



# Large-Scale Land Transactions as Drivers of Land-Cover Change in Sub-Saharan Africa

Dan Brown, Arun Agrawal, Jane Southworth

Chuan Liao, Suhyun Jung, Jon Sullivan, Nathan Chesterman, Sadie Trush, Carly Muir





# Insufficient Research on Land Grabs

- Global data sets on land transactions underestimate the total number of transactions (e.g. LMI=92, Ethiopia=833)
- Not all transacted land is implemented as intensive agriculture
- Non-representative samples confound conclusions about effects of geography, socioeconomic differences, and contractual arrangements

Liao, Jung, Brown, & Agrawal (2016) *Science*, 353(6295).

**INSIGHTS**

**LETTERS**

*Edited by Jennifer Hsia*

### Science stands by 2009 fisheries study

THE EDITORS OF *Science* have become aware of allegations of conflict of interest that Greenpeace has lodged against Ray Hilborn for failing to disclose previous industry funding in connection with his co-authorship of the 2009 *Science* paper "Rebuilding global fisheries" by Worm et al. (1). In fact, it is not possible to conclude that Dr. Hilborn or other co-authors were personally deficient in their disclosures. At that time, journal policy allowed a single lead author to declare conflicts of interest on behalf of all co-authors, a practice that has since been discontinued. Current journal practice requires each author individually to declare any and all relationships (financial or otherwise) that could constitute a real or perceived conflict of interest. Although the policies in place in 2009 may not have resulted in the transparency we have come to expect in 2016, the editors of *Science* stand by the basic conclusions reached in the Worm et al. paper. A group of international fisheries researchers came together from different perspectives to reach consensus on the status of the best-studied marine ecosystems worldwide and agree on solutions and challenges to rebuilding fisheries stocks and achieving sustainable yields.

**Maurice McVitt**  
Editor in Chief

**REFERENCE**

1. R. Worm et al., *Science* **325**:578 (2008).

10.1126/science.1251754

### Insufficient research on land grabbing

OVER THE PAST decade, an unprecedented boom in land transactions—commonly referred to as land grabbing—has occurred globally. At least 46 million hectares of land have changed hands through concessions, long-term leases, and ownership transfers (1, 2). Driven by volatility in agricultural commodity prices, interest in biofuel production, and eagerness of governments to pursue economic development, transnational and domestic investors have acquired land throughout the global



The company Small Star Agricultural Development transports water on the land it has bought in Ethiopia.

South (3). Resulting changes in control over land threaten existing vegetation cover and forests, especially where the new owners successfully implement commercial agricultural production. Changes in control over land can support greater agricultural output, but research on the subject has mostly raised urgent concerns about transactions leading to displacement of local livelihoods and populations (4), and compromised ecosystem services (5).

The effectiveness of research on land transactions, however, is hobbled by three problems. First, global data sets on land transactions underestimate the total number of transactions. Official statistics for Ethiopia, Peru, and Cambodia show that the number of transactions are consistently underestimated in global data (5). Second, it is difficult to calculate how much commercial agriculture is taking place because not all of the transacted land is being developed. Many investors, witnessing the rise in large-scale land transactions, have made speculative investments in land that they hope later to sell for a profit. In many other instances, local residents living in and near transacted lands have resisted the implementation of commercial agricultural practices (6). Third, findings reported in the literature rest largely on samples that are not statistically representative of the variation in factors such as geography, socioeconomic differences, and contractual arrangements that influence outcomes. Instead, they focus on social dimensions of transaction outcomes such as fairness and inequality (7). These are important to consider, but the current dominant focus on social outcomes needs to be supplemented with a greater consideration of ecological outcomes and effects on agricultural output.

A deeper understanding of land transaction outcomes requires studies that are more representative of the range of transactions. More systematic attention to case selection and causal effects of tenure

changes is necessary to address research limitations (8). Improved representation will also enable more robust estimates of social, economic, and ecological effects of transactions (5).

**Chason Liao, Subgryn Jung, David G. Brown, and Arun Agrawal\***

School of Natural Resources and Environment,  
University of Michigan, Ann Arbor, MI 48109, USA.  
\*Corresponding author. E-mail: arun@umich.edu

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1. R. Worm, S. M. Branch, R. Hall, S. Gaines, & Wilton, J. *Planet Earth*, **38**: 523 (2012).
2. J. Capistrano, *Global Policy Feed Agric. Food Land* **11**: 114 (2011).
3. M. A. Williams, & Herrogsson, P. *Global. Policy Econ.* **13**: 84 (2012).
4. R. E. Lovell, K. N. M. E. Hall, L. Pachara, P. O'Connor, *Hum. Dev.* **4**: 777 (2015).
5. Large Scale Land Transactions as Drivers of Land Cover Change? Sub-Saharan Africa (<http://www.worldagroforestrycentre.org/Products/long-scale-land-transactions-as-drivers-of-land-cover-change-in-sub-saharan-africa/>).
6. R. Hall et al., *Planet Earth*, **42**: 467 (2015).
7. K. Anton, *Legal Inquiry World* **44**: 104 (2014).
8. M. W. Jones, C. Lee, S. Gomez, J. Wilkinson, *Gen. J. Dev. Stat. Soc. Can. Statist. Div.* **31**: 403 (2011).
9. *Agricult. Proc. Natl. Acad. Sci. U.S.A.* **111**: 10092 (2014).

10.1126/science.1251754

### Mexico struggles to keep foreign grants

IN HER NEWS In Depth story "Mexico struggles to woo export genome jocks" (15 April, p. 507), L. Wade discusses the bureaucratic hurdles that are slowing research in Mexico. We would like to highlight a hurdle not mentioned in the story: Researchers at social outcomes needs to be supplemented with a greater consideration of ecological outcomes and effects on agricultural output.

Although not always successful, as Wade points out, the Mexican government has gone to great effort to make funds available for local researchers. More worrisome are

SCIENCE sciencemag.org

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Downloaded from <http://science.sciencemag.org/> on April 6, 2017

# Extant Narratives

“Land Grabs”



Harvey, 2004. The “New” Imperialism: Accumulation by Dispossession.

“Agricultural Intensification”



Ittersum et. al., 2016. Can sub-Saharan Africa feed itself? *PNAS*, 113(52) 1–6.

# Project Objectives

## Large Land Deals

*Obj 1:* Collect spatial data on large deals

### Q1: Variation in Patterns of Deals

*Obj 2:* Assess variation in deal profiles across sub-national spatial units

### Q2: Socio-ecological impacts

*Obj 3:* Analyze forest and land-cover impacts  
*Obj 4:* Analyze economic and livelihood impacts

