The Environmental Impacts of Microfinance: Index-Based Livestock Insurance and East African Rangelands

August 2, 2024, New Delhi, India

Christopher B. Barrett, Cornell University

Co-authors: Steven W. Wilcox (lead author), Nathaniel D. Jensen, Patrick Clark, Francesco Fava, Njoki Kahiu, Gerardo E. Soto, Ying Sun

Funding: Bioversity and CGIAR Standing Panel on Impact Assessment

Motivation

- Growth in microfinance to address missing, or weak financial markets and reinforce social protection.

Motivation

- Growth in microfinance to address missing, or weak financial markets and reinforce social protection.

- Agricultural index insurance is one widespread microfinance product.

Motivation

- Growth in microfinance to address missing, or weak financial markets and reinforce social protection.
- Agricultural index insurance is one widespread microfinance product.
- An important, understudied issue: *Does microfinance have unintended environmental impacts?*

Motivation

- Growth in microfinance to address missing, or weak financial markets and reinforce social protection.
- Agricultural index insurance is one widespread microfinance product.
- An important, understudied issue: *Does microfinance have unintended environmental impacts?*
- Theory is ambiguous. Effects could be + or - .

Motivation

- Growth in microfinance to address missing, or weak financial markets and reinforce social protection.
- Agricultural index insurance is one widespread microfinance product.
- An important, understudied issue: *Does microfinance have unintended environmental impacts?*
- Theory is ambiguous. Effects could be + or - .
- Sparse empirical work, in large part due to data constraints.

Motivation

- Growth in microfinance to address missing, or weak financial markets and reinforce social protection.
- Agricultural index insurance is one widespread microfinance product.
- An important, understudied issue: *Does microfinance have unintended environmental impacts?*
- Theory is ambiguous. Effects could be + or - .
- Sparse empirical work, in large part due to data constraints.
- Downside especially worrisome for index-based livestock insurance (IBLI). Upside would expand microfinance's enumerated benefits.

Index-Based Livestock Insurance (IBLI): purpose and impacts

- IBLI is a successful micro-insurance product that has scaled from an ILRI-run pilot to 4 countries and growing:

  – product addresses missing financial services access and catastrophic drought-related herd mortality associated with poverty traps in East African pastoralist communities.

  – contracts provide 12 months' coverage across 2 rainy/dry season sales and payout periods; NDVI-based index; pilots in 2010, 2012, w/broad expansion after.

Index-Based Livestock Insurance (IBLI): purpose and impacts

- IBLI is a successful micro-insurance product that has scaled from an ILRI-run pilot to 4 countries and growing:

  – product addresses missing financial services access and catastrophic drought-related herd mortality associated with poverty traps in East African pastoralist communities.

  – contracts provide 12 months' coverage across 2 rainy/dry season sales and payout periods; NDVI-based index; pilots in 2010, 2012, w/broad expansion after.

- *Big unknown: might IBLI induce the losses it seeks to insure against via negative impacts on rangelands?* rangeland defn.

  – theoretically ambiguous, w/ mixed evidence @ household level regarding sign of impacts on herd size and herding effort. (Matsuda et al. 2019, Jensen et al. 2017, Toth et al. 2017, Son 2021)

  – Models predict neg. effects (Bulte and Haagsma 2021; Jon et al. 2019)

Research question, data, and methods

<u>**Research Question:**</u> *Does IBLI impact rangeland quality? If so, what is the direction & magnitude of impact?*

Research question, data, and methods

Research Question: *Does IBLI impact rangeland quality? If so, what is the direction & magnitude of impact?*

Data: aggregated to index insurance units (11K km^2) and sub-watershed units, down to HUC-12 (125 km^2).

* IBLI: admin data on all semi-annual IBLI sales in East Africa 2010-2020

* Rangeland quality: remotely sensed rangeland health (RH) measures, 2000-2020: 30m land cover and fractional cover (Soto et al. 2024); 250m MODIS data; 5km SIF data

* Controls: weather covariates from gridded weather products.

Research question, data, and methods

Research Question: *Does IBLI impact rangeland quality? If so, what is the direction & magnitude of impact?*

Data: aggregated to index insurance units (11K km^2) and sub-watershed units, down to HUC-12 (125 km^2).

* IBLI: admin data on all semi-annual IBLI sales in East Africa 2010-2020

* Rangeland quality: remotely sensed rangeland health (RH) measures, 2000-2020: 30m land cover and fractional cover (Soto et al. 2024); 250m MODIS data; 5km SIF data

* Controls: weather covariates from gridded weather products.

