

**NASA Science Mission Directorate  
Research Opportunities in Space and Earth Sciences -2018  
NNH18ZDA001N**

**A.2 NASA Land-Cover/Land-Use Change, Step-2**

This synopsis is for the Land-Cover and Land-Use Change (LCLUC) part of the NASA Research Announcement (NRA) ROSES-2018 NNH18ZDA001N-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. NASA received 22 proposals and selected 9 proposals for a total funding of \$7M for three years. More details are available at: <http://nspires.nasaprs.com>.

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**Jiquan Chen/Michigan State University**

**Interdependent Dynamics of Food, Energy and Water in Kazakhstan and Mongolia:  
Connecting LULCC to the Transitional Socioecological Systems  
18-LCLUC18\_2-0017**

This study is proposed to examine the interconnections of food, energy and water (FEW), as well as their interdependent dynamics under the rapid changes in climate and intensified land use in Kazakhstan (KaZ) and Mongolia (MG) over a 40-year period (1981-2020). We will apply the concept, principles and methods of socioeconomic-ecological systems to guide our research at three hierarchical levels: local, provincial and national. Net primary production, albedo, and evapotranspiration will be used as the key indicators for food production, radiation energy, and water balance, respectively, of the rangelands that support continued increases in economies, livestock, agriculture, and human development. Our premise is that the interconnections and interdependencies of FEW measures vary significantly between KaZ and MG, among the provinces within each country, and among the herding landscapes. Four mechanisms will be examined to test three specific hypotheses: socioeconomic, biophysical, institutional, and a localized regulative mechanism. At national and provincial levels, we will take a macro-ecosystem and macroeconomic approach to examine the interdependencies of NPP, albedo, ET, LSK, and their spatiotemporal relationships (Task 1). A hierarchical Bayesian Structural Equation Model (HB-SEM) and modern econometric models will be used as our primary tools to model the complex data from a variety of remote sensing products and available socioeconomic databases. At the provincial level, we propose an innovative downscaling model generate 30-m resolution FEW measures from the coarse resolution MODIS/AVHRR products to explore the direct consequences of LCLUC (Task 2). Three provinces from each country will be studied by treating counties as the sampling units for HB-SEM. At local herding landscapes, we will apply conventional ecosystem and microeconomic methods to explore the direct impacts of herding practices on FEW measures through manipulative experiments (Task 3). We aim to identify the direct

connections between land use practices and FEW measures. Our premise is that herders who are well informed about the local climate, the landscape, market accessibility, and other knowledge/information would conduct their practices more effectively than those without. This information/knowledge, consequently, will improve both their family's livelihood and FEW functions. The experiment will be conducted in the Almaty and Tov provinces through comparing the changes in FEW measures of the two experimental herder groups. Our experiment will be stratified into four counties in each province, with 12 herders per county to be studied. We will provide timely "knowledge & information" to half of the selected herders, while the other half will continue "business as usual". Two animals from each herding family (total = 96\*2) will be randomly selected for movement tracking by installing a GPS collar. Intensive field campaigns, monitoring stations, and large scale household surveys (up to 600) will be organized through applications of UAS, GPS tracking, ground sampling of the herding landscapes, and household surveys. We aim to advance FEW science by focusing on the interactions and feedbacks of major FEW functions and drivers through examining their exogenous processes and underlying mechanisms. Data will be distributed via our project website (which will be hyperlinked to NEFI and LCLUC webpages) along with sufficient metadata to describe the locations and methods. Our data management and access plan will be posted alongside our data both to make our procedures clearer, as well as to provide a contribution to the developing field of data science and informatics. We have organized a vibrant, multi-expertise team that has knowledge and experience in the region. Our well-established working relationships in KaZ and MG and available facilities/equipment will ensure the success of this project despite the multi-national nature of the collaboration.

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**Mark Cochrane/University of Maryland, Cambridge**  
**Land-Use Transitions in Indonesian Peatlands**  
**18-LCLUC18\_2-0043**

Indonesia's tropical peatlands are essential for stabilizing global climate and conserving biodiversity. These peatlands cover an estimated 200,000 km<sup>2</sup>, are biodiversity hotspots, and comprise a 57 Gt carbon reservoir. In recent years, these forested ecosystems have been rapidly degraded through unsustainable logging, drainage, conversion to agriculture and wildfire, leaving only 6% of peatlands unaffected by development. Due to rapid expansion and poor predictability, smallholder oil palm plantations are of particular interest. Indonesia's oil palm has expanded from 70,000 ha in 1961 to 11.8 million ha in 2016, due to strong global demand for vegetable oil and biofuel. It is now the largest producer in the world. Smallholder farmers manage half the oil palm area in Indonesia, with a greater expansion rate (11%) than large-scale plantations (5%). The economic and policy forces driving oil palm expansion are evolving, but include both local and global factors.