### Synthesis

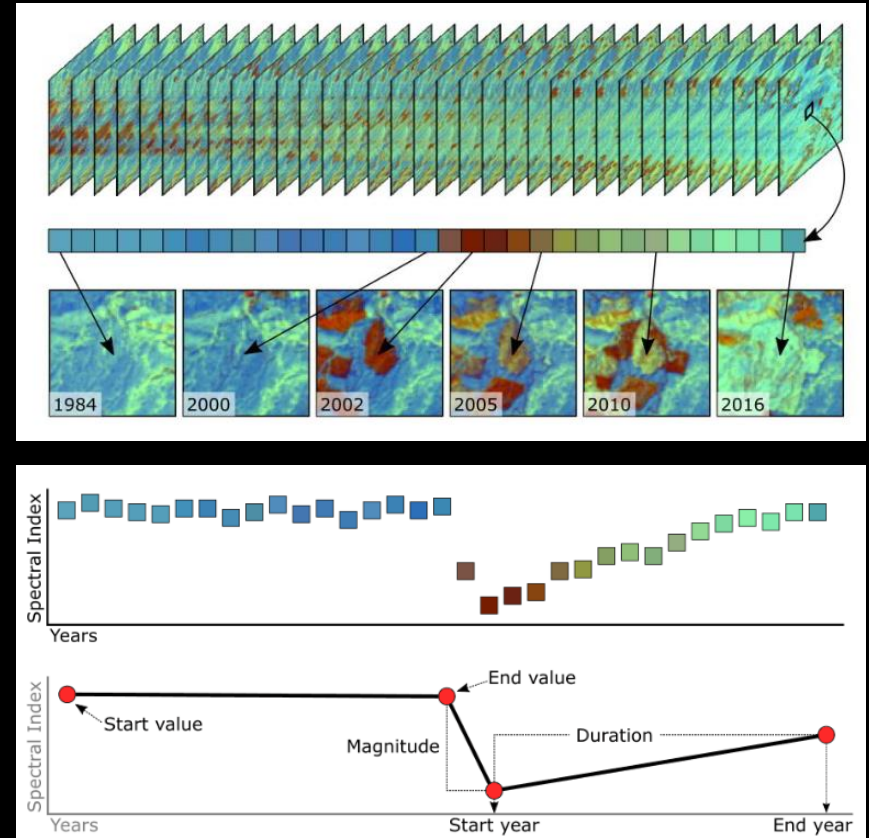
*Obj 5:* Incorporate large-scale land tenure changes into conceptual frameworks on synergies and tradeoffs in LCLUC outcomes.

# Q1: Detecting Transactions

- Boundary data for **tenure changes** difficult to acquire
  - often either over or under-estimate **implementation area**
- Joint workshop with Land Matrix Initiative (LMI) Oct 2018
  - Collaborations initiated with LMI, JRC

Yan & Roy (2014); Graesser & Ramankutty (2017); Yin et al. (2018); Kennedy et al. (2010); Kennedy et al. (2018)

## *Phenological Signatures*

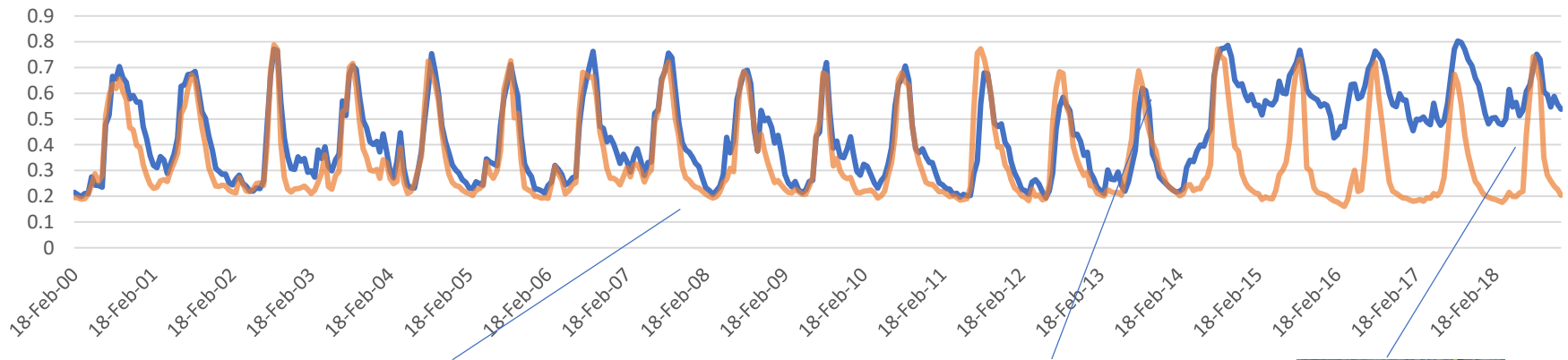


Goal is to identify area and timing of implementation



# Compared to Smallholder Systems in Ethiopia

Trajectory 1 – Smallholder Agriculture to Intensified



— Transaction — Control

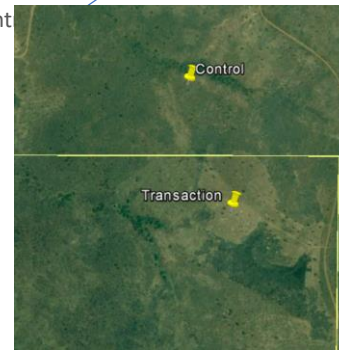
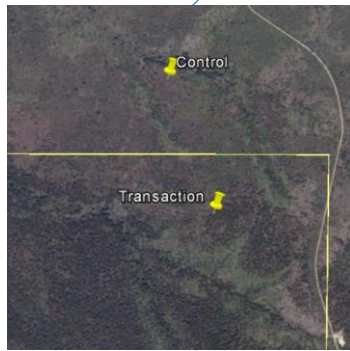
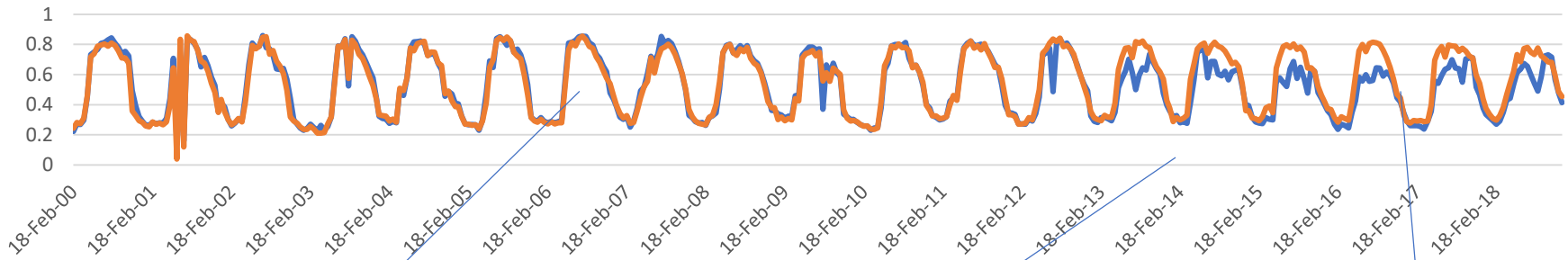
- Control sites from Transaction vs sites from inside the
- Located in the Rift