Methods: *IBLI's staggered roll-out, exogenous to rangeland conditions, lends itself to new DiD methods (Gardner et al. 2024).* estimators

Research question, data, and methods

Research Question: *Does IBLI impact rangeland quality? If so, what is the direction & magnitude of impact?*

Data: aggregated to index insurance units (11K km^2) and sub-watershed units, down to HUC-12 (125 km^2).

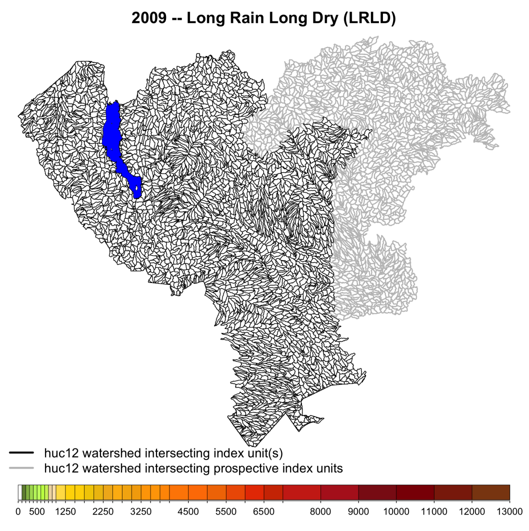
* IBLI: admin data on all semi-annual IBLI sales in East Africa 2010-2020

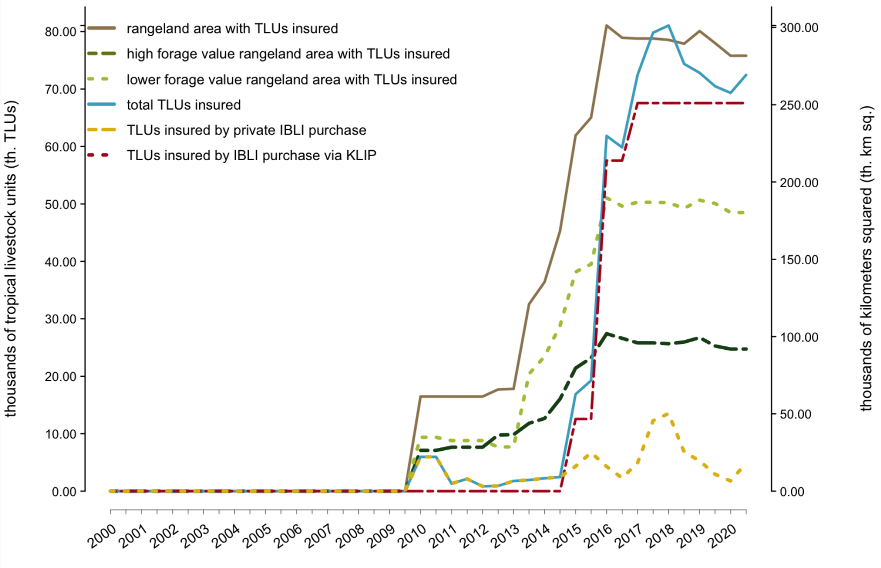
* Rangeland quality: remotely sensed rangeland health (RH) measures, 2000-2020: 30m land cover and fractional cover (Soto et al. 2024); 250m MODIS data; 5km SIF data

* Controls: weather covariates from gridded weather products.

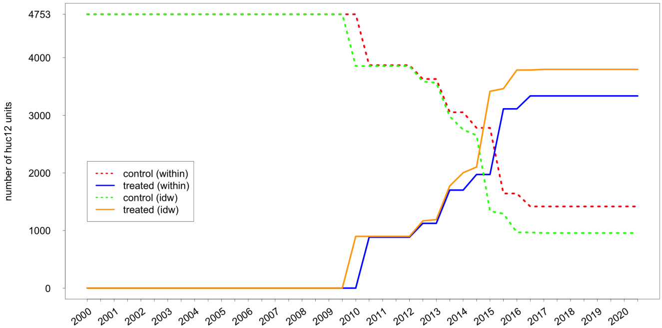
Methods: *IBLI's staggered roll-out, exogenous to rangeland conditions, lends itself to new DiD methods (Gardner et al. 2024).* estimators