The key objectives of this proposal are to understand historical and projected impacts of smallholder oil palm agriculture on Indonesian tropical peatlands and related impacts on aspects of landscape sustainability. To achieve these objectives, we propose to monitor and characterize the land-use and land-cover changes (LCLUC) in this landscape, to

identify major drivers and impacts of those changes, and to use development and conservation scenarios to estimate likely landscape outcomes. The project would employ recently developed techniques to perform continuous change detection from dense stacks of medium resolution remote sensing data (e.g., Landsat and Sentinel). Resulting time series of forest canopy disturbance will be used in conjunction with LiDAR (airborne and NASA Global Ecosystem Dynamics Investigation data), to generate maps of canopy height in existing oil palm agriculture. Based on these products and spatial analysis, we will characterize land use transitions in the following categories from 2000 to present: (1) transition from peat forest to smallholding oil palm; (2) transition from other land uses (e.g., abandoned land) to smallholding oil palm; (3) transition from smallholding oil palm to large industrial estates. The impact of land use transitions will be assessed across a wide range of parameters, including environmental parameters such as carbon emissions, nitrogen loading, and forest cover loss, but also economic factors such as profitability and employment. We will develop statistical models to identify key drivers for each transition. Proposed drivers to evaluate include vegetation type, fire frequency, peat depth, climate conditions, oil palm processing infrastructure, market prices, and demographic characteristics of the labor population. These drivers and ecological impacts will be evaluated synthetically in a coupled assessment model that will be used to develop a decision-support tool capable of projecting future LCLUC transitions and their impacts for potential market, policy, disturbance, and climate scenarios.

The proposed research is directly responsive to the LCLUC call for proposals addressing Land-Use Transitions in Asia, specifically focusing on the critical, but poorly understood smallholder land use dynamics surrounding oil palm expansion in Indonesian peatlands. We will make effective use of NASA observing systems (Landsat and GEDI observations) to refine and expand existing techniques for estimating canopy height across landscapes. For oil palm, this relates directly to age, maturity and likely rotation periods. Our remote sensing products, together with ancillary inputs on socioeconomic drivers of land transitions, will allow us to assess the landscape impact of agricultural production, develop land use transition models, and provide new understanding of how future LCLUC transitions will affect this dynamic and important coupled human-environmental system.

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**Kirsten de Beurs/University of Oklahoma, Norman**  
**Rapid Urbanization, Changing Croplands and Increasing Population Health Vulnerabilities in the China-Central Asia-West Asia Economic Corridor**  
**18-LCLUC18\_2-0004**

This proposal responds to section 2 (Land-Use Transitions in Asia). We propose to investigate the growth of cities and the dryland system land use transitions in Central Asia as a result of China's Belt and Road initiative, a large planned series of Chinese investments in the region. The New Silk road, an enhanced transportation corridor, will traverse the most populous and most fertile agricultural regions of Central Asia. Competition between urban growth and croplands, and their induced interaction, often enhances the risk of disease epidemics. This is an acute concern for Central Asia where

existing health and sanitary conditions compound risks of emerging infectious diseases. Our research area will cover and specifically focus on the Central Asian regions subject to China's Belt and Road Initiative, also called the China – Central Asia – West Asia Economic Corridor. This region ranges from Almaty in southeast Kazakhstan, to Tashkent and Samarkand in southeast Uzbekistan, Bishkek in north central Kyrgyzstan, and Dushanbe in western Tajikistan.

Our research questions are as follows:

1. How have past investment and infrastructure developments (1995-2014) led to varying patterns of urbanization, resource, and population flows, and changing land use across Central Asian cities? How will the ongoing development of the BRI, and/or proximity to BRI connected cities impact the emerging urban ecosystems, microbial and human ecologies in these areas going forward (2014-2020)?
2. What are the economic and social effects of BRI investments on urban and peri-urban areas in Central Asia? How far improved is connectivity between cities, and what impact is this likely to have on patterns of land use, zoonotic disease risks, agriculture, and economic development?
3. What new infectious disease risks exist and how will they impact economic growth? To what extent is BRI-connectivity creating uneven patterns of rural-urban development and how might this impact urbanization, growth, and population health in the future?

