The NASA Land-Cover/Land-Use Change (LCLUC) Program, NASA Headquarters
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This synopsis is for the Land-Cover and Land-Use Change (LCLUC) part of the NASA Research Announcement (NRA) ROSES-2009 NNH09ZDA001N-LCLUC. This NRA offered opportunities for research to develop and use NASA remote sensing technologies to improve understanding of human interaction with the environment, and thus provide a scientific foundation for understanding the sustainability, vulnerability and resilience of land-cover and land-use systems. NASA LCLUC research contributes toward the goals of the U.S. Global Climate Research Program (USGCRP) by providing critical scientific information about LCLUC-climate interactions and the consequences of land-cover and land-use change on environmental goods and services, the carbon and water cycles and the management of natural resources. This solicitation was focused on improving the detection and monitoring of land-cover and land-use changes around the world and consisted of two major components. The first component called for proposals on detecting and quantifying land-cover and land-use changes in rapidly changing regions of the globe (“hot spots”) with an emphasis on agricultural or urban land use. The second component was directed at explaining and attributing land-cover and land-use changes in agricultural or urban areas of the world, in terms of their underlying causes, such as climate variability or change, changing markets, economic development, population dynamics or changes in government policies, and examining the implications of the changes in terms of their impacts on the vulnerability, impacts, and adaptation of the land use or associated social systems. More details are available at: http://nspires.nasaprs.com.

NASA received 135 Step-1 proposals, out of which 67 proposals were encouraged to submit full proposals. NASA/LCLUC selected 9 proposals for funding out of 62 submitted Step-2 full proposals, with additional 4 proposals pending as selectable. A few months later NASA funded those 4 proposals.

Eric Brown de Colstoun/NASA Goddard Space Flight Center
Using Landsat Global Land Survey Data to Measure and Monitor Worldwide Urbanization

Urban areas are expanding as a result of a rapidly increasing urban population. While urban areas still occupy today only ~3% of the Earth's surface, their impacts on local and regional meteorology, pollution and resource utilization are disproportionate to their overall area on the planet. With urban populations expected to reach 60% of the total global population by 2030, it is critical to develop the methods with which to measure and monitor global urbanization and its impacts at the appropriate spatial scale.

The availability of consistent, global scale, satellite data sets such as the Landsat-based Global Land Surveys (GLS) provide a unique opportunity to accurately measure impervious cover at high spatial resolutions, at the global scale, as well as its change over
time. We propose to use the global GLS archives to produce global, high resolution estimates of impervious cover for the 2000 and 2010 time periods, and to quantify the change in impervious cover worldwide over this 10 year period.

The proposed processing framework is based on well-established regression tree and image segmentation algorithms and uses state-of-the-art processing techniques for the Landsat data, including atmospheric correction. Processing of the 2000 GLS data and planned 2010 GLS data to surface reflectance will be performed at the Global Land Cover Facility (GLCF) at the University of Maryland. Sub-pixel fractions of impervious cover are derived at the ~30m Landsat resolution using 1-4m higher resolution training data from the IKONOS and Quickbird commercial satellites, available through the unclassified commercial data service of the National Geospatial-Intelligence Agency (NGA). Product validation is achieved by comparison to independent very high-resolution data but also via direct field measurements at schools throughout the world through a partnership with the GLOBE Program. The tools/products developed are envisioned as the foundation for a future urbanization monitoring network integrating past Landsat data with future data from the Landsat Data Continuity Mission (LDCM).

Lahouari Bounoua/Goddard Space Flight Center

One of the world's most vital needs is a stable supply of food and water. Population is increasing and so is the demand for agricultural products. Agriculture expansion significantly affects land cover and land-use and because it is the largest water-use sector, it has strong influence on water resources through diversion and extraction of fresh water, especially in arid and semi-arid regions.

The scarcity of food and fresh water availability is already the subject of conflicts around the world where political boundaries dissect natural watersheds, aquifers and river flow. For these regions in particular where population, agricultural and water demand are increasing for the same or decreasing precipitation, and where the food and water supply and demand are out of balance, changes in agricultural drivers such as regional climate, population growth, agricultural practices and technology can have potentially predictable environmental and socio-economic consequences.

Understanding the relationships between agricultural production (land-use and water demand), local climate and socio-economic trends can significantly improve agricultural efficiency and optimize its production. This will likely slow its impact on land cover and water resources and provide essential information to farmers, food producers, land-use and water managers, and policy makers.