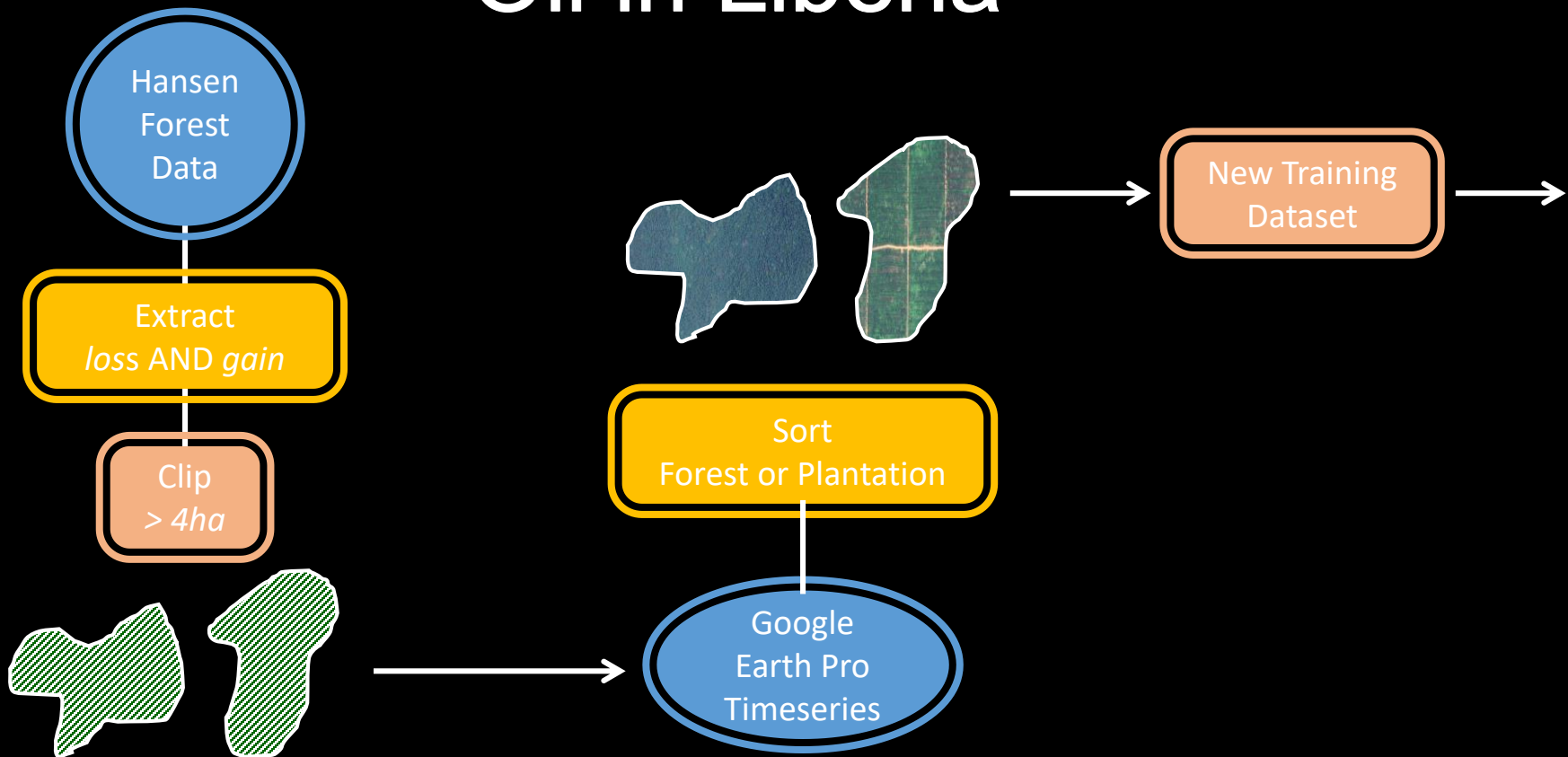
Analysis: Carly Muir, UFI

# Compared to Woody Savanna/Forest in Ethiopia

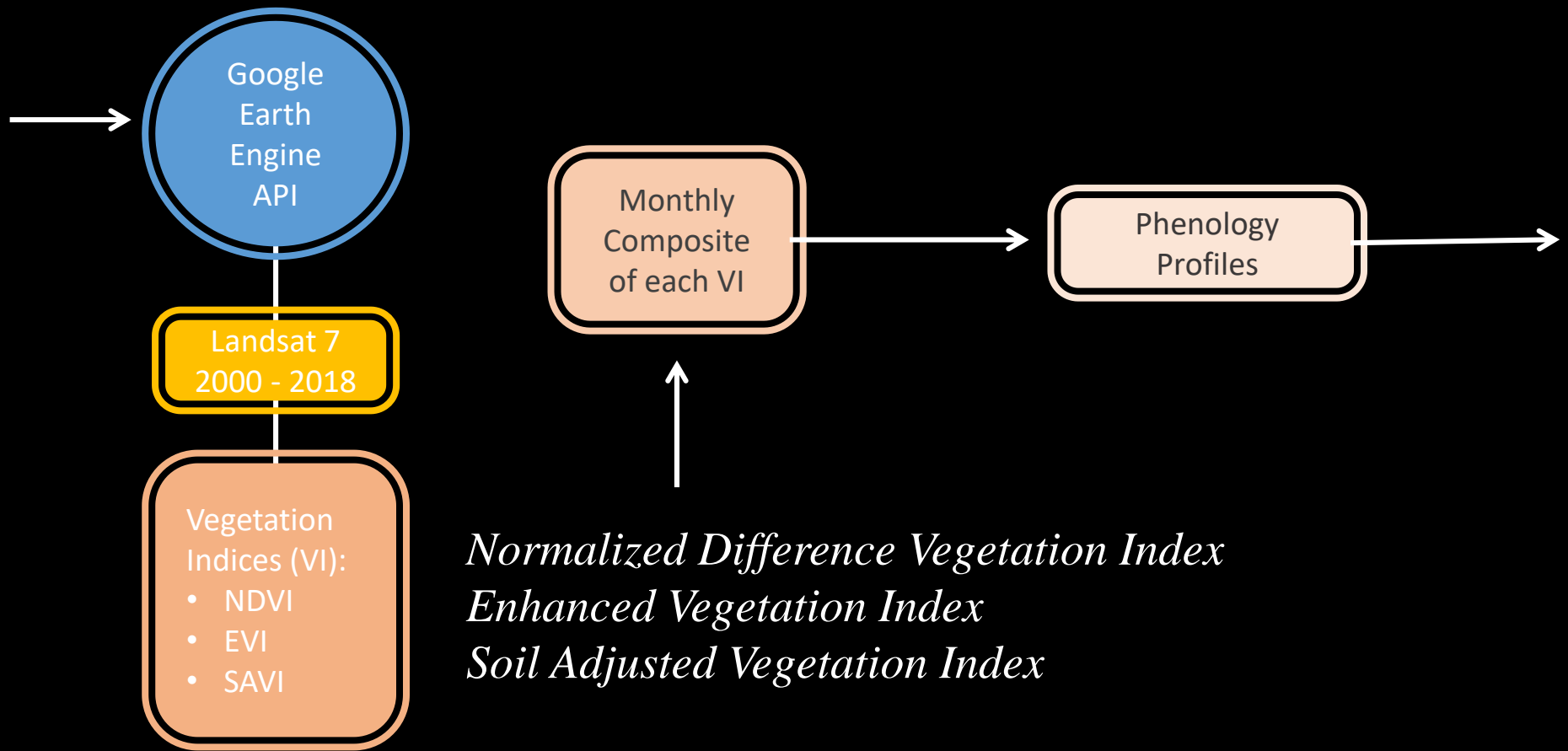
Trajectory 2 - Woody Savanna/Forest to Intensified



