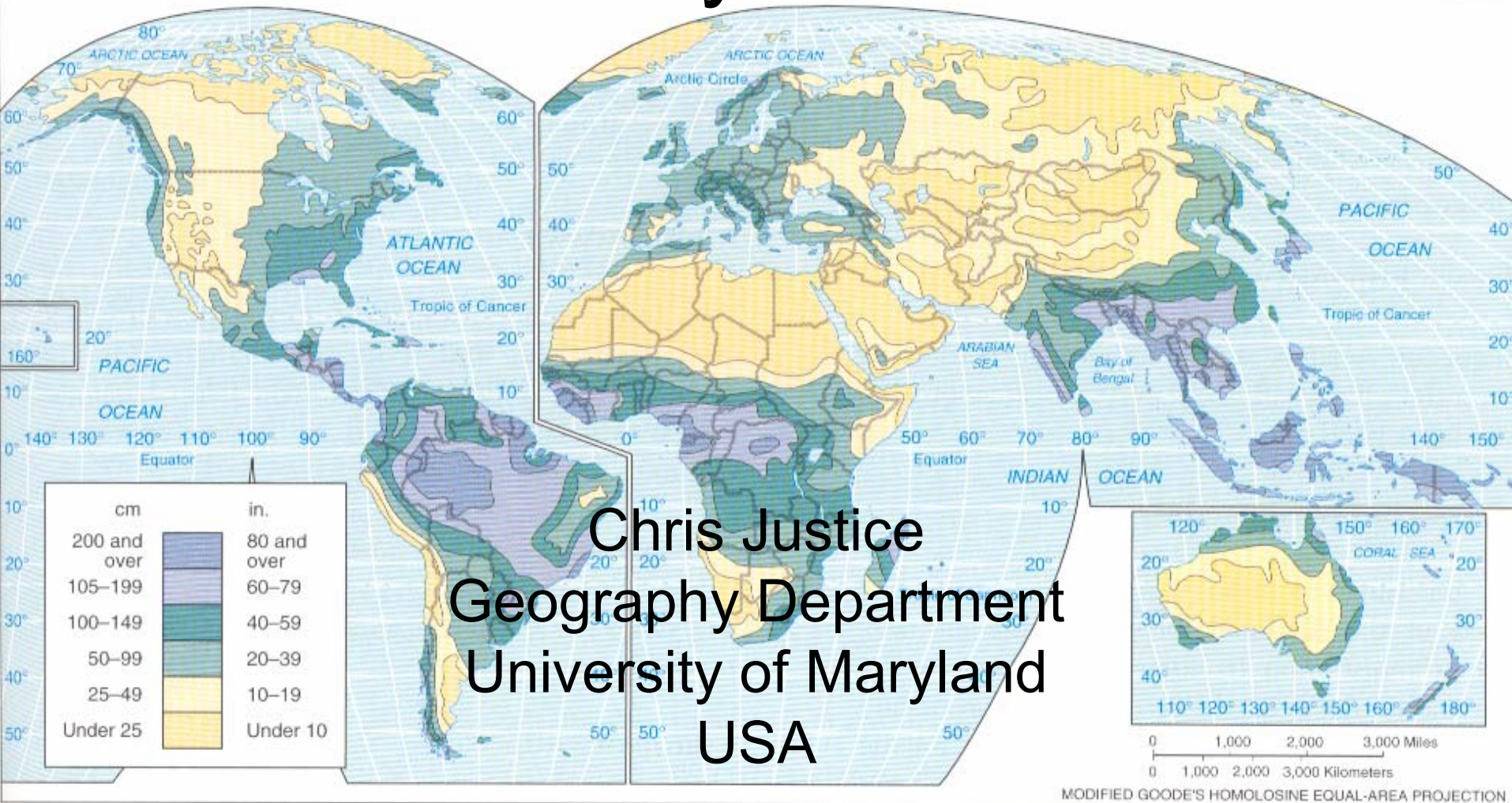


# The NASA LCLUC Program and the Drylands Focus

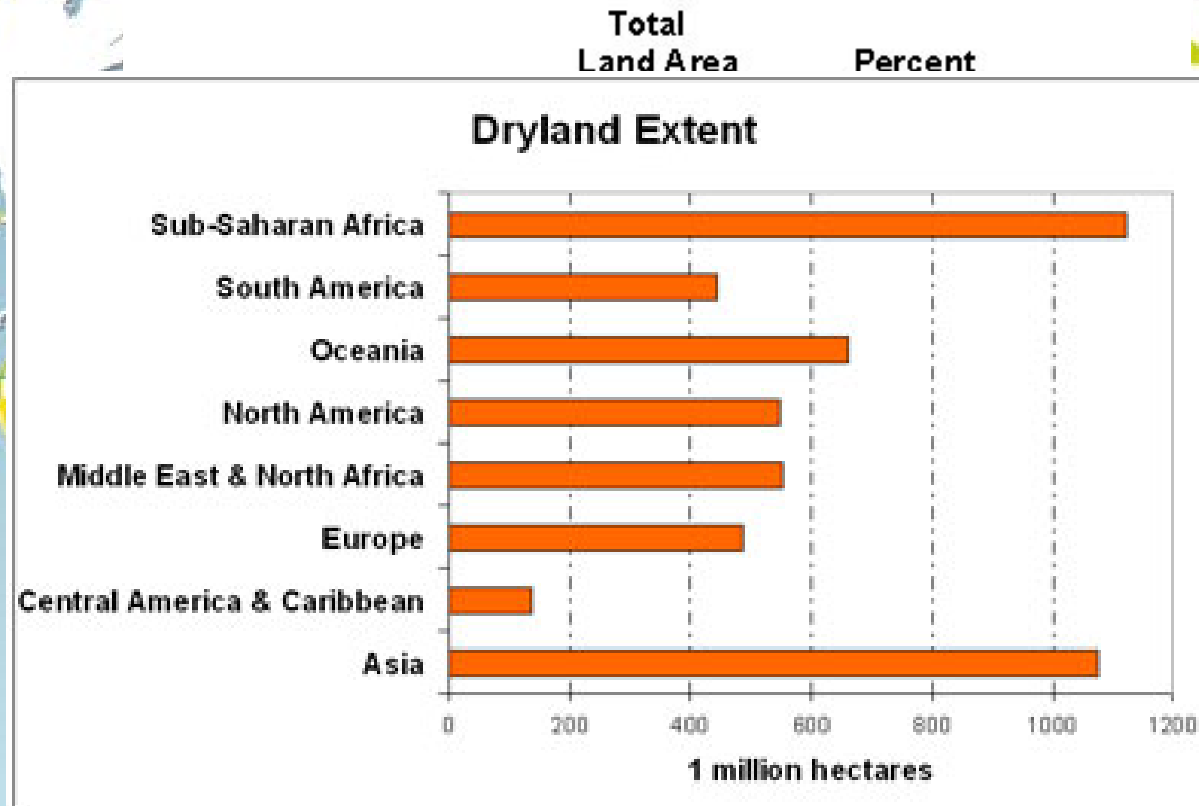


# Drylands

- The worlds drylands are home to 1/3 of the Worlds population
- Drylands cover 40% of the Worlds land area
  - Dominant land uses - farming and livestock
  - Increasing urban areas
- Competition for water resources – irrigation, agriculture, urban areas,
- Drylands subject to drought
  - 1 billion people in 110 countries are threatened by drought – recent droughts in Mongolia, Australia, Southern Africa, US
- Dryland ecosystems important biodiversity