We propose to combine Landsat and MODIS observations along with an inverse biophysical modeling technique to detect irrigated agricultural lands in the arid and semi-arid regions of North Africa, the Middle East and South Central Asia and quantify the
amount of irrigation water needed for agricultural production as influenced by climate, crop type, soil characteristics and other socio-economic drivers. We also propose to develop realistic change scenarios that link the ever-rising demand for agricultural products to changes in local climate, demographic and technological advances and examine the impact of these changes on agricultural lands and their adaptability to a changing climate.

Michael Coe/The Woods Hole Research Center
Linking Historical and Future Land-Use Change to the Economic Drivers and Biophysical Limitations of Agricultural Expansion in the Brazilian Cerrado

The savanna ecosystem is the second largest biome of tropical South America. Although deforestation of the Amazon rainforest has received much public attention, most of the Brazilian deforestation has taken place, and continues to take place, in the savanna environments (locally called Cerrado). Of the original 2,000,000 km² of Cerrado that existed in Brazil before about 1940, about 50% has been converted and fragmented by deforestation and expansion of the agriculture frontier. The Cerrado is considered a hot spot for biodiversity and is the headwater region of major rivers of eastern South America. It is also currently the focus of agricultural expansion in response to domestic and international markets for soy and biofuels.

The potential for expansion of intensive agriculture onto land currently occupied by degraded cattle pastures (i.e. land that is already altered but underutilized) is often presented as a means of avoiding further deforestation in the Cerrado and minimizing environmental degradation while increasing agricultural productivity. However, the capacity and suitability of land for this transition has not been evaluated or quantified on a regional basis. This proposal aims to quantify these degraded lands and their potential to mitigate future environmental impacts.

The specific objectives are:
1) Quantify the area of low productivity pastures using multiple resolution satellite sensors.
2) Assess the impacts of a range of economic scenarios for sugarcane and soybean expansion on future land use changes in the Cerrado.
3) Appraise inter-regional shifts in agricultural production in response to economic drivers within Brazil and the impact they have on deforestation pressure on the Cerrado.
4) Estimate historical and potential future changes in carbon stocks and emissions of N2O and CH4 from conversion to agricultural production.
5) Assess the hydrological impacts of historical and future scenarios of deforestation and conversion to intensive agriculture.

The first objective will be addressed by using a combination of Landsat-TM, MODIS, and ALOS products. TM-derived reflectance values will be related to field measurements of biomass and will be used to scale up to the MODIS resolution to calculate pasture biomass values for the entire Cerrado region.
The second and third objectives will be addressed by expanding and refining an existing Cerrado deforestation model by integrating it with a national and sub-national macroeconomic model. The amount of land allocated to sugarcane crop will be simulated based on national and global market demands for biofuels and conversion from degraded pastures and other land use categories to sugarcane and soybean. The results will be linked to a regionalized model of the Brazilian economy to simulate inter-regional economic effects on the Cerrado.

The fourth objective will be addressed by calculating carbon consequences and the net effect on N2O and CH4 emissions from historical deforestation and each future scenario, using a bookkeeping model based on summaries of changes in C stocks and gas fluxes among land uses derived from LBA research and other data on emissions from agricultural fields.

The fifth objective will be a follow-on activity of our expiring NASA-LCLUC project (Davidson, Coe, et al), where we are estimating effects of historical land use change on the hydrology of the Cerrado, using coupled global climate, vegetation, and surface hydrology models.

The proposed project responds to both components of land-use change detection and identification of economic and social drivers in an area of agricultural expansion that is currently understudied. Because forest conservation efforts in the Amazon under future implementation of Reducing Emissions from Deforestation and Degradation (REDD) could lead to increased pressure for agricultural and pasture land in the neighboring Cerrado region, our work will also contribute to this international program.

Lisa Curran/Stanford University

Socio-economic and political drivers of oil palm expansion in Indonesia: Effects on rural livelihoods, carbon emissions and REDD

Global demand for edible oils and biofuel has stimulated a rapid agribusiness expansion particularly in palm oil. Since 1990s, Indonesia’s oil palm plantation area increased over 7-fold. As a result, Indonesia now dominates global palm oil export markets. Indonesian Borneo (Kalimantan) is the primary region of current and future plantation expansion. Since 1993, West Kalimantan province is undergoing an extensive forest-agricultural transition with a 40-fold increase (3.7 M ha) in plantation area. Occupying >35% of W. Kalimantan’s lowlands, land conversion for plantations is the major cause of deforestation and fires generating carbon emissions. With such rapid plantation development, we urgently require studies on oil palm’s effects on fire vulnerability, ecosystem services, and, in particular, rural agrarian communities.

