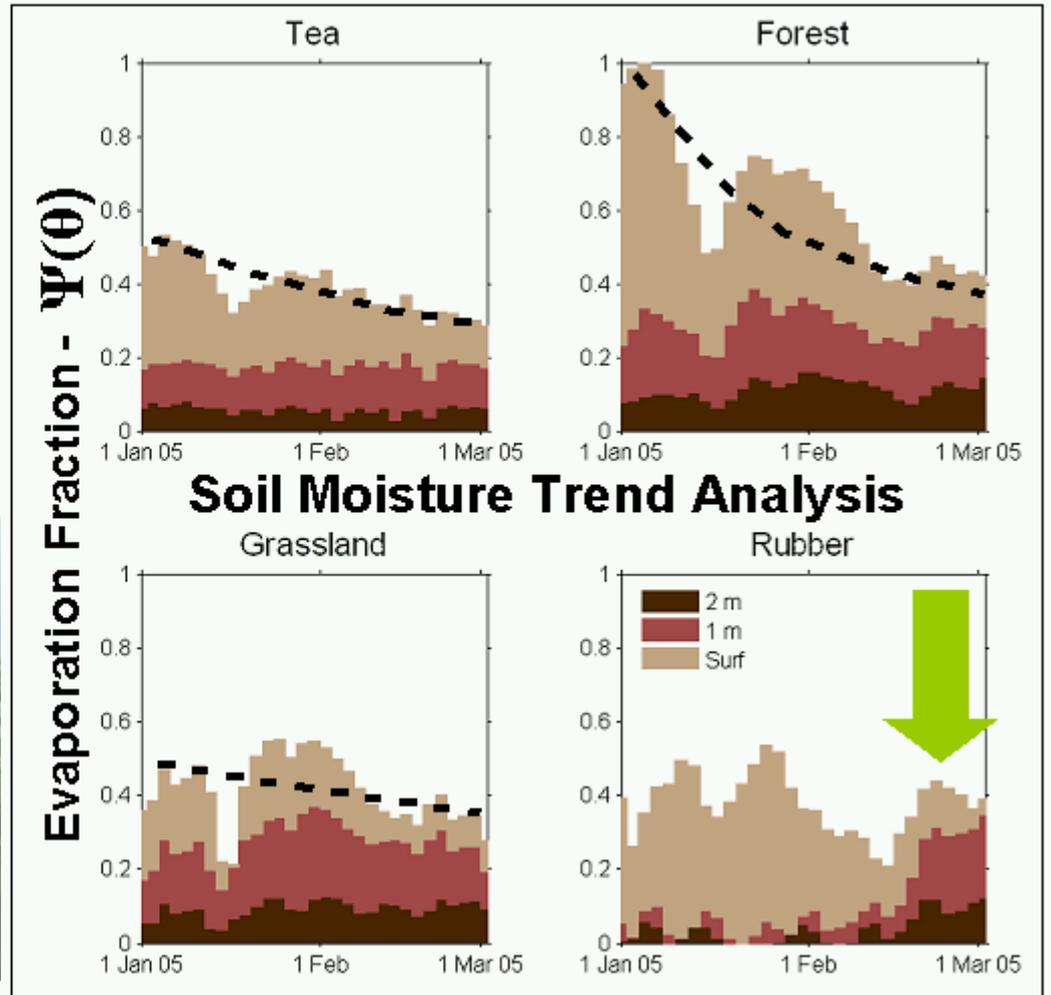
2^{ary} Forest



Grassland



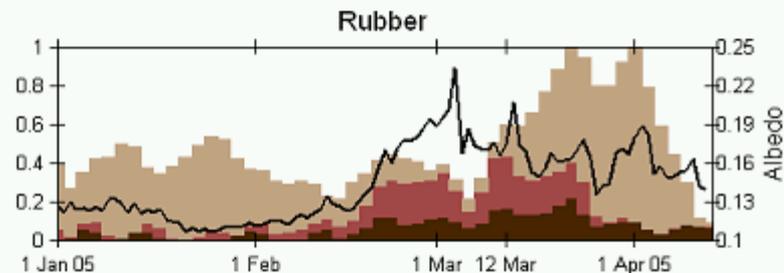
Rubber



Why Root-water uptake during shedding?