# Distinguishing Forest and Palm Oil in Liberia

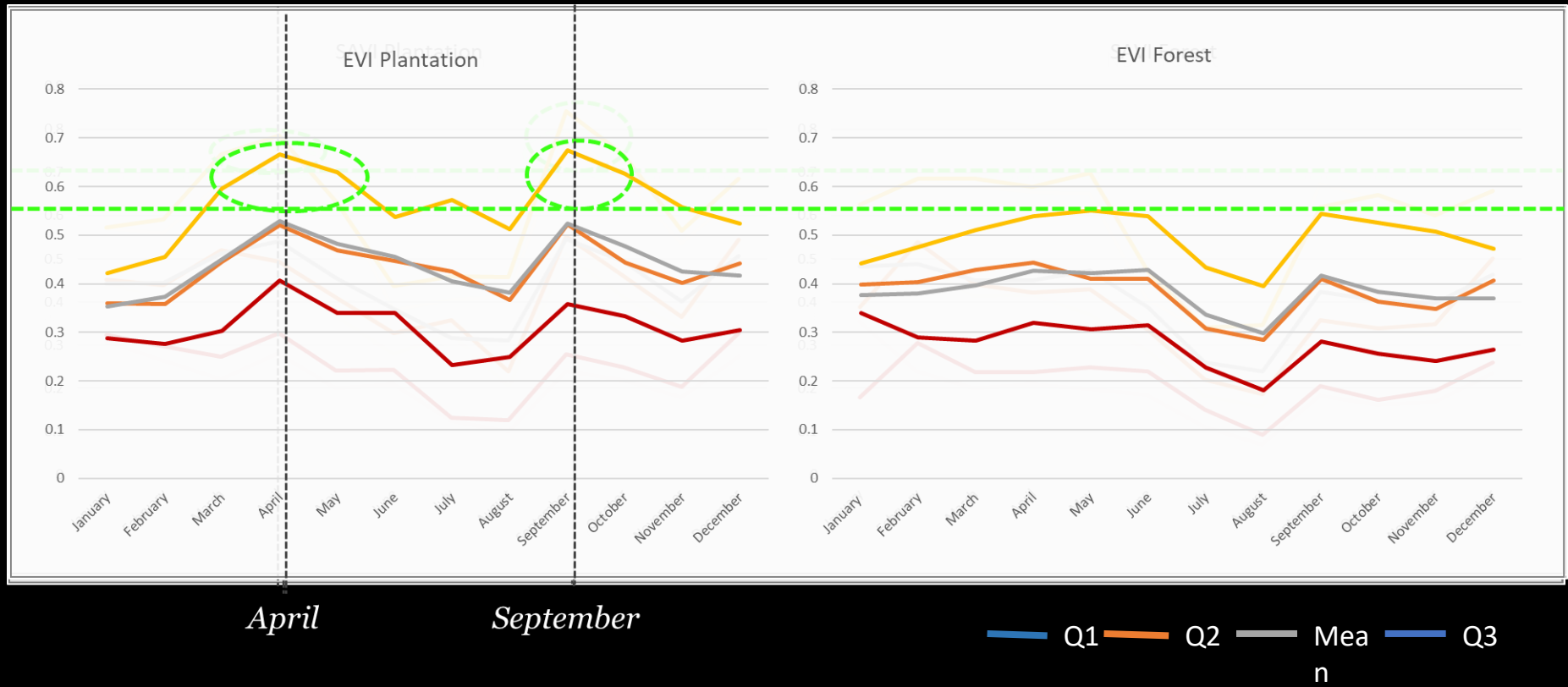


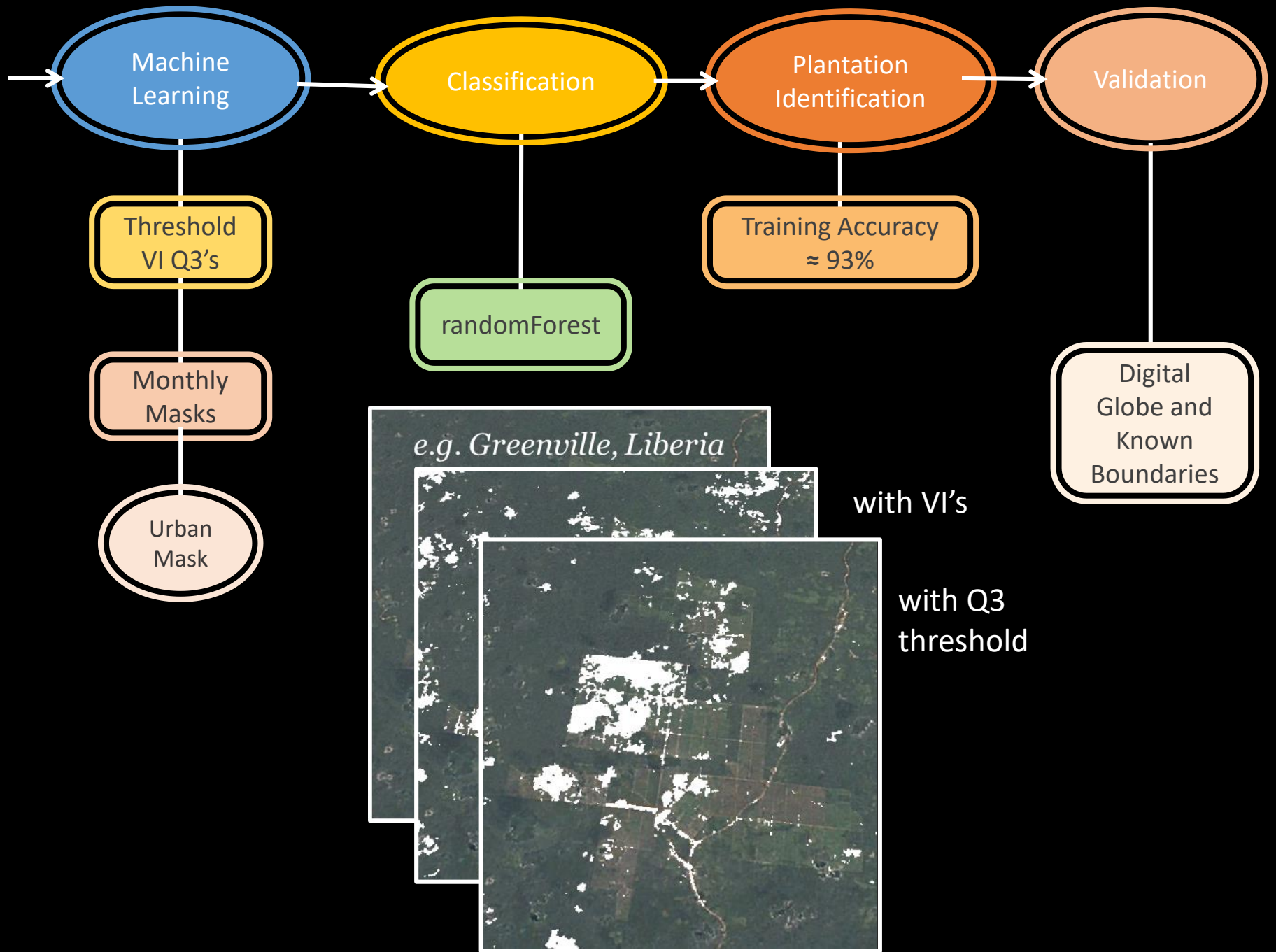




*Normalized Difference Vegetation Index*  
*Enhanced Vegetation Index*  
*Soil Adjusted Vegetation Index*

# Phenology Profiles







# Q2: Site-Based Analysis

## Identify Treatment and Control Areas

Acquire CAD4NASA imagery

Eight sites in Ethiopia, and four each in Tanzania and Liberia

## LULC Classification

Segmentation-based manual classification

Manually mapping house of rooftops

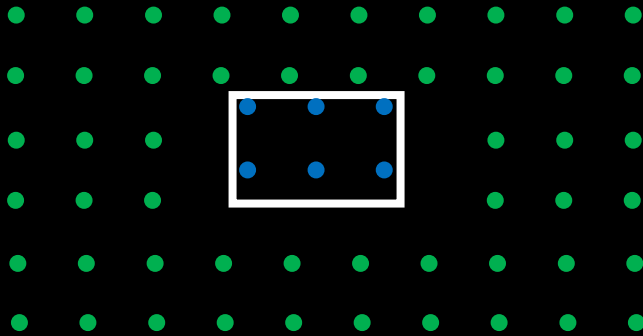
Testing *inter-rater variability* measure