This research is based on a reliable set of remote sensing methods focused on several parts of the electromagnetic spectrum at different spatial and temporal resolutions which can be used to understand urban growth and its interaction with the immediate agricultural environment. We will investigate land surface temperature (LST) measurements from Landsat, time series of nighttime data from VIIRS and urban morphology based on RADAR data and Very High Resolution (VHR) stereo images to better understand urban fringes. In addition, to address the lack of historical transportation network information, we will fuse Volunteered Geographic Information (e.g., OpenStreetMap data) with time series of medium resolution Landsat, ALOS PALSAR and Sentinel 1a/1b data.

We focus on the effect of large, sustained, foreign economic investments spanning four different Central Asian countries. We will link urban development with changing demographic conditions, regional economic integration, and population health risks of zoonotic and vector borne diseases. Key variables will include (1) population density, socioeconomic conditions, and public health resources; (2) the extent of interaction between urban/peri-urban populations and animals (both wild and domestic); (3) the degree of increased susceptibility to mosquito borne diseases (due to the proximity of irrigated regions to a larger portion of the population combined with inadequate vector control); and (4) estimates of risk for imported zoonotic or vector borne diseases that are well adapted to spread in these interconnected and evolving urban environments. We will also investigate the effect of indirect health risks, e.g. changes in the urban heat island effect. Higher land and air temperatures increase the biting rates and northward migration

of *A. aegypti*, a domestic mosquito implicated in the transmission of a number of infectious diseases that spread rapidly in urban areas.

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**Peilei Fan/Michigan State University**

**Divergent Local Responses to Globalization: Urbanization, Land Transition, and Environmental Changes in Southeast Asia**

**18-LCLUC18\_2-0009**

Southeast Asia, a vast area of 4.5 million km<sup>2</sup> with more than 641 million people, experienced rapid urbanization, doubling the urbanization ratio from 24% in 1976 to 48% in 2016, with several cities doubling urban built-up land in just two decades (HCMC, Hanoi, and Yangon from 1990 to 2010) coincident with severe degradation of the urban environment. Globalization has been recognized as one of the most significant driving forces of land transitions in Southeast Asia. It includes flows of commodity (international trade), capital (foreign direct investment (FDI)), money (remittance and overseas aid), and people (rural-urban migration, and international workers, and tourists). Our objective is to examine how diverse local responses to globalization affected land transitions, particularly urbanization, and urban environmental changes across 7 SEA countries, i.e., Cambodia, Indonesia, Lao PDR, Myanmar, Philippines, Thailand, and Vietnam and 12 case cities, with 3 particular tasks of data processing and hypothesis testing:

Task 1. Urban land transition and its relationship to other land transitions

We will evaluate urban land changes, including volumetric change, and its coupled relationships with other types of land from 1990s to 2020s, analyzing how globalization leads to hot spots of land transitions.

Task 2. Urban environmental changes (air pollution) patterns, drivers, and impacts

We will extract urban green space, surface air pollution data of PM<sub>2.5</sub> and NO<sub>2</sub>, and urban heat island and examine how their spatio-temporal patterns have been associated with urban land transformation, traffic congestion, and socio-economic activities, especially those related to local responses to globalization, in Bangkok, Manila, and Jakarta, compared with benchmark cities of Tokyo, Taipei and Shanghai.

Task 3. Divergent local responses to globalization

We will use partial least squares structural equations to model the relationships of globalization, urbanization, and the environmental. We also develop a driving force-flow-land transition-effect-feedback (DFLEF) model to examine 7 types of local responses to globalization:

- (1) FDI-driven industrialization (Metro Bangkok, HCMC, Laguna near Metro Manila)
- (2) FDI-driven service development (business processing outsourcing in Metro Manila)
- (3) Resource extraction export (Vientiane in Lao PDR)
- (4) Tourism driven development (Chiang Mai, Bagan in Myanmar, Bali in Indonesia)
- (5) International migration driven development (Cambodians and Burmese workers in Bangkok)
- (6) Remittance driven development (overseas remittance to Metro Manila)
- (7) Overseas aid driven development (Phnom Penh and Yangon)

This project contributes to the knowledge frontier and generates theories and models for the co-evolved relationships among urbanization, economic development, and

environment under globalization at multiple spatial scales. It integrates remotely sensed measurements with LCLUC, atmospheric models, and socioeconomic analysis and assists Southeast Asia to cope strategically with urban, land, and environmental changes under globalization.