Across Borneo, diverse ethnic communities employ forest product collection, agroforestry, rain-fed “swidden” rice farming with cash income generating activities. Despite centuries long residency, villages do not have formal land tenure nor delineated community lands. Plantation leases (10,000-100,000 ha) are allocated without recognition of villages’ usufructuary rights. Officials assert plantations are established only on “degraded lands”, yet oil palm areas are primarily community-managed lands, logged forests and/or peat with high C stocks. Reducing Emissions from avoided Deforestation and Degradation initiatives provide Indonesia with financial resources to support REDD implementation. With REDD’s promise of C investments that also will “alleviate
poverty” and protect biodiversity, oil palm’s contradictory practices require critical examination.

Given local-global factors influencing Bornean plantations, we propose to examine socio-economic and political drivers affecting agribusiness practices and their impacts on rural communities, land use and ecosystems. Our overarching objective is to assess costs and benefits of plantations to diverse constituencies. We seek to: 1) discern the relative importance of drivers affecting plantations and to assess REDD’s potential to alter these drivers; 2) estimate historic and possible future impacts of plantations on ecosystems services - especially C dynamics - through 2020; and, 3) uncover rural agrarian household and community responses to such change and how they alter their livelihood and land use.

With Indonesia’s complex district-level “governance” yet national regulatory control, we apply nested-scale analyses in: i) two focal districts with extensive oil palm, national parks, peat forest and REDD pilot sites; ii) W. Kalimantan (147,000 km2) and, iii) Borneo (780,000 km2). Long-term iterative studies within focal sites generate: 1) valuable insights into dynamic factors that alter land use with field validation; and, 2) “baselines” of communities’ livelihood practices before plantation arrival. Through participatory land use mapping, repeated household interviews with local valuation of trade-offs, we assess livelihood change and project effects of land scarcity with plantation development. With multi-sensor satellite and radar imagery (e.g. Quickbird, Landsat ETM+, MODIS, PALSAR, ENVISAT) combined with diverse modeling and classification approaches (e.g. eCognition, Dynamica Ego, Agent-Based Models), we will develop and validate several local-to-regional socio-economic and ecological scenarios of land use change. A distinctive contribution - critical for REDD - is our refined land use transitions with Tier II-III above- and below ground carbon budgets (e.g. regrowth) for 8-10 land use/cover types (e.g. secondary forests by age, degradation, logging history, heath/peat swamp phasic zones). To evaluate cultural and demographic change across communities, social network analysis is used to assess non-local labor and rural-urban migration. Through such efforts, we aim to produce several useful products for diverse applications and user groups.

Ruth DeFries/Columbia University
Multi-Sensor Fusion to Determine Climate Sensitivity of Agricultural Intensification in South Asia

This project will detect the spatial patterns and temporal variability of cropping patterns throughout South Asia. We will develop approaches to fuse multitemporal MODIS, Landsat, TRMM and data from other sensors to develop and disseminate a 250m resolution dataset on cropping patterns since the year 2000. Comparison with patterns and trends in climate variability will enable us to assess the sensitivity of agricultural productivity to climate variability. The dataset will establish a baseline against which future anomalies can be assessed and the methodology will facilitate operational monitoring of cropping patterns in South Asia. Higher-resolution analyses in selected areas will be used to assess accuracy and improve interpretation of the multitemporal data.
Matthew Hansen/Geographic Information Science Center of Excellence
Advancing Methods for Global Crop Area Estimation