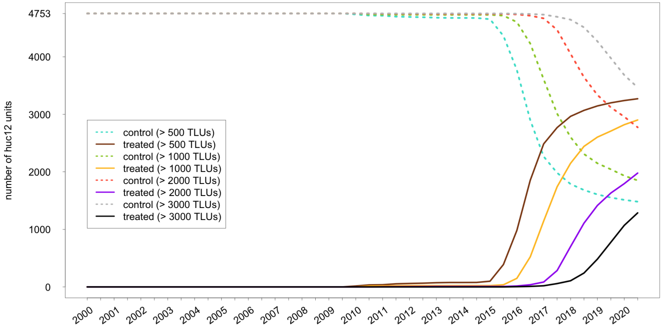
Treatment: binary variables reflecting margins of IBLI exposure (*down-scaled to sub-watershed units & inverse-distance weighted to incorporate spill-over effects from herder movement*). exposure


2009 -- Long Rain Long Dry (LRLD)
huc12 watershed intersecting index unit(s)
huc12 watershed intersecting prospective index units
0 500 1250 2250 3250 4500 5500 6500 8000 9000 10000 11000 12000 13000



rangeland area with TLUs insured
high forage value rangeland area with TLUs insured
lower forage value rangeland area with TLUs insured
total TLUs insured
TLUs insured by private IBLI purchase
TLUs insured by IBLI purchase via KLIP
thousands of tropical livestock units (th. TLUs)
thousands of kilometers squared (th. km sq.)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020


number of huc12 units
4753
4000
3000
2000
1000
0
control (within)
treated (within)
control (idw)
treated (idw)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020


number of huc12 units
4753
4000
3000
2000
1000
0
control (> 500 TLUs)
treated (> 500 TLUs)
control (> 1000 TLUs)
treated (> 1000 TLUs)
control (> 2000 TLUs)
treated (> 2000 TLUs)
control (> 3000 TLUs)
treated (> 3000 TLUs)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Rangeland quality trends

- Vector of fractional cover metrics, vegetation indices, summarized by 8 rangeland types, 4 different levels of aggregation.

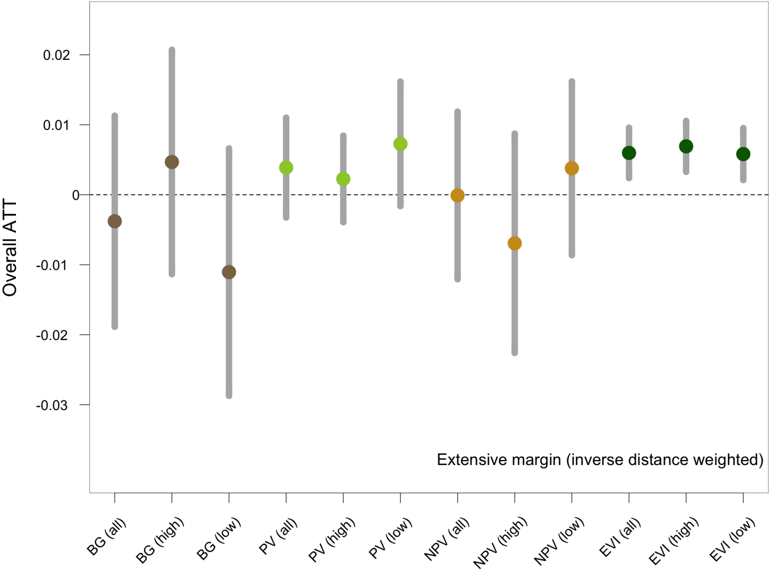
  – fractional cover in SRSD only (21 years of variation); observe vegetation indices in LRLD and SRSD (42 periods; 250m MODIS).

- Unconditional trends:

  – Swings associated w/ weather apparent (esp. wet/dry periods); no obvious trend breaks; slow and slight increases is bare ground and photosynthetic vegetation. fc vi

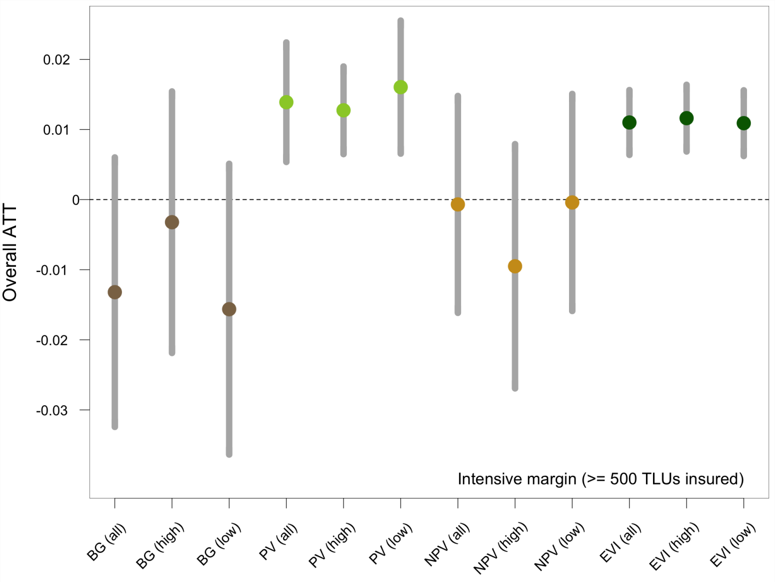
- Conditional trends: Comparison of average trends before exposure to IBLI are very similar. conditional-fc conditional-vi