## Social Surveys

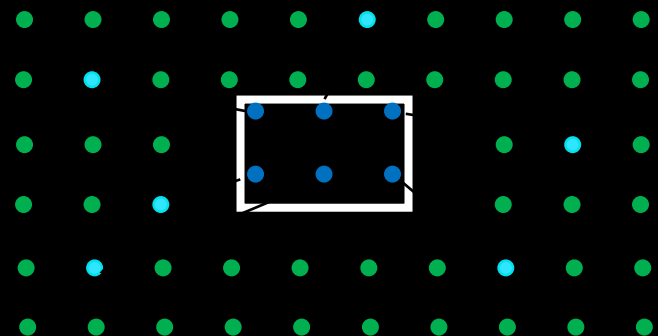
Collection of ~1200 household surveys in each country

# Propensity Score Matching

Before matching



After matching



Transacted area (treatment)

Buffered area (control)

- Systematic points in control area
- Systematic points in treatment area



Transacted area (treatment)

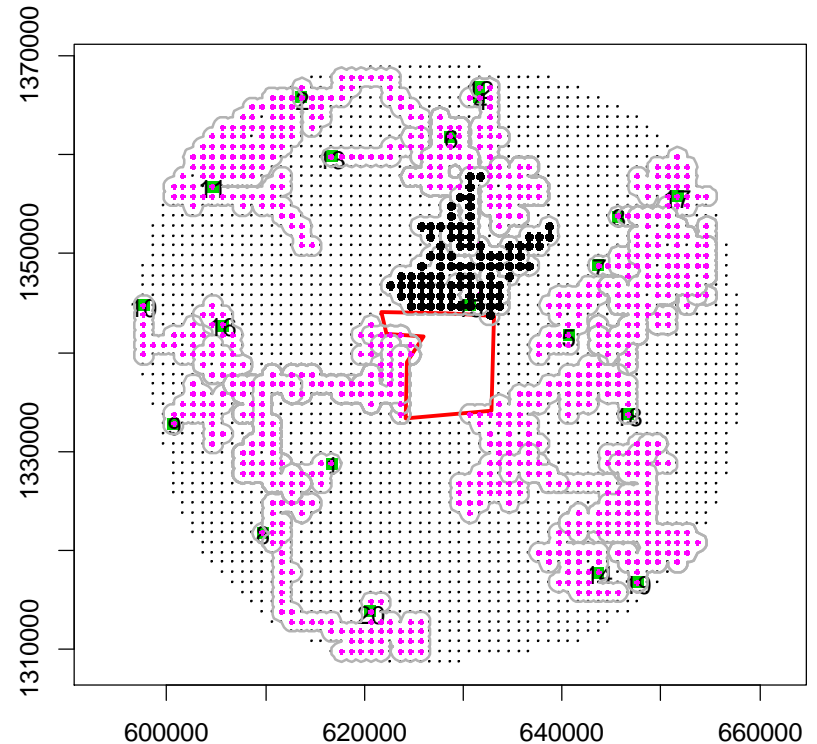
Buffered area (control)

- Non-matched points in control area
- Systematic points in treatment area
- Matched points in control area

# Polygon-based Matching

Grow 20 polygons as candidates

[1] "Number of iteration: 1"	[1] "Number of iteration: 11"
[1] "Difference: 38.0269373455795"	[1] "Difference: 138.555676152362"
[1] "Number of iteration: 2"	[1] "Number of iteration: 12"
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[1] "Difference: 5.2277974333028"	[1] "Difference: 5.62500496549428"
[1] "Number of iteration: 4"	[1] "Number of iteration: 14"
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[1] "Number of iteration: 5"	[1] "Number of iteration: 15"
[1] "Difference: 4.79069891965021"	[1] "Difference: 0.401614156962953"
[1] "Number of iteration: 6"	[1] "Number of iteration: 16"
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[1] "Number of iteration: 7"	[1] "Number of iteration: 17"
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[1] "Number of iteration: 8"	[1] "Number of iteration: 18"
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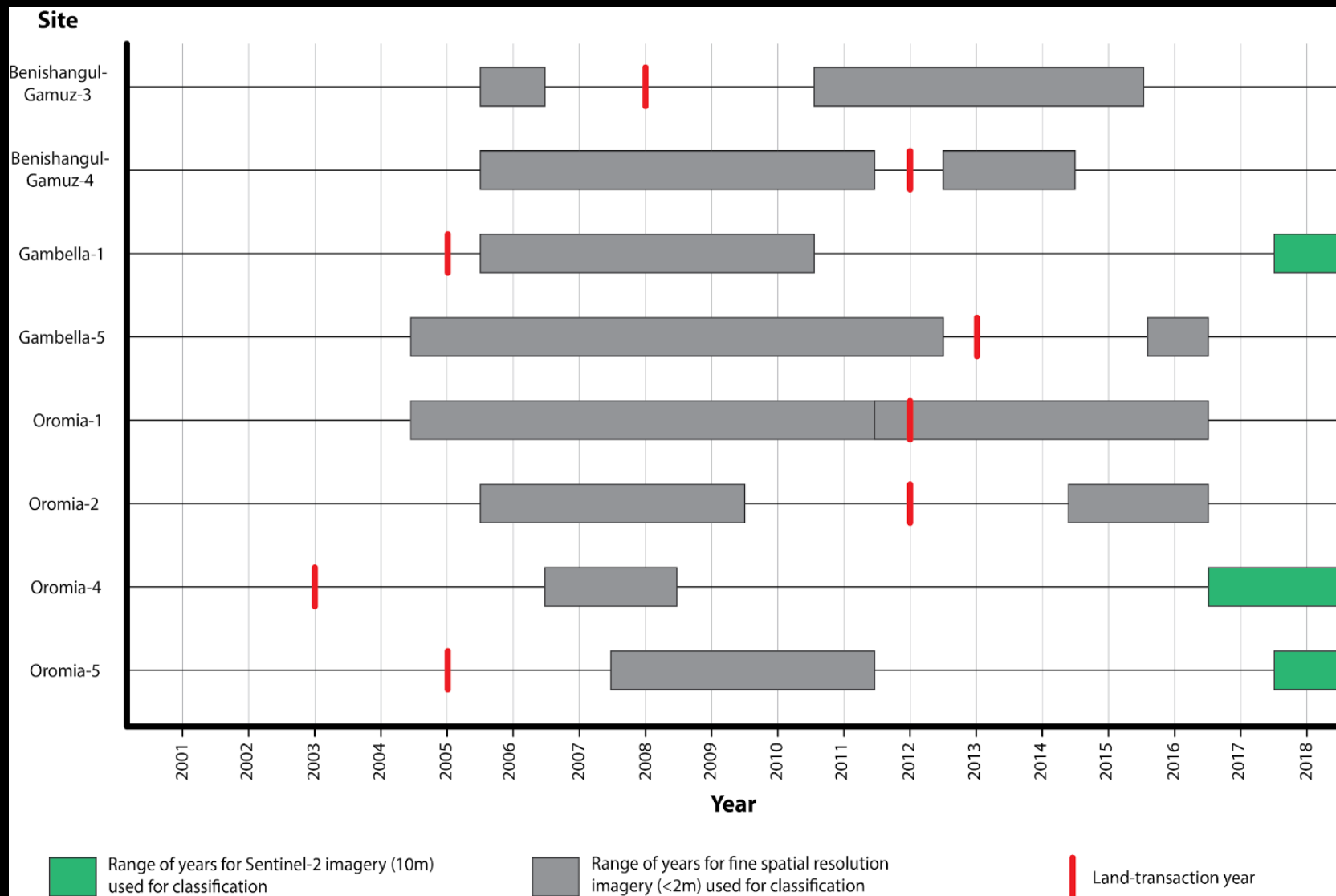