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**Josh Gray/North Carolina State University**  
**Sowtime: Climate Adaptive Agriculture in the Eastern Gangetic Plains**  
**18-LCLUC18\_2-0025**

Agricultural transformations have increased food production five-fold in South Asia, but that progress has not been realized in the Eastern Indo-Gangetic Plains (EGP), a region spanning India, Nepal, and Bangladesh. Meeting future food demand while coping with climate change will require substantial adaptation by EGP farmers. But we know little about the nature or outcomes of agricultural adaptations by EGP farmers, and even less about future possibilities. Our proposed research will answer the question: What is the adaptive potential of smallholder agriculture in the EGP? Our central hypotheses are: 1) Smallholder farmers have already adapted to a changing climate by planting earlier, adopting faster maturing varieties, and switching crop types. 2) These adaptive practices have mitigated the effect of climate change on crop yields. And, 3) additional transformations will further increase crop yields and resilience but socioeconomic barriers prevent widespread adoption. We will test these hypotheses by combining innovative remote sensing analyses, statistical and biophysical crop yield modeling, in-region field data collection, and causal analyses of fused household survey and remote sensing datasets. We will quantify contemporary cropping patterns and practices, and the extent and spatiotemporal variation of adaptive strategy adoption with remotely sensed assets and available ground and administrative data from regional partners. The effect of future climate change under various scenarios of agricultural adaptation will be quantified using climate projections and yield models. These analyses are integrated with a household survey and choice experiments that will reveal farmer's attitudes towards climate change, adaptive agricultural practices, and the barriers to further transformation.

Our effort will produce annual cadence, finely resolved maps of crop types, including the characterization of multicropping rotations, the timing and duration of critical crop growth stages, and changes in these variables over the period 2001-present. No existing products map these variables at the scale of individual smallholder fields, and for the time period and temporal cadence necessary to evaluate the adaptive potential of the EGP. We will create these products using a newly developed approach to data fusion capable of assimilating a wide variety of heterogeneous satellite imagery, including newly available high resolution commercial assets. We will use phenology algorithms to extract the timing of growth stages, and emerging approaches to classification that use a Bayesian framework to assimilate existing heterogeneous crop type maps and ancillary data. Statistical and biophysical crop yield models will be fit, driven by historical weather and downscaled climate projections, and used to quantify the climate mitigating effects of adaptive practices. Our household surveys and analysis of map products will guide the design of realistic future scenarios of agricultural adaptation.

By characterizing and quantifying the adaptive potential of smallholder agriculture in the EGP, our study will support decision makers, regional food and water security, efforts to alleviate rural poverty, and the adoption of feasible climate adaptive strategies. Our project will further develop and apply innovative remote sensing methodologies such as data fusion and classification approaches, and will thus be useful to the broader remote sensing science community. Additionally, because the goals of our project are well-aligned with those of several large initiatives like SARIN, CIMMYT, and GEOGLAM, we expect our results to find a broad audience with the means and impetus to ensure they support on-the-ground change, and ultimately, a more sustainable and resilient food future for the EGP.

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**Geoffrey Henebry/Michigan State University**

**Atmospheric Teleconnections and Anthropogenic Telecouplings Drive Land Change in Central Asian Highlands: How Environmental Changes, Migration, and Remittances Threaten Montane Agropastoralist Livelihoods and Community Viability (18-LCLUC18-0038)  
18-LCLUC18\_2-0052**

Due to remoteness and sparse population, the highlands of Central Asia, particularly the Tien Shan and Pamir mountain ranges, have not received the amount of scientific investigation that they merit. In particular, this region can be regarded as a climate change hotspot as a result of being influenced by multiple climate oscillations. The last two IPCC Assessment Reports pointed out the paucity of information on the actual and potential impacts of climate change on natural and human systems. Our LCLUC project builds on our prior research findings in the region support to advance understanding of the land change occurring in the rural highlands of montane Central Asia due both to changing environmental conditions and socioeconomic processes. Our study region encompasses all highland pastures between 1800 and 4800 m amsl in the Tien Shan and Pamir mountain ranges in Central Asia. This area includes much of Kyrgyzstan (92.3K km<sup>2</sup>) and Tajikistan (56.3K km<sup>2</sup>), and smaller portions of Kazakhstan (15.1K km<sup>2</sup>), Uzbekistan (12.6K km<sup>2</sup>), and Turkmenistan (158 km<sup>2</sup>). The project's three key questions are: (1) How, where, and when do changes in environmental drivers affect pasture productivity and land degradation? (2) How, where, and when do environmental changes (e.g., changing snow season, natural disasters, pasture degradation, risk perception) trigger/drive migration? and (3) How, where, and when do migration and remittances increase risk of pasture & land degradation? We focus on quantifying the various factors affecting migration out of the region, with a particular emphasis on pasture degradation (loss of productivity) and natural disasters, and the effects of feedback from urban to rural systems through migrant remittances back home. We leverage advances in Cubesat sensing in synergy with conventional sensor data to enhance the capacity for resolving land surface phenology and productivity dynamics. We also leverage ground data from a network of sites in Kyrgyzstan and Tajikistan collected by four teams over the past decade. We bring together US expertise in landscape ecology, quantitative remote sensing, and environmental demography with a team of young investigators from Central