# Drylands Distribution

Table 3: Countries with Over 90 Percent Dryland



## Dryland Systems

-  Hyper-arid
-  Arid
-  Semiarid
-  Dry subhumid

## Sources:

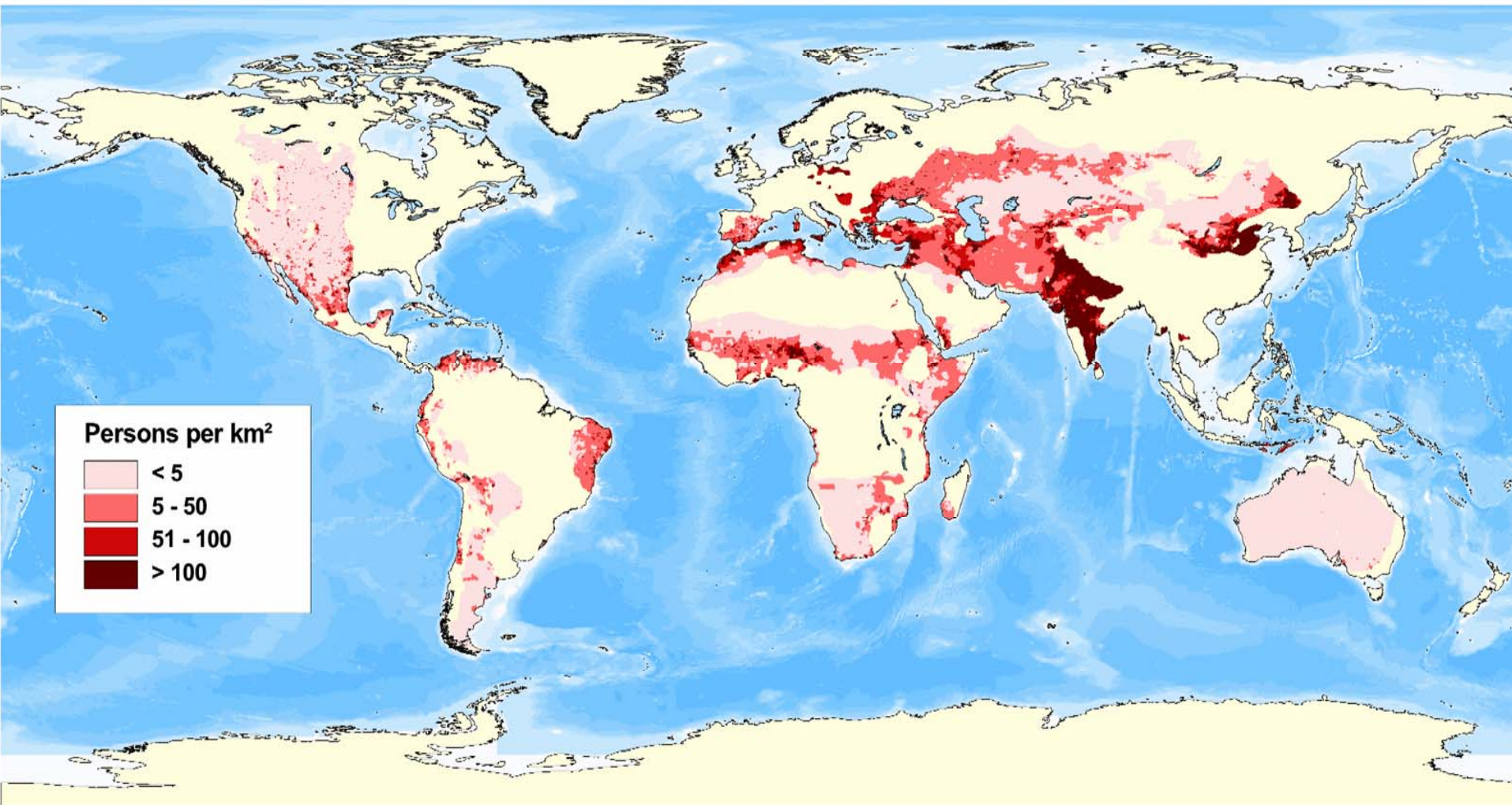
WRI calculations based on ESRI 1993 and UNEP/GRID 1991.

Source: Millennium Ecosystem Assessment

in percent of the global population

Drylands are home to 34.7 % of the global population in 2000

# Population Density In Drylands



40% of the Worlds Poorest Countries Consist Mostly of Drylands



# Climate Change in the Region

- IPCC WG 2 Report - Central Asia
  - Glaciers are melting
  - Freshwater availability will decrease due to climate change, population growth and increased living standards
  - Crop yields could decrease by 30% by 2050
  - Climate change will impinge on sustainable development as it compounds the pressure on natural resources and the environment associated with rapid urbanization, industrialization and economic development



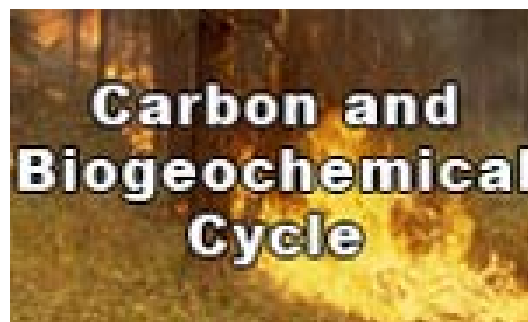
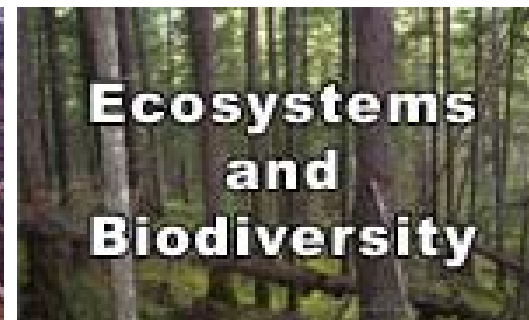
# NASA Land Cover and Land Use Change



- LCLUC is an interdisciplinary scientific theme within NASA's Earth Science Enterprise (ESE). The ultimate vision of this program is to:
  - **develop the capability to perform repeated global inventories of land-use and land-cover from space, to develop the scientific understanding and models necessary to simulate the processes taking place, and evaluate the consequences of observed and predicted changes.**
  - **further our understanding of the consequences of land-use and land-cover changes on environmental goods and services, the carbon and water cycles and providing the science underpinning for improved management of natural resources**
  - **improve understanding of human interaction with the environment, and thus provide a scientific foundation for sustainability, vulnerability and resilience of land systems and their use.**
- <http://lcluc.gsfc.nasa.gov/>

# LCLUC Science and Related Themes

A Competitively Funded Research







# NASA LCLUC Program Elements

<ul style="list-style-type: none"><li>• <b>Processes of Change</b><ul style="list-style-type: none"><li>– <b>Climate and Ecological Drivers</b></li><li>– <b>Socioeconomic Drivers</b></li></ul></li></ul>	<ul style="list-style-type: none"><li>• <b>Technique Development</b><ul style="list-style-type: none"><li>– <b>Remote Sensing R and D</b></li><li>– <b>In-situ data collection - surveys / validation / process studies</b></li><li>– <b>Data Management</b></li></ul></li></ul>
<ul style="list-style-type: none"><li>• <b>Responses and Consequences</b><ul style="list-style-type: none"><li>– <b>Land cover conversion, abandonment</b></li><li>– <b>Land use intensification</b></li><li>– <b>Land degradation</b></li><li>– <b>Landscape fragmentation</b></li></ul></li></ul>	<ul style="list-style-type: none"><li>• <b>Satellite Observations</b><ul style="list-style-type: none"><li>– <b>Long - term measurements</b><ul style="list-style-type: none"><li>• Landsat series L7&gt; LDCM</li><li>• AVHRR.&gt;MODIS&gt; NPP (VIIRS)</li></ul></li><li>– <b>Experimental missions</b><ul style="list-style-type: none"><li>• EO-1 – hyperspectral</li><li>• MISR – directional</li><li>• ASTER – thermal</li><li>• GLAS</li></ul></li><li>– <b>Commercial fine resolution</b><ul style="list-style-type: none"><li>• Ikonos, Quickbird</li></ul></li></ul></li></ul>
<ul style="list-style-type: none"><li>• <b>LU Modeling and Feedbacks</b><ul style="list-style-type: none"><li>– <b>LCLUC modeling projections</b></li><li>– <b>Coupled modeling of LCLUC with biogeochemical and water cycles</b></li><li>– <b>Modeling land -atmosphere interactions</b></li><li>– <b>Climate impacts on land use</b></li></ul></li></ul>	

# LCLUC Component 1

- **Regional Case Studies of LU Change addressing LU Science Questions**
- **Engage with Regional Science Partners**
  - Observe the changes (satellite and ground based)
    - Rates of change
    - Characteristics of the changes
  - Understand the processes (drivers/causes)
    - Physical
    - Socioeconomic
    - Local and External
  - Understand the impacts / consequences of change
  - Develop Predictive Models of LU
    - Process Driven
    - Understand couplings and feedback

# **EXAMPLE of Currently Funded REGIONAL LCLUC DRYLANDS CASE STUDIES**

- Effects of Land Use Change on the Energy and Water Balance of the Semi-Arid Region of Inner Mongolia
  - Jiquan Chen, University of Toledo, Funded 2005-2008
- Quantifying Changes in Carbon Pools with Shrub Invasion of Desert Grasslands Using Multi-Angle Data from EOS Terra and Aqua
  - Mark Chopping, Montclair State University, Funded 2004–2007
- Interactions of Edaphic and Land Use Factors on Water Budgets in Cerrado and Semi-Arid Caatinga Region of Brazil
  - Eric Davidson, Woods Hole Research Center, Funded 2006-2009
- Regional Hydrologic Response of Semi-Arid Mediterranean Climate Watersheds to Land-Cover/Land-Use Variability: Predictive Models Based on MODIS Products
  - Allen Hope, San Diego State University, Funded 2005-2008