Summary: Area estimation of croplands is a challenge, made difficult by the variety of cropping systems, including crop types, management practices, and field sizes. The goal of this project is to work towards a standard method for estimating cultivated crop area at the global scale. Two approaches, one employing sampling and another mapping, will be examined for application at the global scale. The sampling method will use MODIS data to target crop type at national scales for stratified sampling of higher spatial resolution data to estimate cultivated area. This method, given appropriate data for area estimation at the higher spatial resolution, represents an efficient and accurate approach for large area crop type estimation. This approach will be tested for major production countries. For example, 93% of soybean cultivation is found within 5 countries: the United States, Argentina, Brazil, China and India. MODIS indicator mapping and high-spatial resolution samples can be applied annually at national scales for these countries to provide an internally consistent, satellite-based area estimation of global soybean cultivated area. The second approach will involve developing a method for cropland area estimation at the global scale. This approach is meant to be generic and to exploit the recently opened EROS Landsat archive. Time-series Landsat data will be analyzed to develop a generic multi-temporal signature for cropland identification. The method will be tested for a number of global sites in conjunction with the Joint Experiment on Crop Assessment and Monitoring (JECAM) of the GEOSS activity. Improving crop area estimation at the global scale will lead to improved quantification of food and feedstock production. Remote sensing data allow for the generation of internally consistent estimation of land cover at the global scale. The methods proposed here will advance our understanding of global cultivated area by applying data and algorithms that will yield consistent results across space and through time. Demands for increased crop production are due to increasing and increasingly affluent populations, as well as new emphases on biofuel production. Improved monitoring methods will be required to quantify resulting global cropland dynamics designed to meet these demands.

Cristina Milesi/Ames Research Center
Mapping of Urban Expansion Using Multi-Decadal Landsat and Nightlights Data Over North America

Accurate representations of urban expansion are of interest to a large scientific, socio-economic and policy-making community. The increasing aggregation of population and concomitant modification of land cover has both socio-economic and micro and meso-climatic, hydrologic, biophysical and ecologic impacts on the ambient environment. In order to quantify, monitor and model these impacts it is necessary to have accurate depictions of the spatial extent and physical properties of the urban area, however defined. Characterizing large-scale historical changes in urban spatial extent, however, remains a challenge due to the inherent complexity and variability of the urban environment. Even in data-rich countries there is little spatially explicit, land-cover specific, information on how much land is being converted for urban land use over time,
how this expansion compares to increases in urban density and relates to a whole host of drivers and environmental changes. The problem is compounded by the lack of a single unambiguous definition of what distinguishes urban from non-urban. The broad diversity of urban forms compounds the problem of classification because the physical properties of urban environments are more diverse than most indigenous land cover classes.

The goal of the proposed work is to develop a consistent, robust, scaleable, physically-based methodology for characterization of urban expansion using Landsat-style observations. We propose to use atmospherically corrected Landsat GLS time series in conjunction with DMSP/OLS nighttime lights, MODIS 500m land cover and high resolution imagery such as Ikonos, QuickBird and Worldview-2 to define a methodology for mapping time series of urban settlements and their built-up and vegetated components at 30m resolution through multi-temporal spectral mixture analysis (MTSMA). We will circumvent the persistent problem of inconsistent or arbitrary definitions of “urban” by categorizing distributions of measurable physical properties for different independent categorizations of urban extent (e.g. population density, brightness and temporal consistency of emitted light, spectral heterogeneity) as well as a representative sample of non-urban environments and then quantifying the variation in land cover properties for each independent spatial extent. The methodology will be tested and validated over North American settlements of a range of sizes and will be used to a) produce continental maps of physical properties for different categories of developed land cover for the nominal years 1990, 2000, 2005, and 2010; b) quantify the spatial extent of different land cover and their temporal changes for the period 1990 to 2010; and c) summarize how rates of urban expansion relate to changes in both physical properties and socio-economic metrics. The project will take advantage of the new NASA Earth Exchange collaborative with significant computing and storage resources. This proposal addresses the “detection” component of this NRA. It aligns with NASA’s research objective to “Quantify global land cover changes” and will contribute to answering 2003 U.S. Climate Change Science Program strategic plan question: What observations and methods are needed to quantitatively characterize historic and current land-use and land-cover dynamics, that influence the sustainability of human societies and the environment, by providing the first historic quantification of urban expansion and vegetation abundance changes from 1990 to 2010 for North America. This study will also address the third Objective of the MEGAPOLI project: “to develop and implement improved, integrated tools to assess the impacts of air pollution from megacities on regional and global air quality and climate and to evaluate the effectiveness of mitigation option”. The products developed as part of this study will be made publicly available through NASA’s Land cover Land Use Change program.