Asia through the University of Central Asia and the Tajik Agrarian University. This project addresses multiple aspects of the current LCLUC call including: (1) Central Asia; (2) land degradation; (3) agricultural smallholders; (4) linkages between urban and rural populations that affect land change; and (5) international collaboration. This project builds upon recent LCLUC support to make major technical advances in characterizing, analyzing, and assessing landscape dynamics in mountain land systems where agropastoralism is the foundational rural livelihood.

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**Peter Potapov/University of Maryland, College Park**  
**Shifting Cultivation at a Crossroad: Drivers and Outcomes of Recent Land-Use Changes in Laos PDR**  
**18-LCLUC18\_2-0024**

In low-income countries of Southeast Asia shifting cultivation remains the dominant agriculture technique in remote upland areas, where rough terrain, low soil productivity, and lack of market access historically precluded the expansion of permanent agriculture. In recent decades, however, the use of shifting cultivation has declined rapidly across the region. Government policies, conservation agendas, and market forces all contribute to changes in the shifting cultivation landscape. The on-going debate regarding economic and environmental impacts of shifting cultivation transformation in Southeast Asia indicates considerable uncertainty. This transformation may produce a full spectrum of outcomes, from highly positive for the national economy to negative for local rural communities and forest ecosystems. The Lao People's Democratic Republic (Laos) presents a unique opportunity to examine transitions in smallholder shifting cultivation extent and intensity while also investigating the socio-economic drivers reshaping rural agricultural practices. In the forested upland regions of Laos, shifting cultivation is still the dominant land-use practice due to limited access to markets, low population density, and surplus of forest lands. While shifting cultivation was practiced in the region sustainably for thousands of years, recently its future appears to be at a crossroads. In addition to rapid population and economic growth, government market liberalization policies that promote the expansion of commercial agriculture and agroforestry have intensified land use pressures. Increasing demand for raw materials, specifically rubber, from neighboring countries are fueling land development and conversion of the former community shifting cultivation lands into rubber and timber plantations. Village resettlement and expansion of concessions, both for permanent agriculture and rubber plantations, reducing land access for the poorest farmers.

The overarching goal of the proposed study is to quantify trends in the evolution of smallholder shifting cultivation systems, to understand drivers of these changes, and to predict their environmental and social outcomes. To reach this goal, the proposed project will (I) map shifting cultivation activities annually, and quantify changes in their extent and rotation intensity over the last three decades, from 1988 to 2018; (II) examine how changes in shifting cultivation extent and intensity correspond to changes in population well-being at the national scale; and (III) document and explain the consequences of transformation in shifting cultivation landscapes at the community level. The proposed study will assess and compare different evolutionary paths of shifting cultivation in

Northern and Southern Laos, two regions that are pervasively dominated by smallholder farming but within different economic and conservation policy contexts. We will integrate data derived from remotely sensed imagery and socio-economic surveys to better understand the underlying causes of changes in shifting cultivation systems and provide tools for monitoring and predicting these transitions. Our project is innovative in that it will combine a high-resolution analysis of land use change trajectories with the study of rural livelihoods at multiple scales. The study will employ a broad conceptualization of multidimensional poverty to better understand how changes in agricultural practices affect human well-being. As an output, we will provide a summary of the rates of change of traditional shifting cultivation practices due economic, policy and demographic factors during the last three decades. This study will contribute insights into the fundamental linkages between regional land use change dynamics, rural development policies, and rural livelihoods, while also producing information relevant to the development of more meaningful forest management practices.