Results: extensive margin average impacts across all rangelands

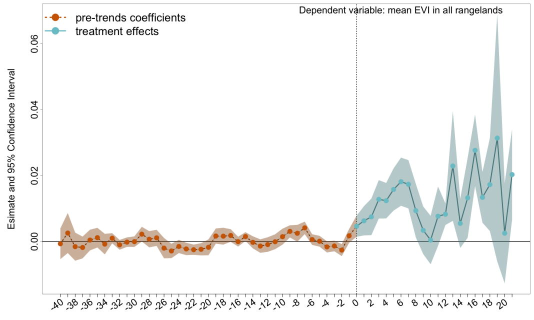


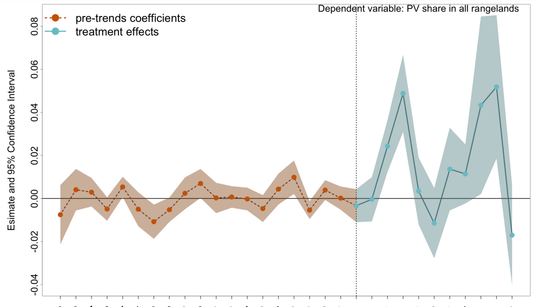
pre-trends-ext

Results: intensive margin average impacts across all rangelands

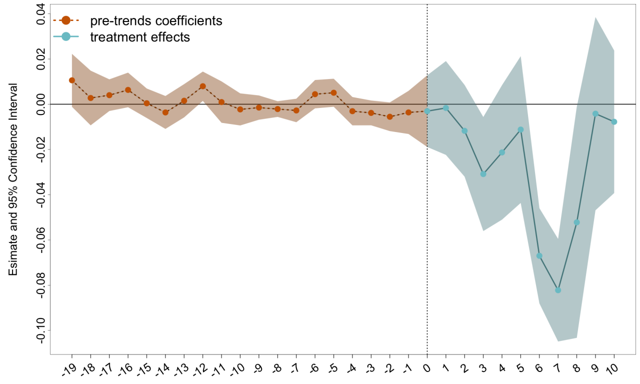


Results: intensive margin event study view, EVI/PV (all)





Results: intensive margin event study view, bare ground (all)



Conclusion

- Our findings clearly do **not** support the hypothesis that IBLI has had negative impacts on rangeland quality. Indicators are all neutral to positive (e.g., increase greenness and photosynthetic vegetation cover).

Conclusion

- Our findings clearly do **not** support the hypothesis that IBLI has had negative impacts on rangeland quality. Indicators are all neutral to positive (e.g., increase greenness and photosynthetic vegetation cover).

- Implications: not only are the worst fears – that IBLI might induce overstocking, causing the losses it is trying insure against – not true, there may even be favorable rangelands impacts.


Thank you! Comments welcome: cbb2@cornell.edu

Appendix

Econometric approach

TWFE and associated tests from Jakiela 2021:

$$Y_{i,s,t} = D_{ist}\delta + \mathbf{X'_{i,s,t}}\beta + \gamma_i + \sigma_t + \varepsilon_{i,s,t}$$

negative weights

Gardner et al. 2024 two-stage DiD:

Step 1: For treatment D_{ist}, subset to all untreated observations (i.e., such that $D_{ist} = 0$) and regress $Y_{i,r,s,t}$ on fixed effects and controls $\mathbf{X}_{i,s,t}$:

$$Y_{i,r,s,t} = \mathbf{X'_{i,s,t}}\theta + \gamma_i + \sigma_t + \mu_{i,r,s,t} \tag{1}$$