NB. Previous LCLUC Drylands Projects in Southern Africa, Mexico and SW US

# Effects of Land Use Change on the Energy and Water Balance of the Semi- Arid Region of Inner Mongolia

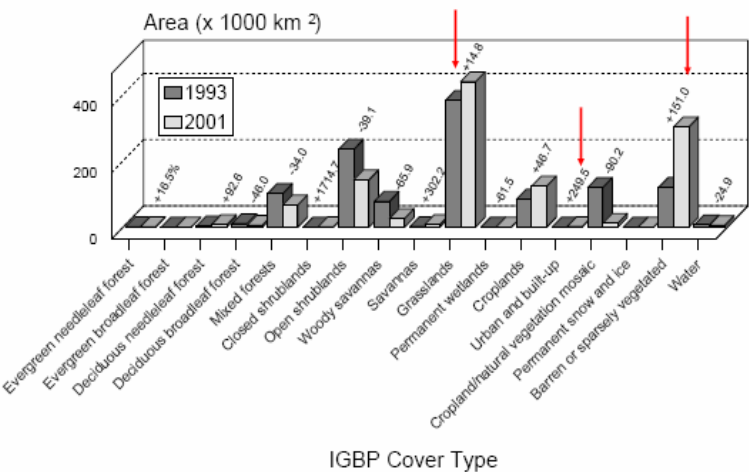
Jiquan Chen, University of Toledo

Funded 2005-2008

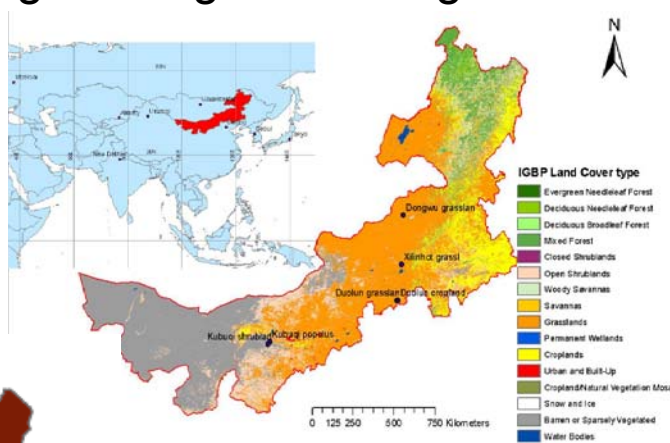
# Objectives

- Mechanistically explain the variability of energy ( $R_n$ ,  $L$ ,  $G$ ,  $Q$ ,  $H$ ,  $T$ ) and water ( $ET$ ,  $E$ ,  $EF$ ,  $Tr$ ,  $LWSI$ ,  $W_{leaf}$ ,  $M$ ) fluxes along a climatic and land use gradient using a network of in situ eddy flux towers at 9 representative ecosystems
- Partition whole ecosystem  $ET$  into evaporation and transpiration components based on stable isotope composition ( $\delta^{18}O$ ,  $\delta H$ , and  $\delta^{13}C$ ) of different water pools
- Develop and validate MODIS-based models water fluxes
- Evaluate and improve SiB model for regional simulations of water and energy fluxes at multiple spatial and temporal scales

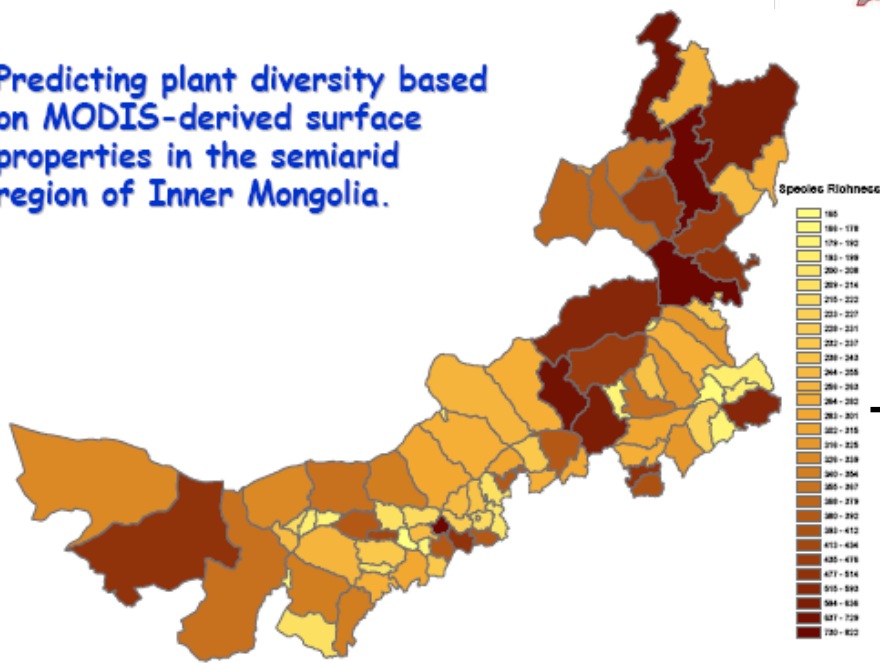
# Results



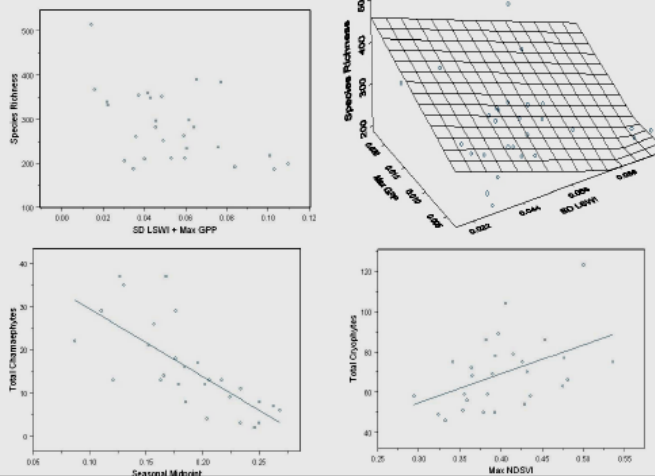
Land cover change between 1993 and 2001 in Inner Mongolia. The numbers are net percent change with negative sign indicating a decrease



Predicting plant diversity based on MODIS-derived surface properties in the semiarid region of Inner Mongolia.



Empirical relationship between species richness & MODIS products



Quantifying Changes in Carbon Pools  
with Shrub Invasion of Desert  
Grasslands Using Multi-Angle Data from  
EOS Terra and Aqua

Mark Chopping, Montclair State University  
Funded 2004–2007

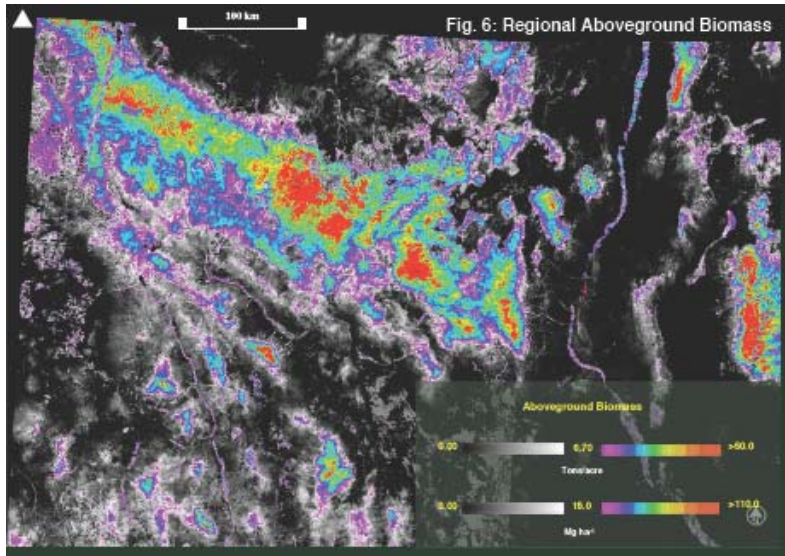
# Objectives

- Quantify changes in carbon pools with shrub invasion of desert grasslands
- Map aboveground biomass, canopy height, and crown cover in Southwestern U.S. forests, shrublands and shrub-invaded grasslands