Purple points are those within all 20 candidate polygons

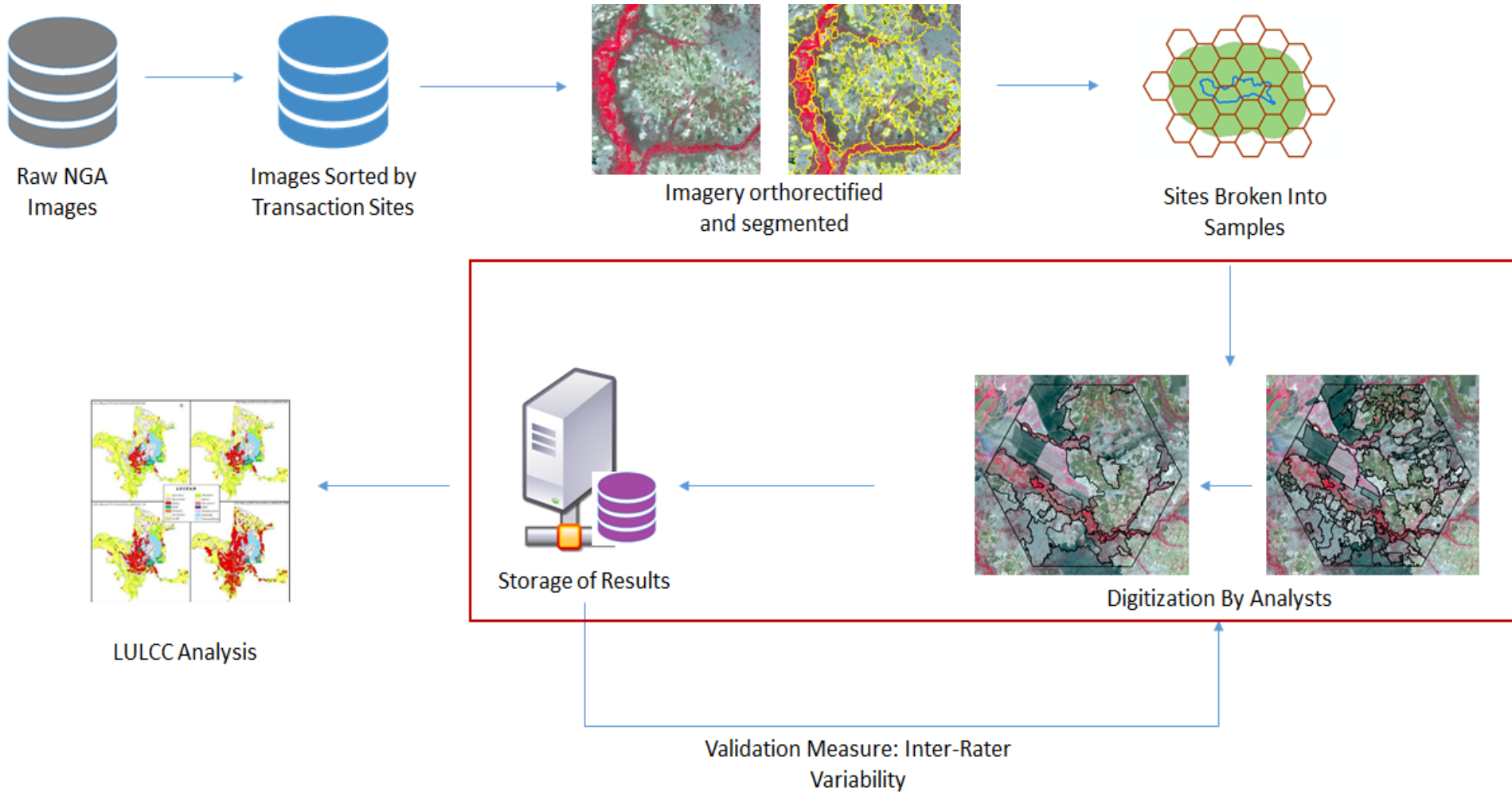
Black points (n=92) are those within polygon 15



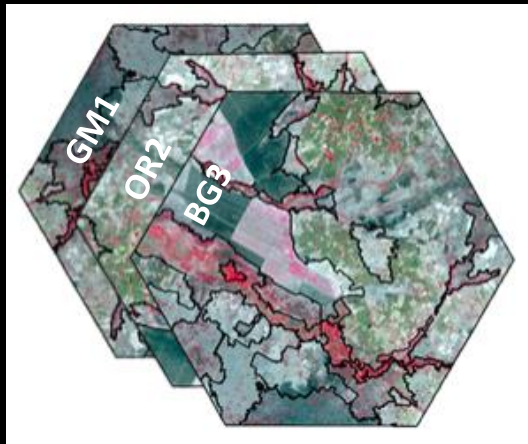
# CAD4NASA Acquisition Strategy



# Image Processing Workflow



# Inter-Rater Variability



Selection of polygons:  
GM1, OR2, and BG3

Classification  
by each  
analyst



Confusion Matrix,  
Contingency Tables  
and  
Comparative  
agreement statistic



Inter-rater agreement:  
72% from multi-spectral  
imagery, lower for pan

- (11) Small-holder Ag 80.5%
- (13) Intensive Agriculture 70.2%
- (21) Forest 58.4%
- (23) Woodland/Sav. 78.7%
- (32) Bare/Exposed Soil 34.3%
- (41) Rural Settlement 14.0%
- (42) Development 78.9%
- (51) Water 10.6%

Class	Validation Data					
	Woodland	Cropland	Built up	Bare soil	Water	UA (%)
Woodland	158	0	0	0	0	100.00
Cropland	31	173	0	0	0	84.80
Built up	1	8	200	9	16	85.47
Bare soil	1	0	0	191	0	99.48
Water	9	19	0	0	184	86.79
PA (%)	79.00	86.50	100.00	95.50	92.00	
OA (%)	90.60		Kappa	0.8825		