Rubber



NOV - DEC - JAN - FEB - MAR - APR - MAY

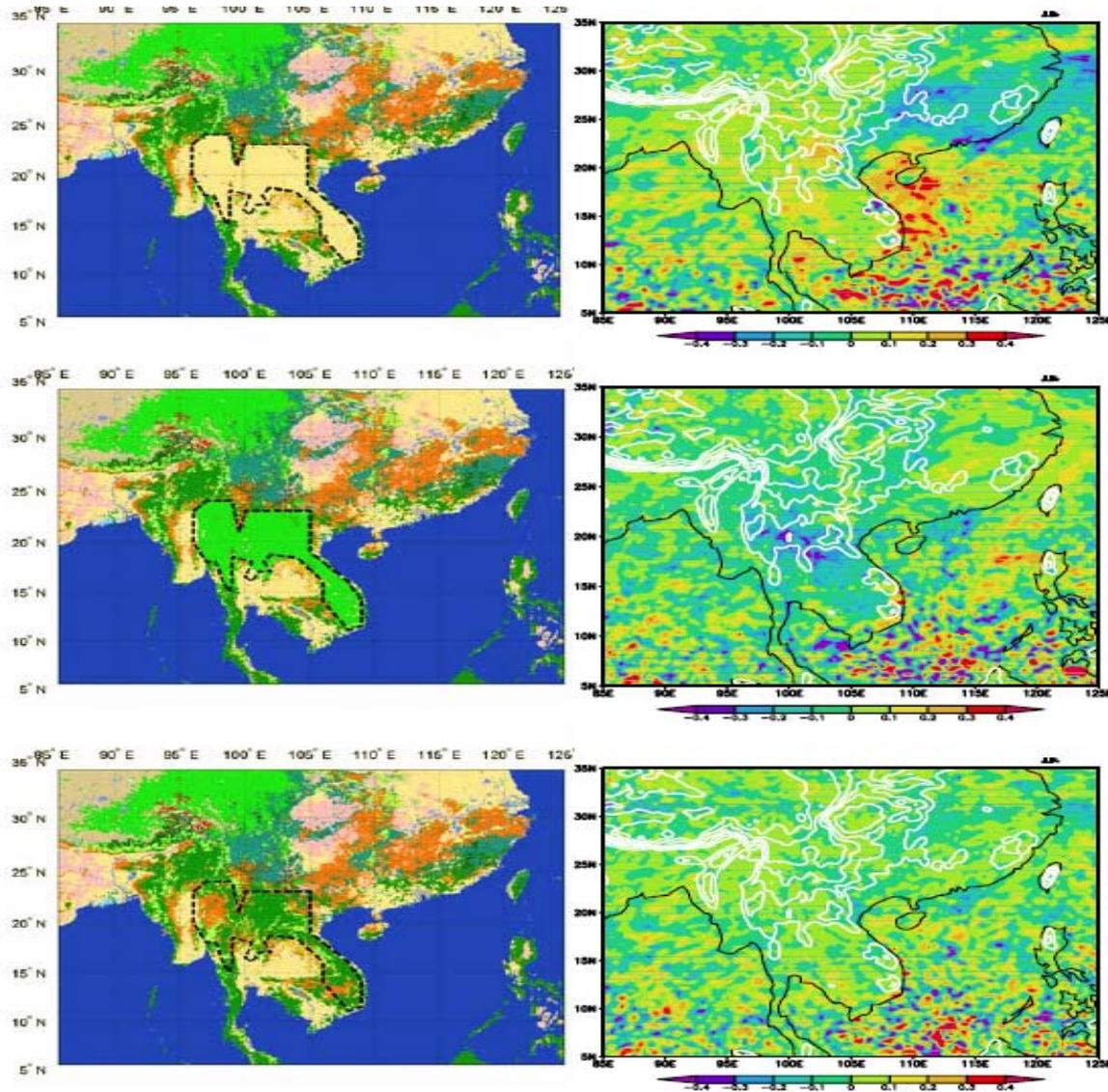
Leaf flushing during the dry season:

- 1) New leaves during hottest & driest season
- 2) Trees rely heavily on subsurface water
- 3) Climate is not the primary control of phenology, but rather Day Length

Climate Simulations

- Regional climate model (RegCM3)
International Centre for Theoretical Physics in Italy
- Modeled LCLUC in MMSEA using
 - Control simulations, present LCLU (2001) MMSEA
 - LCLU replaced with irrigated crop
 - LCLU replaced with short grass
 - MMSEA's projected 2050 LCLU

Perturbed LCLU maps (left side) and relative changes in regional precipitation (right side)

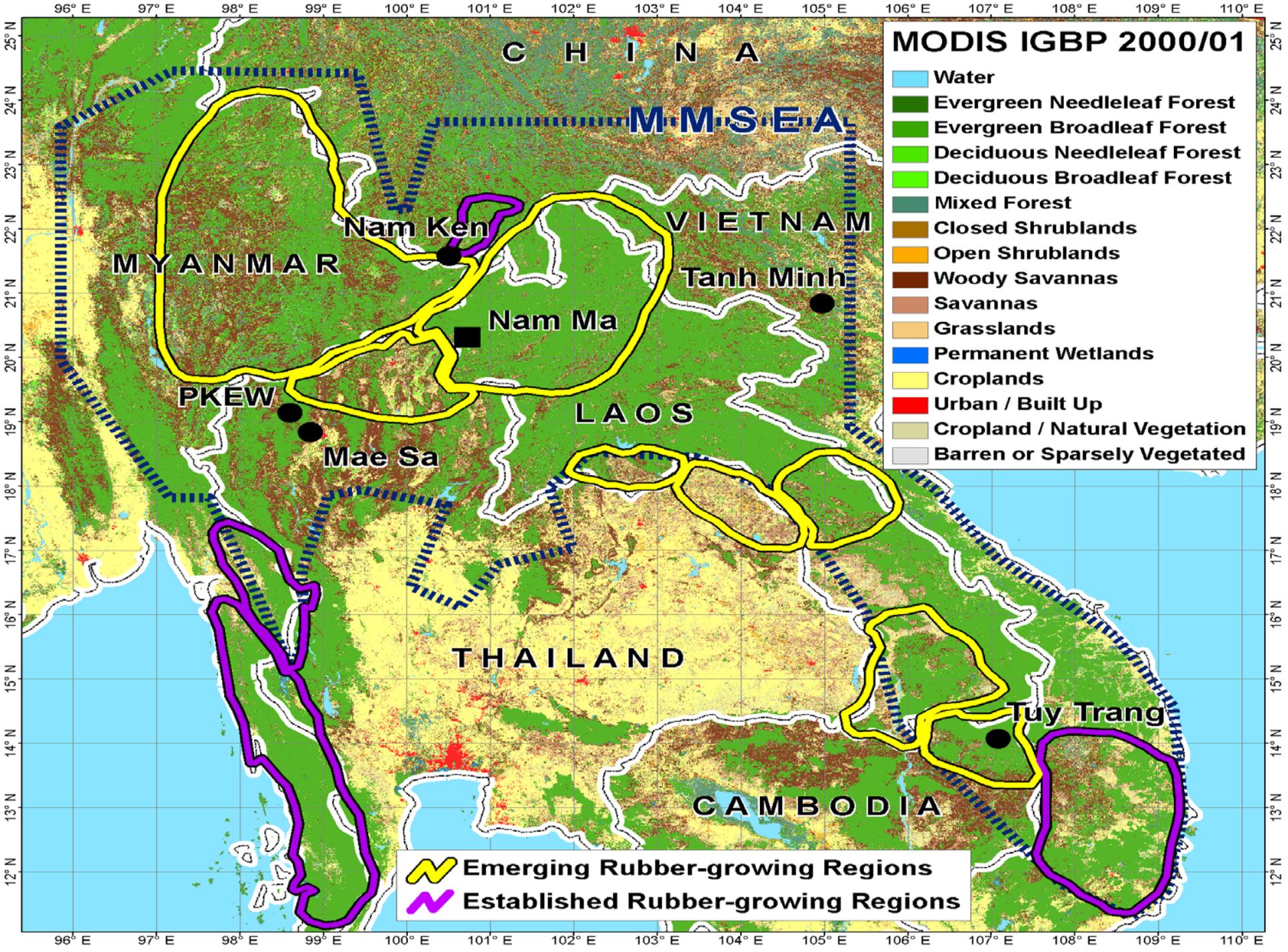


Regional scale results

- Projected LCLUC to 2050
Evergreen broadleaf trees → Deciduous broadleaf trees
(Forest → Rubber and Cashews)
- Under 2050 LCLU scenario → changes in precipitation over MMSEA, the Indochina Peninsula, and eastern China are usually less than 10%.
- Global warming-related effects will have a greater impact on precipitation than our predicted 16.41% changes in land cover.

The Expansion of Rubber and its Implications for Water and Carbon Dynamics in Montane Mainland Southeast Asia





Project Objectives

- Where is rubber being planted in the region and what are current and predicted patterns of this expansion in relation to other land-cover types?
- What are the diurnal, seasonal, and interannual patterns in energy exchange, evapotranspiration, net ecosystem exchange of carbon, and aboveground net primary productivity for rubber and the principal vegetation types being replaced by rubber?
- How does the unique phenological behavior of rubber influence the timing and rates of water flows through affected watersheds and carbon exchange and sequestration?
- How will the expansion of rubber and related land-use change alter the region-wide storage of carbon?
- How will climate change interact with rubber-related land-cover/land-use change (LCLUC) to alter the regional stocks and fluxes of carbon and water over the next 50 years?

Methods

- Map and Model Emerging Rubber-growing Regions
- Use the Ecosystem Demography (ED) model to simulate ecological processes, including leaf-level physiological processes (such as photosynthesis, respiration, and ET), individual-based vegetation dynamics (growth, allocation, mortality, phenology, and reproduction), landscape-scale disturbance events (fire, wind-throw), and belowground decomposition and soil hydrology.