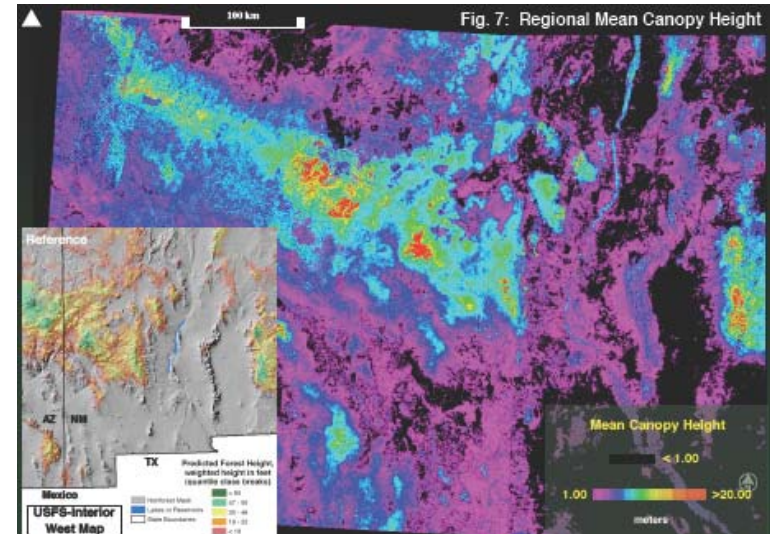


# Results

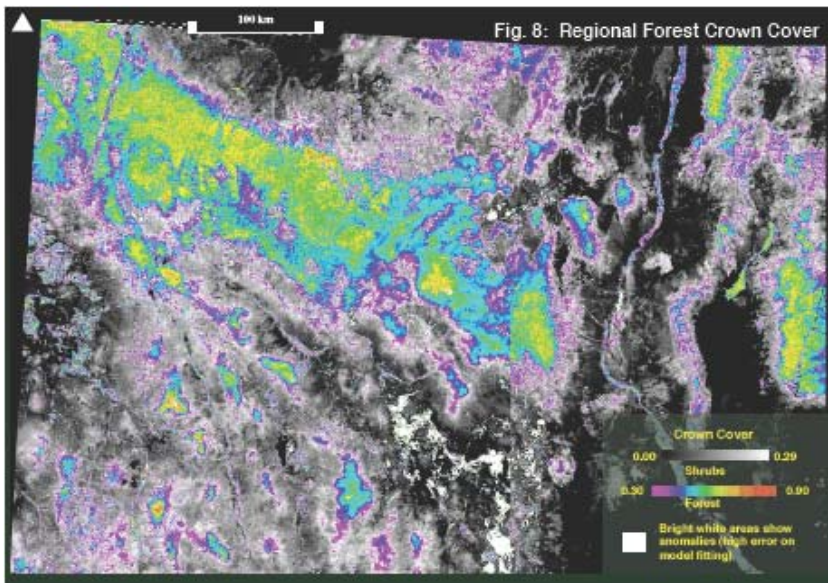
Aboveground biomass



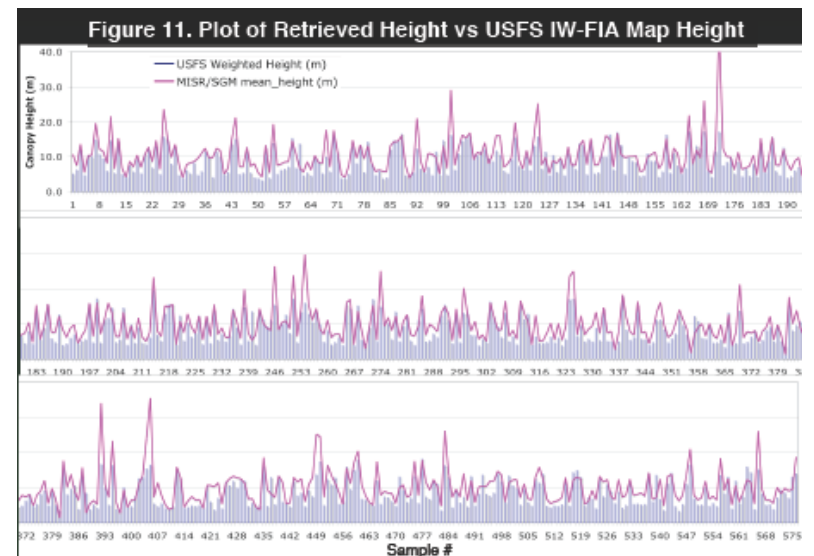
Canopy height



Crown cover



MISR canopy height vs. Forest Service data



# Interactions of Edaphic and Land Use Factors on Water Budgets in Cerrado and Semi-Arid Caatinga Region of Brazil

Eric Davidson, Woods Hole Research Center

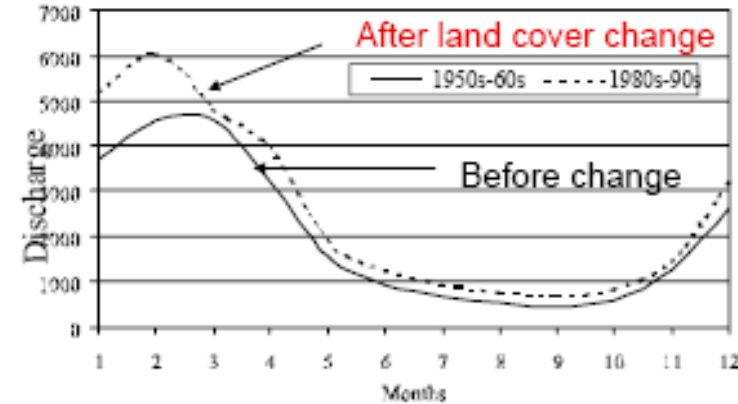
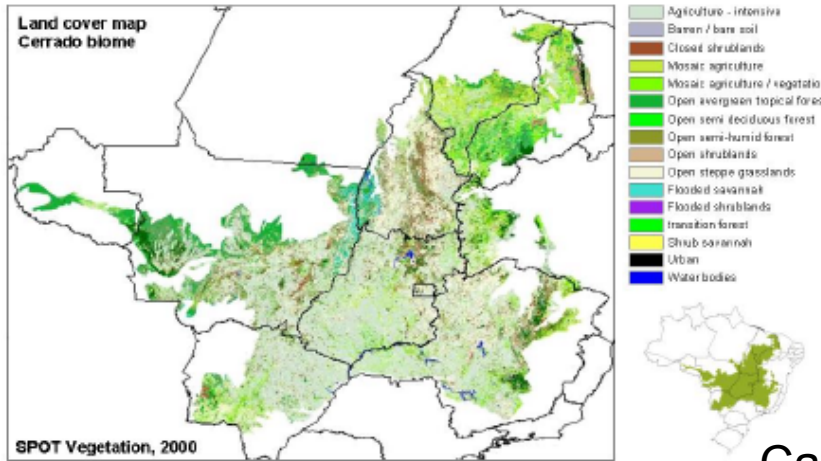
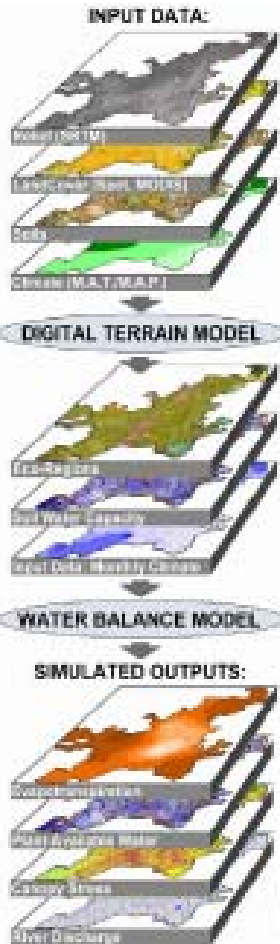
Funded 2006-2009

# Objectives

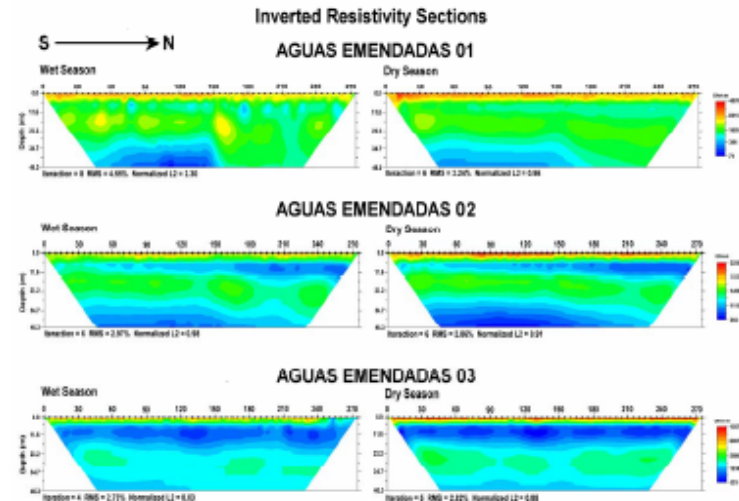
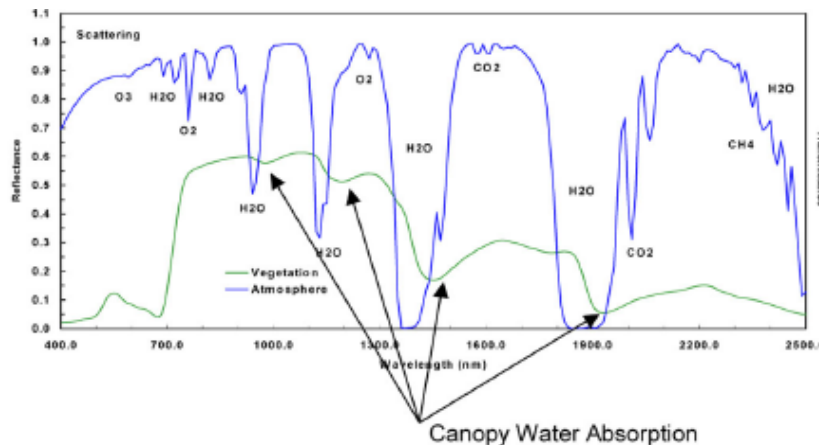
- Use satellite derived data and numerical models to better understand the relationships between land use and water resource changes in large semi-arid region of Brazil
- Demonstrate the linkages among shallow and deep soil water storage, climate, plant demand for water, vegetation structure (land cover, LAI, deep rooting, life form, etc.), phenology, and regional water balance in the Brazilian Cerrado
- Estimate the effects of land-use and land-cover change on regional water budgets, including water that will be available for agricultural and municipal uses, by applying mechanistic land cover and hydrologic models to the Araguaia/Tocantins Basin and selected small catchments

# Results

Savannah vegetation, 40% converted to agriculture  
 ~25% increase in discharge after land cover change



Canopy and soil water content inputs



# Regional Hydrologic Response of Semi-Arid Mediterranean Climate Watersheds to Land-Cover/Land-Use Variability: Predictive Models Based on MODIS Products