John Mustard/Brown University

Rates and Drivers of Land Use Land Cover Change in the Agricultural Frontier of Mato Grosso, Brazil

We propose to analyze in detail the rapidly changing agricultural frontier in the state of Mato Grosso Brazil (Figure 1), a part of the Legal Amazon but encompassing both tropical forest and savannah natural landscapes. This region provides us a unique
opportunity to study both one of the most rapidly changing agricultural frontiers in the world and two globally important biomes, using a phenological approach to characterizing land cover change from remotely sensed data over a longer period than was previously possible. The research consists of two primary themes: 1) detection and characterization of land cover change, and 2) explaining and attributing the observed changes. The proposed research will use MODIS data to detect and characterize land cover change, and moderate resolution sensors (e.g. Landsat) to assist the analyses and to aid in verification and validation. It builds on our previous successful application of these approaches to characterize land cover change over a shorter period. The new research will incorporate analyses of socioeconomic drivers of extensification (conversion of natural vegetation to human use) and intensification (conversion of pasture to row-crop or single- to double-cropping) at the county level using standard spatial econometric approaches and a dataset assembled during this research.

Volker Radeloff/University of Wisconsin-Madison

200 Years of Land Use and Land Cover Changes and Their Driving Forces in the Carpathian Basin in Central Europe

Land use is a major aspect of global environmental change, but most land cover and land use change (LCLUC) research has examined deforestation, and assessments of agricultural LCLUC have focused on frontier conversions in the tropics. Less is known about agricultural change in regions with long land use histories. We propose to study long-term agricultural change in the Carpathian Basin (i.e., the Pannonian Plain and the Carpathian Mountains) in Central and Eastern Europe, a region that has experienced several major socio-economic transformations during the 19th and 20th centuries (i.e., WW I; the end of the Austro-Hungarian Monarchy; WW II; the rise and fall of socialism; and the eastward expansion of the European Union). These transformations have triggered drastic LCLUC, rendering the region a hotspot of agricultural land use change. Our proposal will contribute to both components of the NRA: we will detect patterns of agricultural LCLUC in a rapidly transforming region and we will provide novel insights into drivers of agricultural land use change in response to major institutional, economic and societal changes.

Our first goal is to improve knowledge about long-term agricultural land use change by reconstructing historic land use change since the mid 1800s for a comprehensive sample of case study regions across the Carpathian Basin. Our objectives are to:
- Map long-term land use change from historic military topographic maps from the 1840s, pre WW I (1890s), pre WW II (1930-40s), and the 1960-70s, for forty 100 km2 case study regions, focusing on farmland expansion, agricultural abandonment and cropland-pasture transitions
- Quantify long-term agricultural LCLUC and analyze changes in the fragmentation of agricultural land.

Our second goal is to quantify the rates and patterns of recent agricultural change from satellite imagery. Our objectives are to:
- Map agricultural land and its changes in 1979, 1989, 2000, and 2010 for the entire Carpathian Basin (397,400 km²) using Landsat MSS/TM/ETM+ imagery
- Develop new approaches to quantify changes in agricultural intensity with dense Landsat image time stacks and map changes in the case study regions
- Map changes in agricultural fragmentation using image segmentation and image texture measures.

Our third goal is to understand the drivers of recent agricultural change. Our objectives are to:
- Use geographically weighted regression models to understand the drivers of recent agricultural change across the entire Carpathian Basin
- Build spatially explicit panel data models to analyze the drivers of long-term agricultural change such as the environmental conditions, agricultural production, socio-economics, population, and land use legacies
- Use propensity score matching to isolate the effects of different ownership regimes during socialism, land reform strategies, and EU accession on agricultural land use change.

Besides these scientific goals, our project will further strengthen collaborations among American, Hungarian, Polish, Slovak, Swiss, and German scientists, and ensure maximum synergy among our research activities.

Patterns and processes of agricultural LCLUC are poorly understood, especially in regions with long land use histories. Similarly, we know little about the effects of drastic socio-economic and institutional transformations in triggering non-linearity in land use transitions, and the role of land use legacies. Our proposed research thus will make a substantial contribution to the basic understanding of socio-ecological systems and its relevance will far exceed the geographic scope of our work. Our research will pertain to three of the major international programs supported by the LCLUC program, specifically GOFC-GOLD, the IGBP-IHDP Global Land Project, and NEESPI. At the same time, this proposed work will contribute to the LCLUC program goals, NASA’s mission, and support several GOESS societal benefits.