Methods

ED Model Experiments

- To examine the impact of rubber expansion, other LCLUC, and climate change on water and carbon dynamics, we will use ED to conduct the following four experiments:
 - current rubber and land use (2000), current climate (2000);
 - projected rubber and land use (2001-2050), current climate (2001-2050);
 - current rubber and land use (2001-2050), projected climate (2001-2050);
 - projected rubber and land use (2001-2050), projected climate (2001-2050).
- We will investigate the marginal effects of a) rubber expansion and other LCLUC, b) climate change, and c) the combined effects of both on regional carbon and water dynamics by comparing experiment 4 against 3, 2, and 1, respectively.

Field Observations

- The model will include six major plant functional types (PFTs): early-, mid-, and late-successional broadleaf woody vegetation (excluding rubber), grass/shrub, crop, and rubber.
- Ground-based lidar will be used to measure vegetation attributes such as height, DBH, structural biomass, leaf biomass for each PFT. We will estimate the leaf area index (LAI) using a pair of LAI-2000 plant canopy analyzers. Sapwood area will be estimated using a variety of methods. These various measurements will be used to derive allometric relationships needed to parameterize the growth and allocation sub-models.

- The water and carbon exchange characteristics of early-, mid-, successional broadleaf woody vegetation (excluding rubber), grass/shrub, and rubber are not well understood.
- We will confine our observations of water and carbon fluxes and related processes to those four vegetation groups
- We will establish four eddy covariance tower sites near.
- A permanent tower over rubber will be monitored continuously throughout the study period.
- In addition, three nearby sites, each dominated by a different key PFT, will be monitored sequentially using a second, mobile, instrument set.
- The mobile instrument set will be moved among the three sites every six months, scheduled to allow adequate dry and wet season monitoring at all three sites. Situated in a broad elevated plain, with relatively large contiguous areas of rubber cultivation, and various types of successional vegetation and grass/shrub cover.