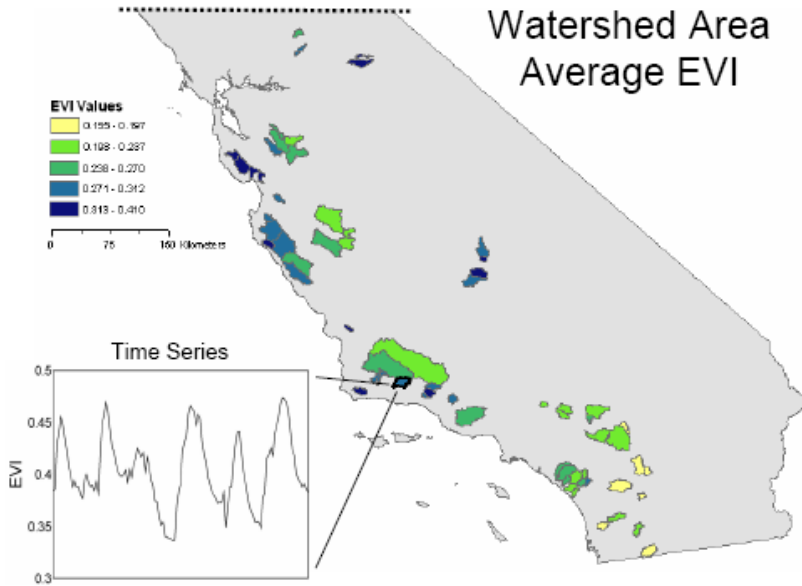
Allen Hope, San Diego State University

Funded 2005-2008

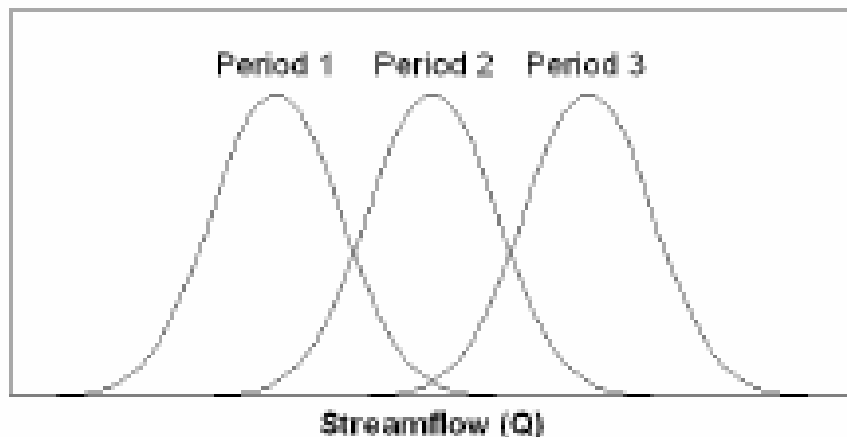
# Objectives

- Develop a regionalization scheme for lumped parameter, conceptual hydrological models for prediction of daily river flow in ungauged basins
- Quantify the effects of:
  - Wildland fires on river flows in the Mediterranean climate region of California
  - Invasive alien vegetation on river flows in the Cape Floristic Region of South Africa

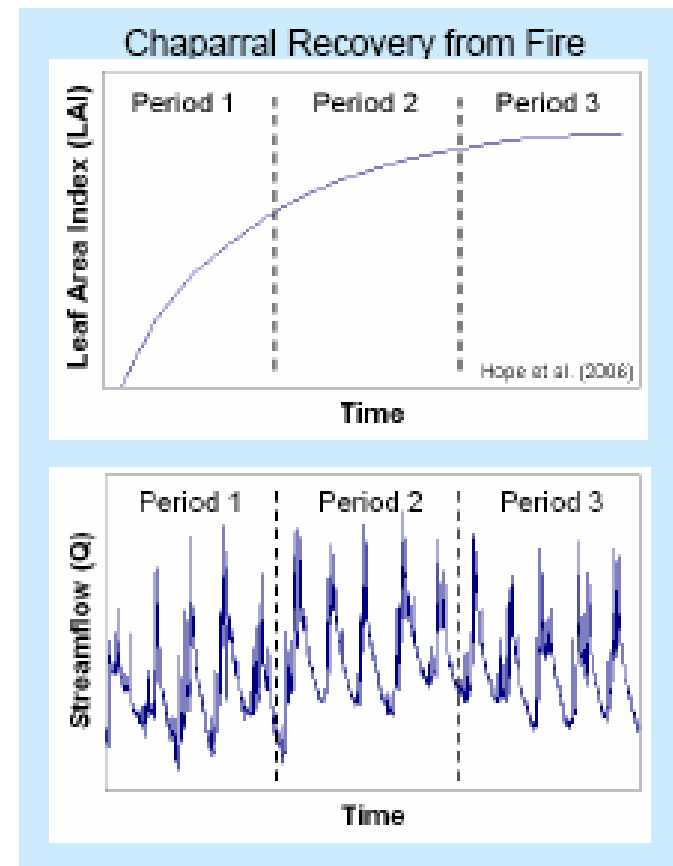
# Results



Condition a hydrologic model on each recovery period using extended weather records



Need to determine if the river flow differences in each period are a consequence of the vegetation condition or the meteorological forcing



- **Ecological Monitoring in Semi-Arid Central and West Asia: Drivers and Trajectories**
  - Roland Geerken, Yale University, Funded 2005-200
- **Evaluating the effects of institutional change on regional hydrometeorology: Assessing the vulnerability of the Eurasian semi-arid grain belt**
  - Geoffrey Henebry, South Dakota State University, Funded 2005-2008
- **Northern Eurasian C-Land Use Climate Interaction in the Semi-Arid Regions**
  - Dennis Ojima, H. John Heinz III Center for Science, Economics and the Environment, Funded 2004-2007
- **Land Use and Land Cover Dynamics of China in Support of GOF/GOLD and NEESPI Sciences**
  - Jiaguo Qi, Michigan State University, 2004-2007
- **Understanding the Role of Changes in Land-Use/Land-Cover and Atmospheric Dust Loading and their Coupling on Climate Change in the NEESPI Study Domain Drylands**
  - Irina Sokolik, Georgia Institute of Technology, Funded 2005-2008
- **Relationship between Land Cover/Land Use Change and Surface Hydrology over Arid and Semiarid Regions**
  - Xubin Zeng, University of Arizona, Funded 2005-2008



# LCLUC Component 2

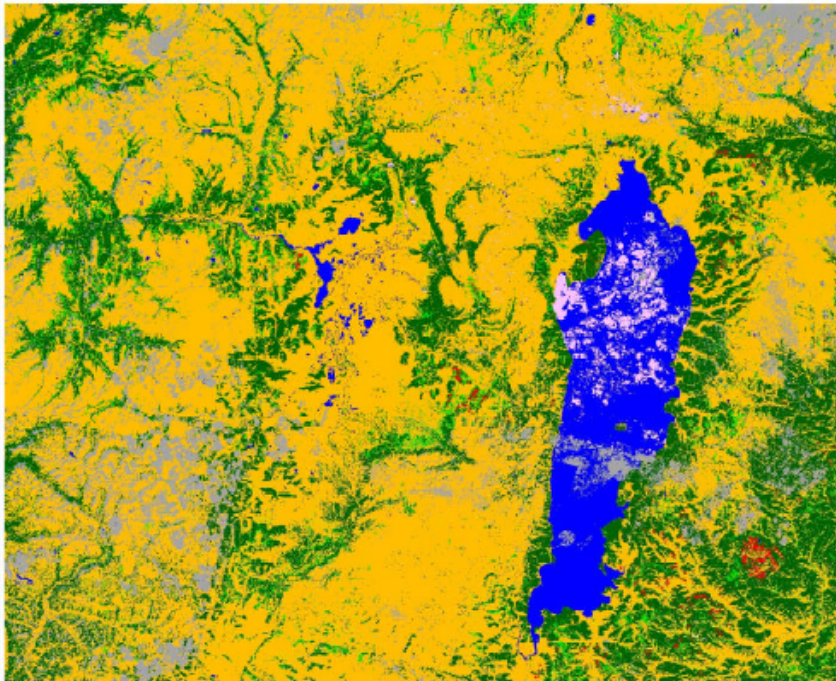
- **Develop and Distribute Global and Regional Observations and Data Sets to support LCLUC Science and Foster Periodic Global Inventories of Land Cover and Data Sharing**
  - Landsat 1972-present
    - Global data sets GEOCOVER > 2005 (Day 4 presentation)
  - AVHRR 1981- present
  - EOS MODIS (Day 4 presentation)
    - Land Cover, Vegetation Continuous Fields, Fire and Burned Area
  - Long Term Data Record Study AVHRR>MODIS>NPP
    - Consistent Data Records
  - SRTM 90m
  - Sample Data from ASTER, EO1
  - Microwave Data mostly from ESA, Japan