**David Roy/South Dakota State University**

**Changing Field Sizes of the Conterminous United States, a Decennial Landsat Assessment**

This research will first develop and validate an automated computational methodology to extract cropland and grassland field boundaries and derive field sizes from the WELD processed Landsat data, second generate CONUS field size data sets for three decadal periods: 1987, 1997 and 2007, third characterize the spatio-temporal distribution of field sizes for the CONUS, and fourth address explanatory hypotheses concerned with CONUS field size evolution.
Multi-Scale and Multi-Sensor Analysis of Urban Cluster Development and Agricultural Land Loss in China and India

Over the next two decades, the combined urban population in China and India will grow by more than 700 million. China's urban population is expected to increase by 400 million and India's urban population will nearly double from today's 350 million. The urban transitions underway in these two countries represent the largest urban transition in history. Put into a global context, by 2030, nearly one-third of the world's urban inhabitants will live in either China or India.

The proposed project aims to quantify and understand the growth of urban clusters in these two rapidly urbanizing countries. The emphasis on urban clusters reflects recent research from the allied fields of economics, urban planning, and political science that indicate that the urban cluster is an important functional unit for economic, policy, and land use planning. The project has three primary goals:

Goal #1: Detect and quantify the growth of urban cluster “hot spots” in China and India. We will use time series MODIS and DMSP OLS imagery to develop remote sensing methods that can rapidly identify urban clusters that are experiencing rapid expansion.

Goal #2: Identify the types of land cover changes in these urban cluster hot spots and when they occurred, with an emphasis on the loss of agricultural land. Within the urban cluster hot spots, we will use time series MODIS and DMSP OLS data in complementary ways to develop new algorithms that can rapidly assess what types of land cover changes are occurring and when they occurred. We will use Landsat-derived data sets developed from the Chinese Academy of Sciences and previous NASA LCLUC projects to accuracy assess our analysis of types and timing of urban land conversion and agricultural land loss.

Goal #3: Explain the drivers of the growth of urban clusters and urban land conversion within them. We will evaluate the drivers of urban land conversion within an individual urban cluster and among urban clusters at the national scale. We will assess why urban growth occurs within a single urban cluster, and why some clusters grow faster than others.

The proposed research responds to both elements of the NASA LCLUC solicitation (detection and drivers) and has at its core, a strong remote sensing component complemented by analytical frameworks from political science, economics, urban planning, and geography. Expected significance and benefits of the research include: 1) An improved scientific understanding of urban land conversion processes and their underlying drivers in China and India; 2) Developing new remote sensing algorithms that can rapidly detect and characterize the growth of urban cluster hot spots; 3) Creating new data sets that quantify and characterize urban land dynamics and agricultural land loss at regional and national scales useful to other Earth system science research efforts.
RESPONSIVENESS TO SOLICITATION The proposal responds to both components of this NRA. The first component of the project will use multi-sensor and multi-scale satellite data to detect and quantify "hotspots" of urban expansion. The second component of the project is to identify land cover changes within the hot spots, and the third component is to identify and model the drivers of urban expansion.

REMOTE SENSING METHODS We will use a multi-scale approach to highlight and detect areas of urban expansion using a combination of the Defense Meteorological Satellite Program Operational Line Scanner night lights, multi-temporal Landsat imagery, and data from MODIS.

SOCIETAL SIGNIFICANCE

The proposed research contributes directly to NASA's goal of studying Earth from space for societal benefits, and NASA's objectives of quantifying global land cover change. The research also contributes to two international projects closely aligned with NASA's LCLUC program: the IGBP/IHDP Global Land Project and the Monsoon Asia Integrated Regional Study.

Daniel Slayback/SSAI
The Impact of Disappearing Tropical Andean Glaciers on Pastoral Agriculture

The tropical glaciers of Peru and Bolivia are the keystone element of regional pastoral agricultural systems that support large Andean populations. The glacier meltwaters sustain associated alpine peatbogs, and these in turn provide critical year-round islands of nutritious forage for an extensive highland system of pastoral agricultural that has endured for several millennia.

However, as rapid climate change continues and tropical Andean glaciers recede, the consequences for peatbogs, and the pastoral agriculture they support, are not well understood. Our proposed research will identify the impacts by first quantifying recent glacier and peatbog landcover change, and then analyzing these changes in concert with data on climate, hydrology, and pastoral production to determine drivers of landscape change and impacts on land use.