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**David Skole/Michigan State University**

**New Transitions in Smallholder Agricultural Systems that Promote Increased Tree Cover Outside of Forests**

**18-LCLUC18\_2-0041**

Scientific reports are calling attention to an apparent global LCLUC trend where tree cover is increasing in small holder agricultural landscapes. Evidence suggests that while forests world-wide are being converted and degraded, tree cover outside of forests may be increasing at a rapid pace, especially in developing countries and in semi-arid agricultural landscapes. Systems of trees outside of forests (TOF) include agroforestry complexes, small-holder plantations, orchards, energy farms and woodlots, hedgerows and shelterbelts, scattered individual trees and other woody perennial establishments in predominantly small holder agricultural landscapes. This project will quantitatively examine the notion of increasing TOF in small holder agriculture landscapes of India. We shall also examine the farmer processes that promote increases in TOF in small holder agriculture systems. The conventional wisdom for more than two decades has been to see LCLUC in Asia through a lens of agricultural expansion and concomitant loss of natural ecosystems. Moreover, land degradation is viewed as a dominant characteristic of agricultural land use in Asia. When viewed this way we often overlook how significant increases in tree cover in small holder agricultural landscapes is to our understanding of carbon sequestration, new transitions and drivers of LCLUC, and the needs of policy and development communities. This project is central to understanding where and how natural ecosystem conversion and land degradation are being reversed.

This project examines the following hypotheses, using India as a test: (1) Throughout Asia, especially in semi-arid landscapes, there is a trend toward increasing stems and biomass in systems of trees outside of forests (TOF), and (2) Small holders, generally in semi-arid agricultural landscapes, promote the establishment of TOF to capture the value of ecosystem services (ES). which include (a) perceived or realized co-benefits of trees, such as increasing water retention, and (b) direct value from tree products, such as food

and fuel. The project focuses two on objectives: (Obj 1) Develop and deploy a remote sensing detection and inventory approach to TOFs in agricultural land, with a focus on mapping individual trees and small tree patches which are not in forest. This objective will be able to quantify a trend of increasing tree cover in agricultural landscapes. (Obj 2) Integrate methods from economic analysis to determine the factors that are driving these trends using quantitative econometric valuation of ecosystem services to ascertain if there is a correlation between increases in tree cover and high financial valuation of ES. Although some literature has begun to document TOF, few have deployed large area mapping, few have also looked at the drivers, and none have yet to formulate a systematic framework or theory of land transitions in these landscapes.

The first component of research involves remote sensing to detect and measure the area of TOF through a combination of Landsat-class data and hyperspatial (0.6-1m) data. The second component involves field surveys and econometric analysis to assess small-holders economic valuation of ecosystem services (ES) in their promotion of TOF. Our methodological to tackle the problem of TOF detection and quantification is a convergence of observations approach that analyzes the agricultural landscapes in five states in three broad measurement Tiers. A Tier 1 analysis deploys fractional tree cover (fC) mapping using sub-pixel spectral unmixing of Landsat data. A Tier 2 analysis is direct mapping of three TOF geometries using 6m LISS IV data. A Tier 3 analysis is an object-based image analysis (OBIA) with 0.6-1.0m hyperspatial data to map individual trees in the TOF spatial geometries. We then deploy quantitative econometric analysis of Ecosystem Services valuation to inform the processes of smaller holder promotion of TOF in agriculture.

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**Lin Yan/South Dakota State University**

**Forced and Truncated Agrarian Transitions in Asia Through the Lens of Field Size Change**

**18-LCLUC18\_2-0040**

This proposal is directly responsive to the NASA NNH18ZDA001N-LCLUC call to address "Land-Use Transitions in Asia" and in particular to those "in smallholder agricultural systems". The research characterizes field size changes extracted from medium and high resolution satellite data and investigates them with social science research methods. Rice growing areas in northeastern Thailand, Red River Delta in Vietnam, and Jiangsu Province in China, which are at different stages of agrarian transition, level of development and have different land tenure regimes, will be considered. The main tasks are to (#1) extract fields from moderate resolution contemporary Landsat-8 and Sentinel-2 data acquired circa 2020, (#2) extract fields from commercial high resolution data acquired circa 2010 and 2020, (#3) extract fields from declassified Corona data acquired circa 1970, (#4) characterize the spatio-temporal distribution of field sizes and their changes, (#5) quantify how biophysical and socioeconomic variables influence field size evolution and the agrarian transition, and (#6) Examine the relationship between field size and crop yield per unit of land. The proposed research is novel, timely and important. Comparison of agrarian transition

under different land tenure regimes has not been undertaken before. Forced transition in China and Vietnam may foreshadow transitions in the rest of Asia.

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