# Data Distribution

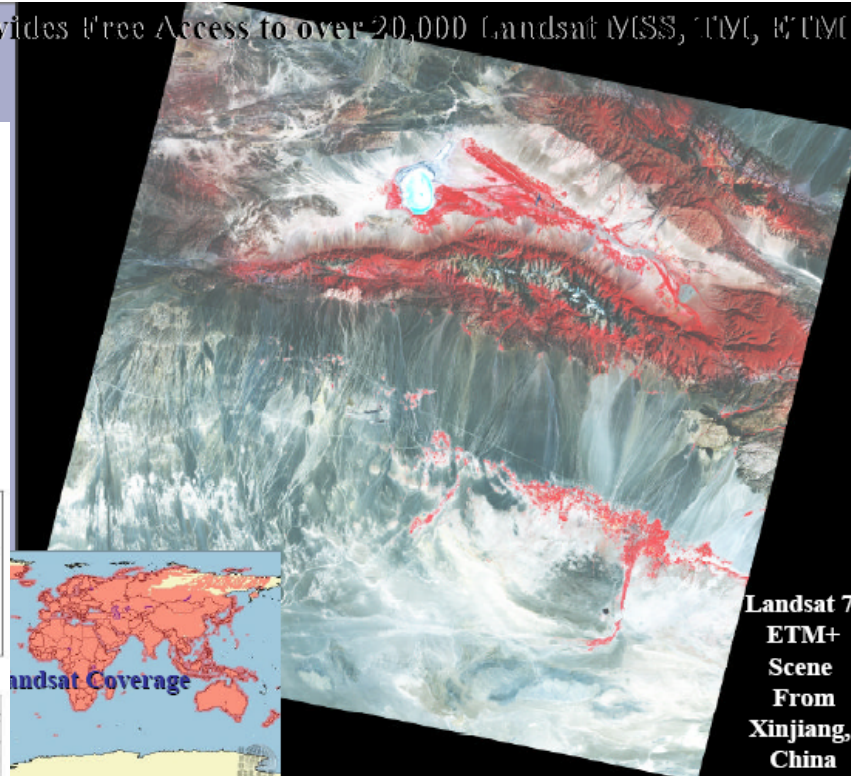
- Free and Open Sharing of EOS Data from the NASA DAACS & SCFs
- Free and Open Sharing of Landsat GEOCOVER Data from DAACS
- Free and Open Sharing of Data from the GLCF
- Free and Open Sharing by LCLUC PI's and Partners

GLCF Provides Free Access to over 20,000 Landsat MSS, TM, ETM+

Global Land Cover Facility - Deforestation Mapping Group



Lake Hovsgol, Mongolia



# List of standard MODIS Land Algorithms/Products

## Energy Balance Product Suite

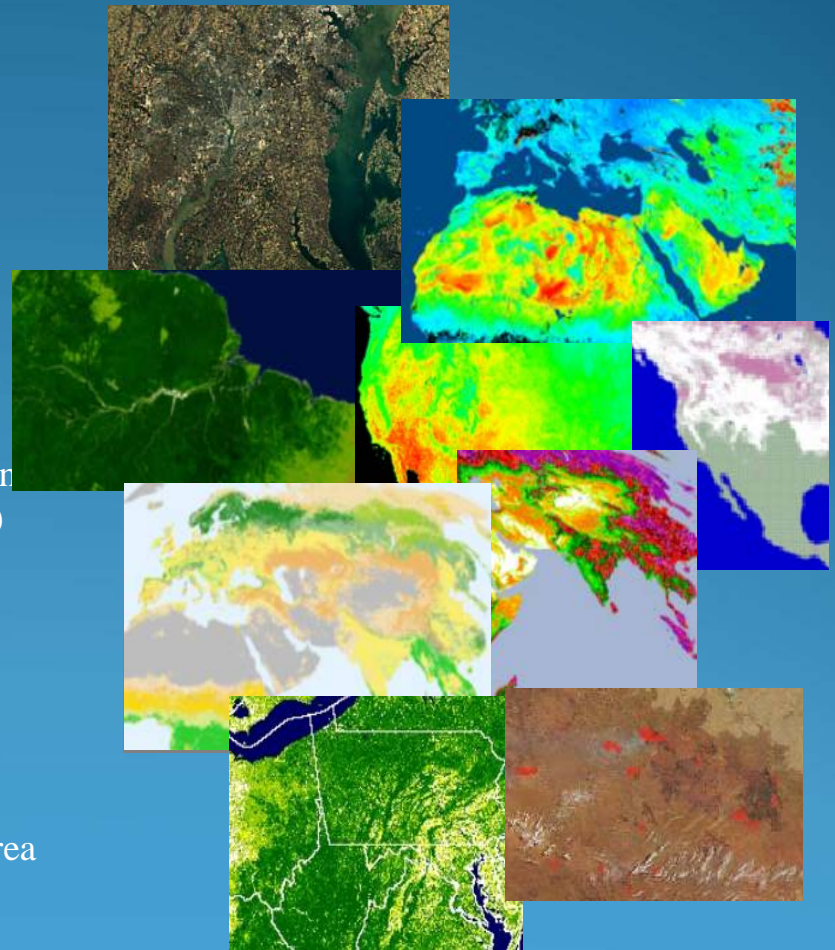
- Surface Reflectance
- Land Surface Temperature and Emmissivity
- Bi-directional Reflectance Distribution Function (BRDF) and Albedo
- Snow cover and sea-ice extent

## Vegetation Parameters Suite

- Vegetation Indices
- Leaf area index and Fraction (LAI) and Fraction of Photosynthetically Active Radiation (FPAR)
- Gross and Net Primary Production (GPP/NPP)

## Land Cover/Land Use Suite

- Land Cover/Vegetation Dynamics
- Vegetation Continuous Fields
- Vegetation Cover Change
- Active Fire/Thermal Anomalies and Burned Area