Our proposed research will map glacier and peatbog extent over the past 30 years using satellite imagery, and couple these landcover maps with surface measurements to model the regional to meso-scale climate and hydrological drivers of peatbog change and to predict the impact of these changes on pastoral agriculture.

This proposal directly addresses both solicitation components: (1) detection, we will map the extent of glacier and peatbog landcovers and identify change in these over the past three decades of available imagery; and (2) drivers, we will model the hydrologic drivers of peatbog change (an important component of which will be the current rate of glacier recession, as quantified in the first component), and we will examine the socio-economic implications of changes in peatbog extent on pastoral agriculture. The proposed work
also meets other solicitation guidelines: it has a very strong remote sensing component; the work is centered on a large mountainous region (in the tropical Andes), approximately 1500 km in length; and the work involves a multi-disciplinary social scientist who has directly relevant research experience in the region.

The monitoring of Andean glaciers and hydrological assessments have been recognized as important research topics for the Andes, where global warming is expected to cause a significant impact at higher elevations. Satellite-based glacier-extent studies, providing regional coverage, have also been identified as a research priority for environmental monitoring and planning.

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Xiangming Xiao/University of Oklahoma

Quantifying changes in agricultural intensification and expansion in monsoon Asia during 2000-2010

The Food and Agriculture Organization (FAO) of the United Nations and the World Food Program estimated that in 2009 approximately 1.02 billion people are undernourished, the highest number in four decades, and 29 countries currently have alarming levels of malnutrition, mainly in Africa (e.g., Ethiopia, D.R. Congo, Niger), and South Asia (e.g., India, Bangladesh, and Pakistan). Long-term agricultural development is critically needed to ensure more self-sufficient in crop production, food security and the livelihoods of poor people in developing countries. This requires updated and accurate information on the area and spatial distribution of cropping intensity (single, double, and triple crops per unit land in a year), irrigation, and crop yields; these agro-ecological attributes are sensitive to climate change, extreme weather events (e.g., drought and flood), and macro-scale socio-economic (e.g., use of food crops for bio-fuels) and demographic (e.g., population growth, urbanization) conditions.

In this proposal a multi-institution and international research team is organized to address two key LCLUC questions: (1) What are the rates of changes of agriculture intensification and expansion in monsoon during 2000-2010, the 1st decade of the 21st century? (2) What are the dynamics of the macro-scale driving factors that led to the observed changes in land use and land cover during 2000-2010? The overall approach is built upon the recent progress in our ongoing NASA LCLUC project that combines Landsat images (Global Land Survey 2005 dataset) and L-band PALSAR images to map land cover types in Southeast Asia. We plan to augment the GLS2000 and GLS2005 datasets with additional Landsat images available from the USGS EDC and partners in monsoon Asia countries, and provide pilot case study for supporting the future GLS2010 activity. We will develop phenology- and pixel-based algorithms to identify and map cropping intensity, irrigation and paddy rice fields, using time series PALSAR images and/or Landsat images.
This project will deliver a number of datasets, products and tools that would substantially enhance our capacity to address both LCLUC science and food security and sustainability:

1. Annual maps of cropping intensity and irrigation in monsoon Asia from multi-temporal Landsat and PALSAR images in 2007-2010 (30-m spatial resolution);
2. Geospatial datasets of changes in cropping intensity and irrigation in monsoon Asia in 2000, 2005, and 2010 (30-m spatial resolution);
3. Maps of paddy rice in monsoon Asia in 2000, 2005 and 2010 (30-m spatial resolution);
4. Co-registered time series Landsat and PALSAR images that could be used for other land cover studies and retrieval of biophysical parameters; and
5. An enhanced geo-web data portal system for data distribution, collection and evaluation from both experts and citizen scientists, and decision makers.

http://www.eomf.ou.edu

This proposal will address both the Detection and Driver components of this NASA ROSE2009 A.2 NRA. It will also benefit the NASA Agriculture Application Research and Development element. The proposal will help develop a strategy for global agriculture monitoring, a component of the international program, the GEO Task AG-07-03a Global Agricultural Monitoring System of Systems. This proposal will also provide key datasets to the International Monsoon Asia Integrated Regional Study (MAIRS) program, which focuses on the complex dynamics of coupled human-nature system in monsoon Asia.