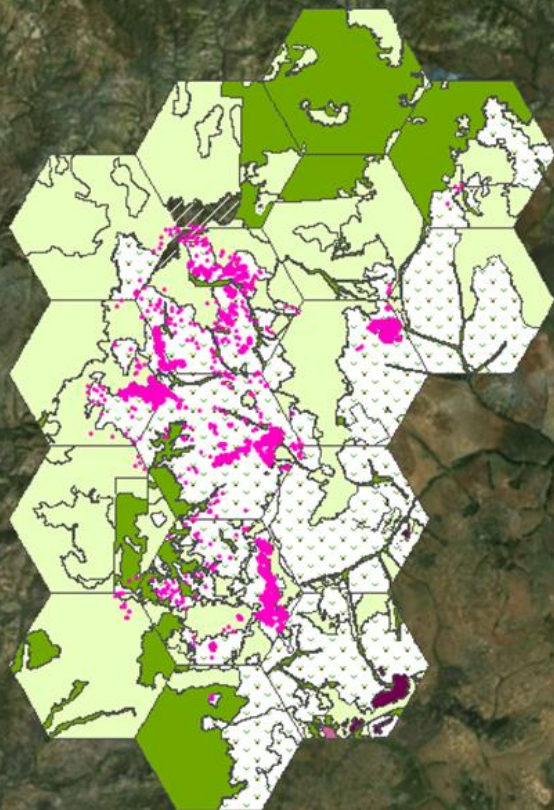


# One of Eight Ethiopian Sites

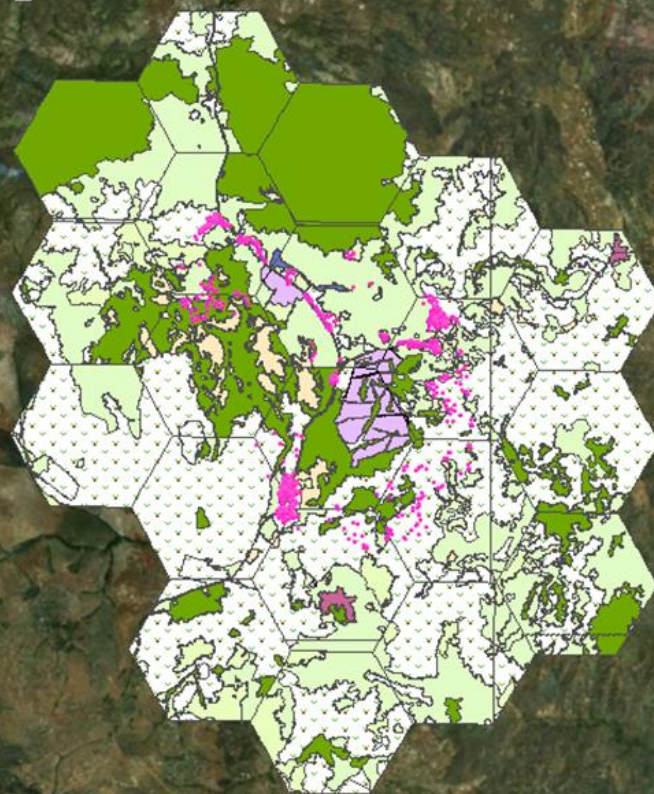
Control

Treatment

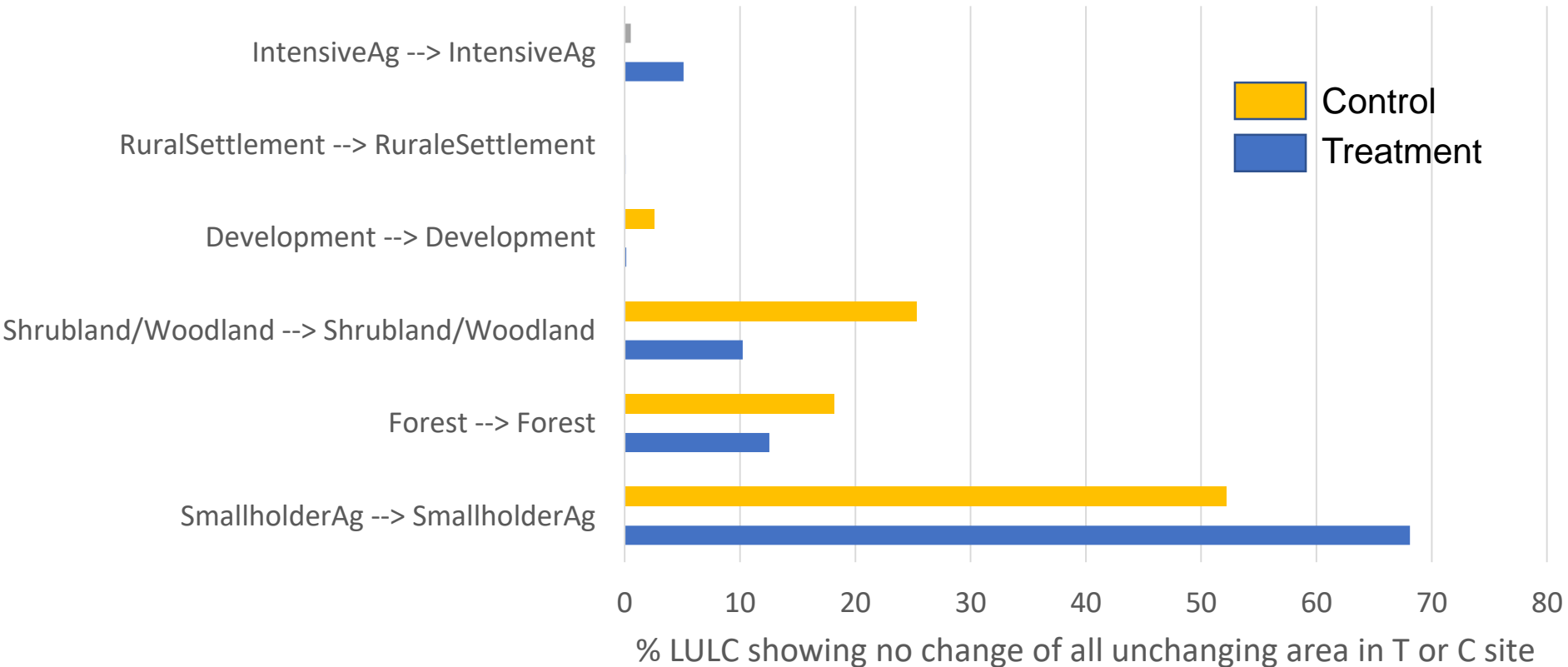
Post -



Post -



# Persistent Cover Types in Ethiopia

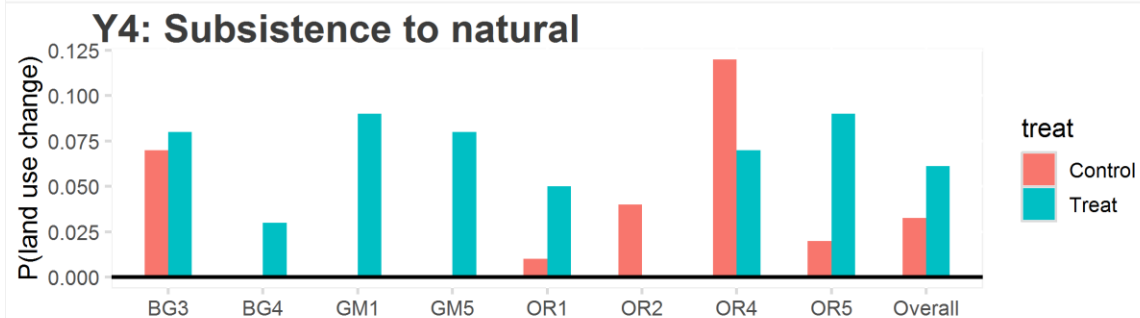
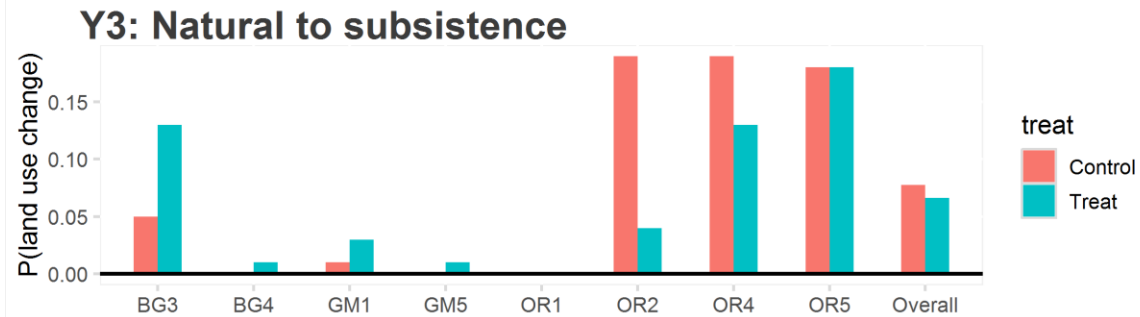
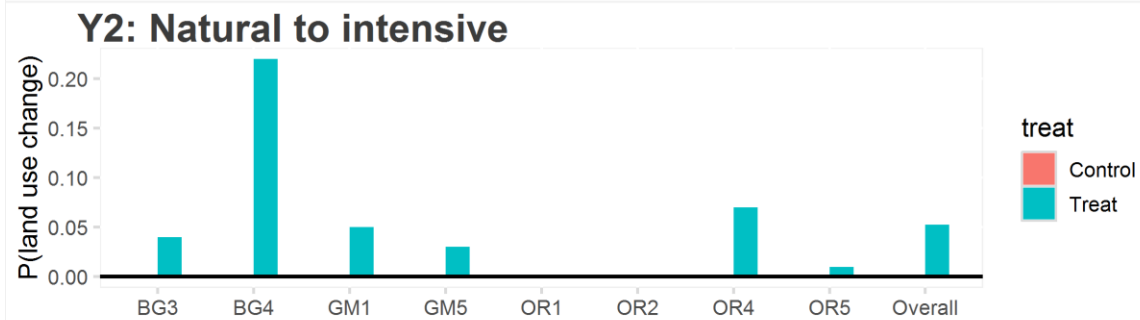
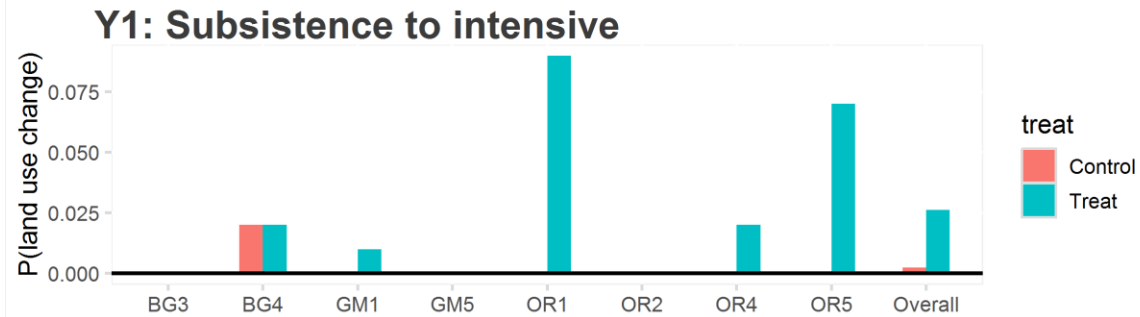