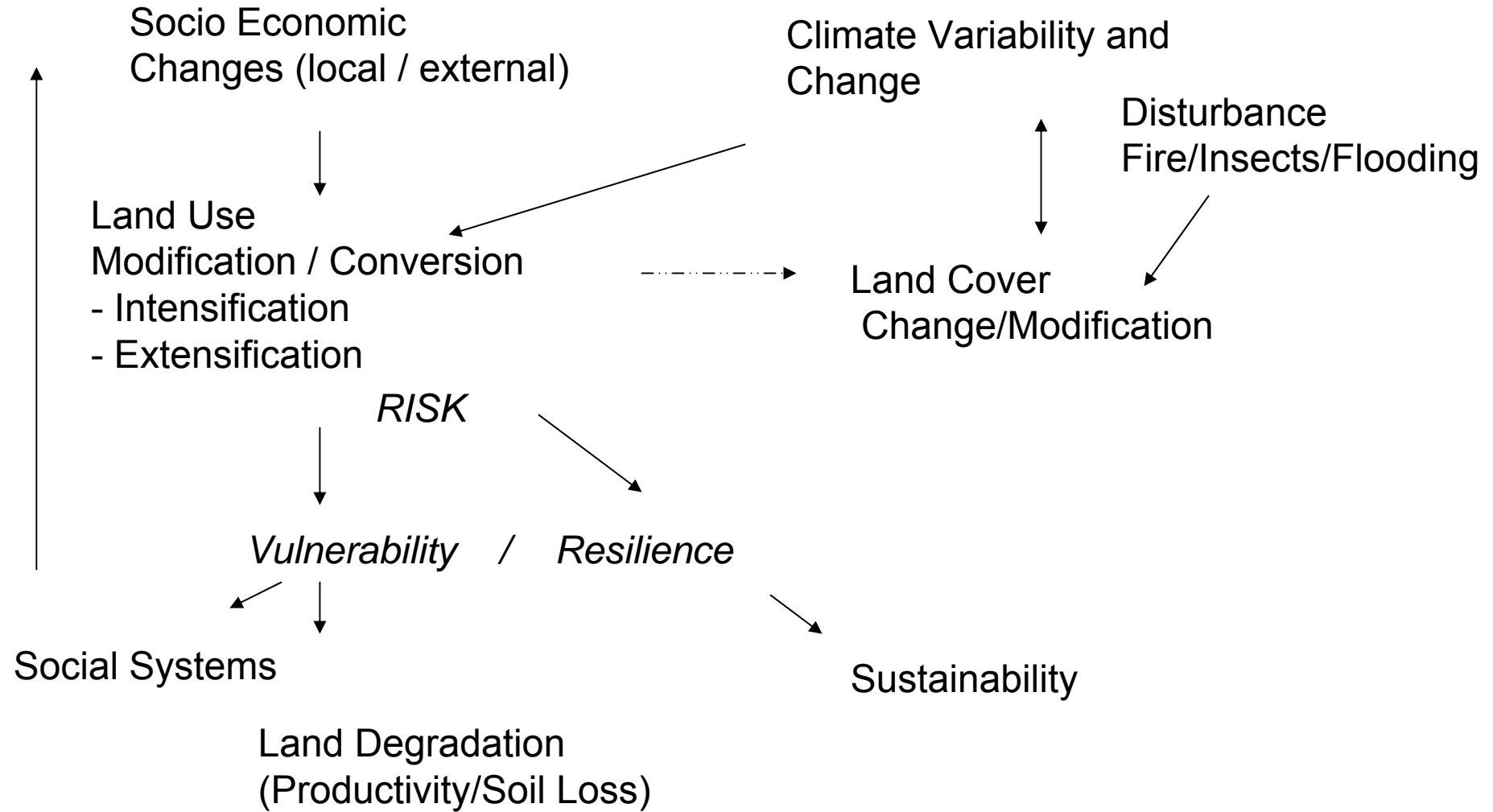
# MODIS Rapid Response Data

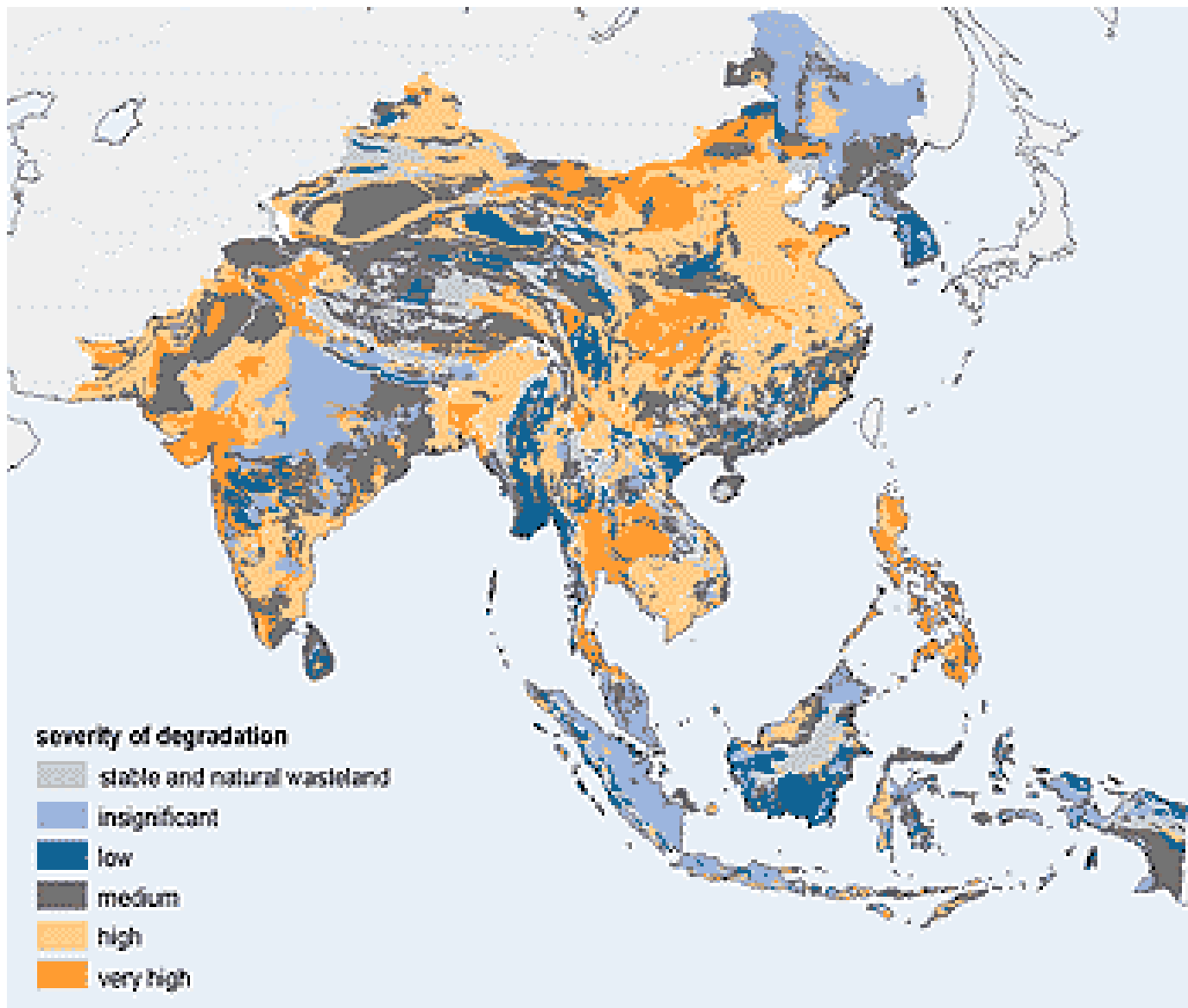


2-3 Hours From Acquisition

# LCLUC Component 3

- Developing conceptual frameworks for LCLUC Research





LCLUC is Contributing to The Emerging Sustainability Science

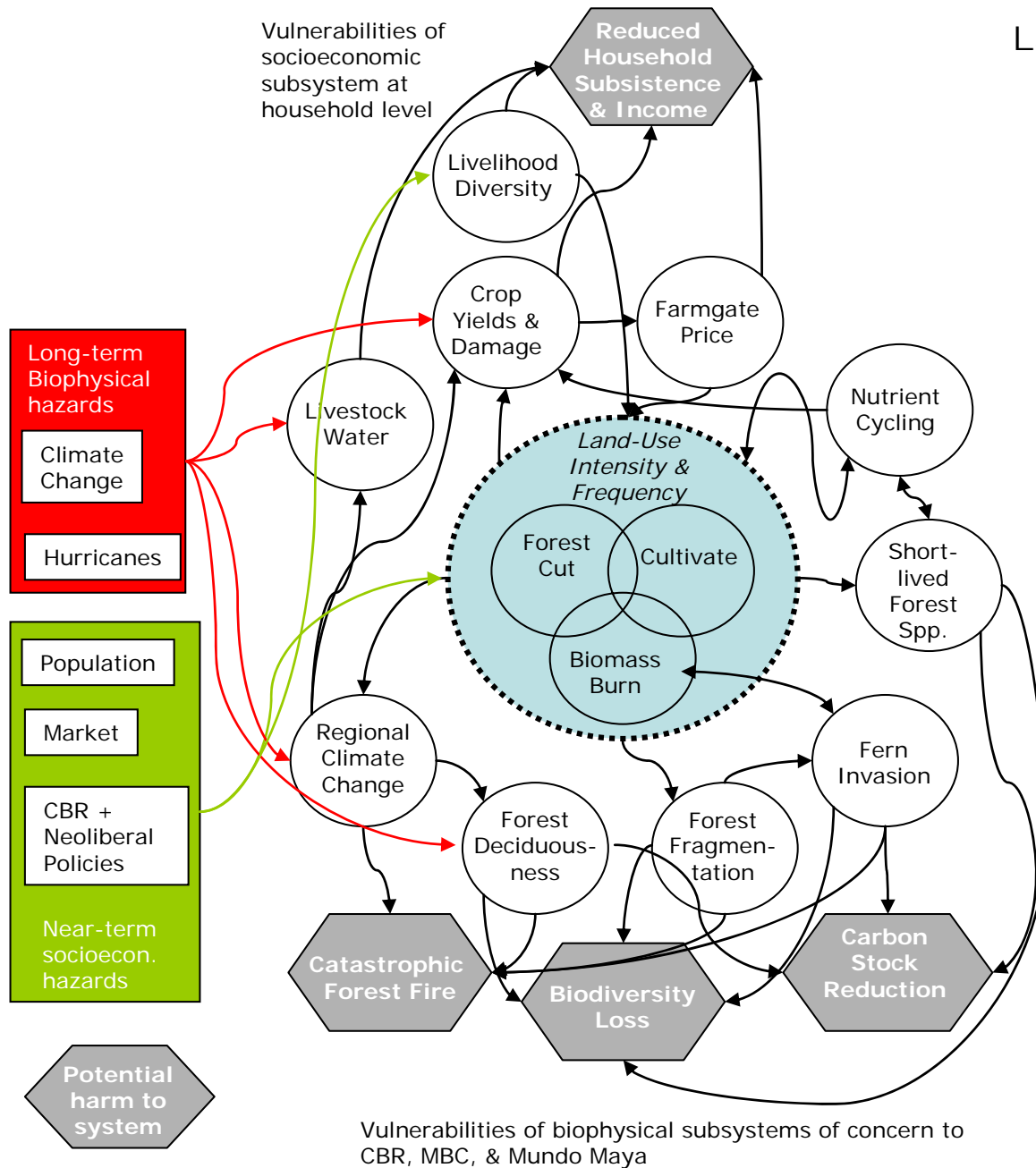
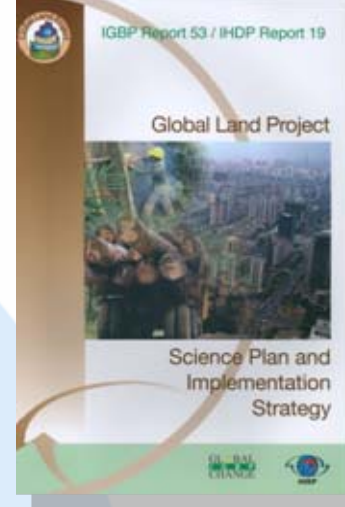
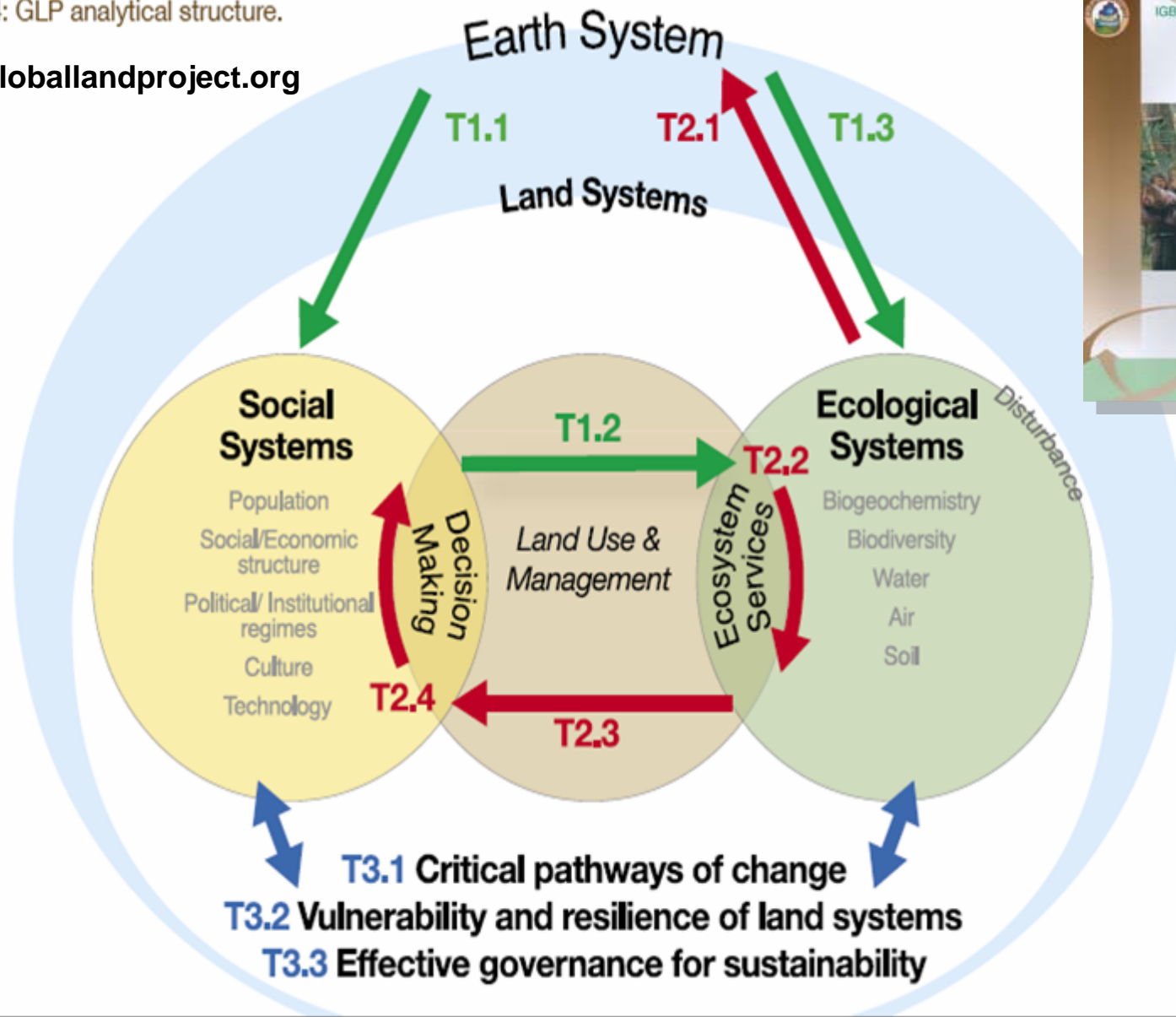


Fig. 2: Coupled System Vulnerability to Hazards in SYPR

Figure 4: GLP analytical structure.

[www.globallandproject.org](http://www.globallandproject.org)



## T3.1-3: Sustainable Land Architecture



# Component 4

- Modeling Land Use to understand processes, interactions and feedbacks
  - Coupled Land Use and Hydrological Models
  - Coupled Ecosystem and Land Use Models
  - Coupled Climate and Land Use Models
  
  - Predictive Land Use Models
  
  - Integrated Assessment Models

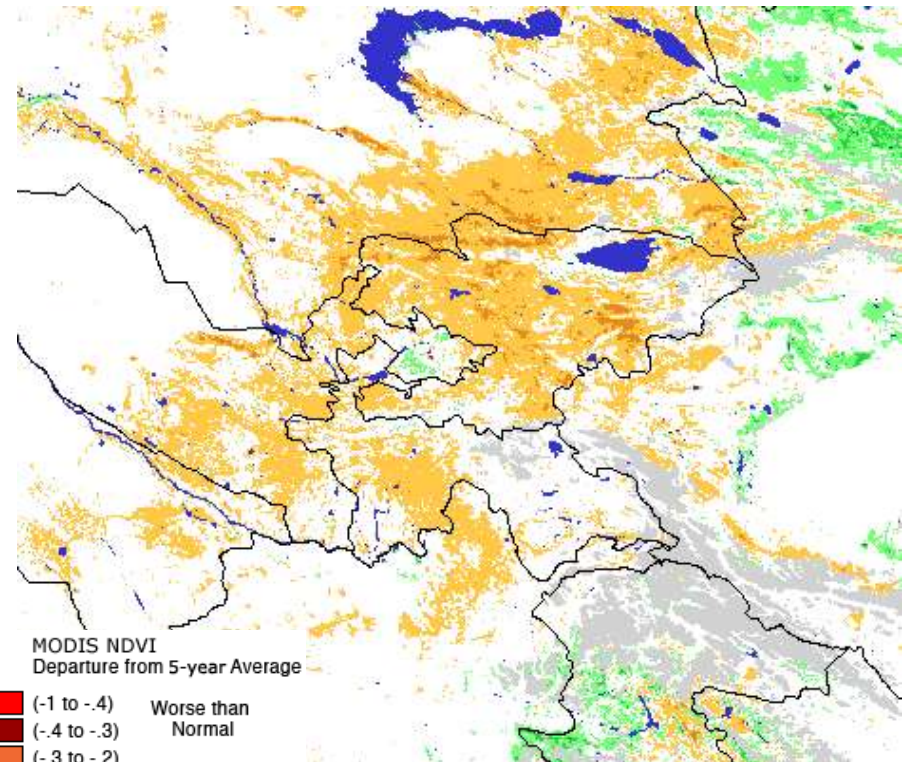
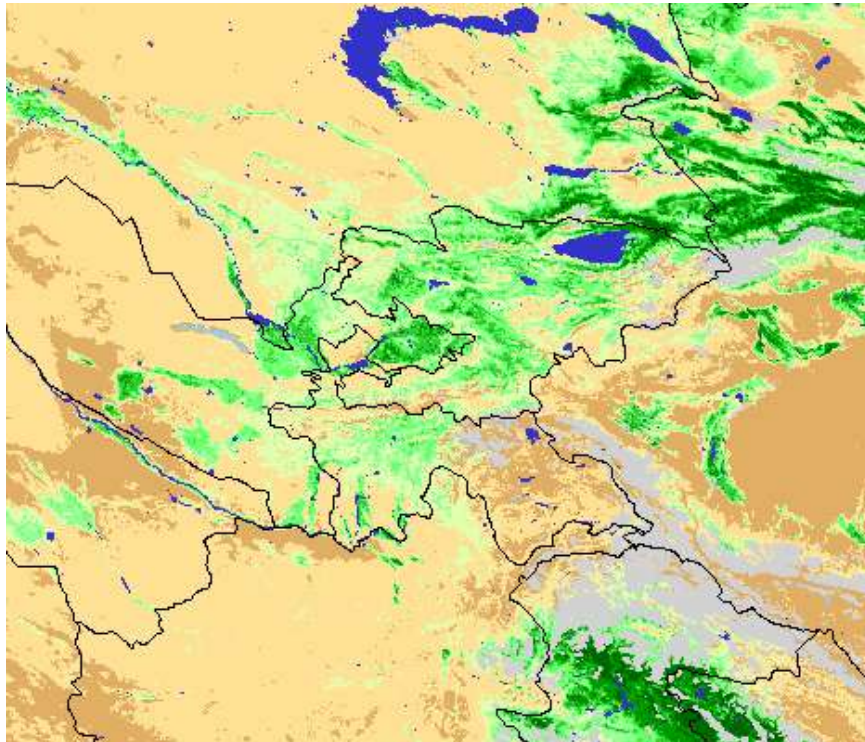
# LCLUC Component 5

- **LCLUC Studies Providing Science Underpinning to Applications of Societal Benefit to Drylands Management e.g.**
  - Water Use and Resources (irrigation)
  - Shrub encroachment and Nutrient Cycling
  - Fire Management and Fuelwood Use
  - Livestock management
  - Biodiversity and Protected Area Management
  - Monitoring of Marginal Agriculture
  - Famine Early Warning
  - Climate predictions

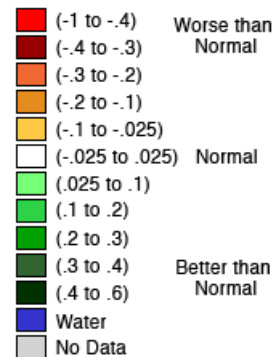
# Vegetation Monitoring

asia\_central2

(08/13/07 - 08/28/07) \*



MODIS NDVI  
Departure from 5-year Average



MODIS 16 Day Vegetation Index

# LCLUC Component 6

- Support and Promote National and International Scientific Collaboration through Partnerships and Linkages