*Smallholder Ag persisted in **68% of Treatment sites** and **52% of Control sites**.*

# Prevalence of Transitions

- Treatments had more conversion to intensive ag
  - Controls had very little
- Also more abandonment of smallholder
  - Slightly less extensification

Preliminary Results





# Household Surveys



Status:

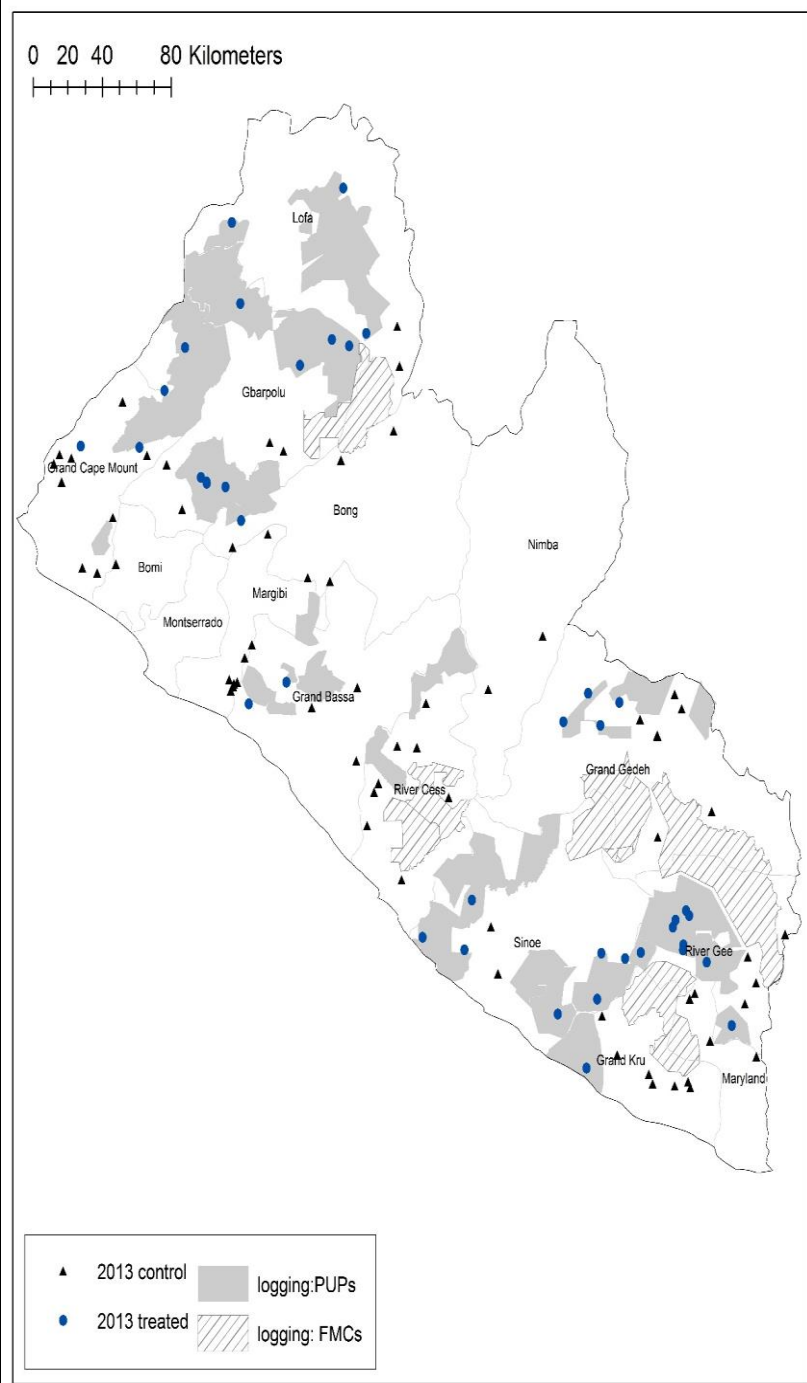
Liberia, complete

Ethiopia, stalled  
by civil unrest

Tanzania,  
underway

# Effects on Livelihoods in Liberia

- More than 45% of total land area is under some type of concessions
- Forestry concessions
  - 7 Forest Management Contracts (FMCs)
    - larger and have not been fully implemented
  - 39 Private Use Permits (PUPs)
    - smaller and have been fully implemented
- We evaluated livelihood impacts
  - DHS asset-based wealth index (electricity, tv, table, water source, floor, roof, etc)
  - 2007, 2009, 2011, 2013



- Treatment group
  - Household clusters within 2km of concession boundaries
- Control group
  - Household clusters between 2km and 10km from concession boundaries
  - Sensitivity check: up to 12, 14km

# Estimation Results – Wealth index

Results show :

- **Higher** wealth for households living closer to *active* forest concessions
- Driven by demand for goods and services and increased employment in all-year and non-subsistence jobs.
- Could be short-lived

# Q3: Synthesis Activities to Date

- Invited workshop on Land Transactions, Ann Arbor, April 2016
  - Focus on bridging qualitative-quantitative approaches, and case studies to generalized patterns.
- Organized session at AAG, Boston, April 2017
  - Focus on Coupled Human-Natural Systems
- Workshop on Remote Sensing of Land Transactions with Land Matrix Initiative, Bern, Switzerland, Oct 2018
- Organized session at AAG, Washington DC, April 2019
- Organized session at GLP, Bern, Switzerland, April 2019
- Planned Special Issue, manuscripts due Sept 2019.
- High-profile synthesis publications.



# Thank You