Step 2: Take the $\widehat{\theta}$ estimates from step 1 and regress adjusted $Y_{i,r,s,t}$, defined as $\ddot{Y}_{i,r,s,t} = \widetilde{Y}_{i,r,s,t} - \widetilde{\mathbf{X}'}_{\mathbf{i,s,t}}\widehat{\theta}$, on treatment dummy D_{ist} where $\widetilde{Y}$ and $\widetilde{\mathbf{X}'}$ are residualized from the fixed effects estimated in the first step.

$$\ddot{Y}_{i,r,s,t} = D_{ist}\beta + \ddot{\varepsilon}_{i,r,s,t} \tag{2}$$

back

Data: constructing IBLI exposure

Challenge: *How to account for herder movement and down-scale IBLI exposure to affected rangelands within each unit?*

Answer: *Use the all rangelands mask and define a "neighborhood" to inverse distance weight exposure from units j in unit i.*

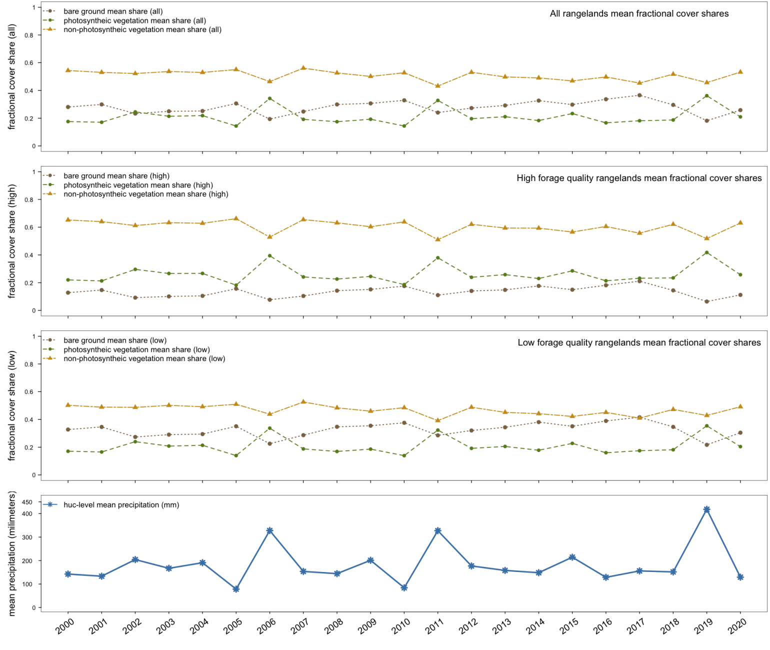
$$WIBE_i = IBE_i + \sum_{j-i} \frac{(\mathbf{1}_j \ w_{ij} \ IBE_j)}{\sum_{j-i} \mathbf{1}_j \ w_{ij}}$$

Define neighborhood, $\mathbf{1}_j$: SRSD grazing extent ≈ 63 km grz fig

Divide the neighborhood: split neighborhoods into buffers b_n buffer ;
use distances to the boundary of unit i as building block for weights, w_{ij}.

Define exposure: *a unit becomes exposed to IBLI in the first period when ≥ 1 insured tropical livestock unit (TLU) is observed. At intensive margin, can discretize into bins using cumulative exposure.*

back

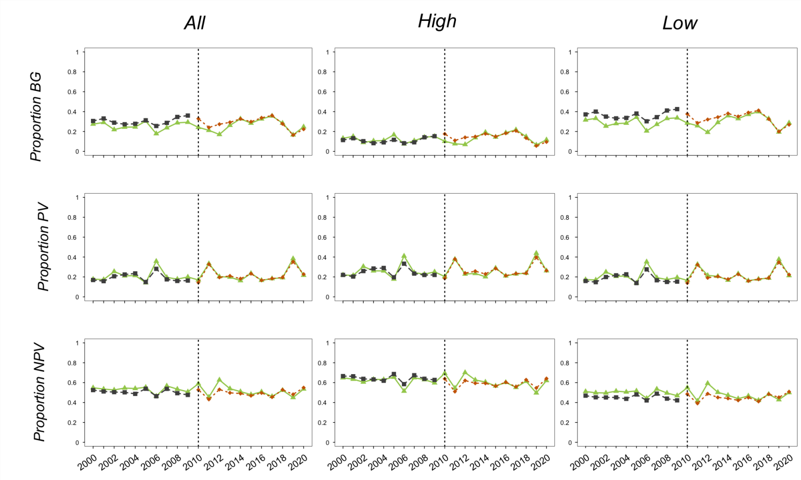


bare ground mean share (all)
photosyntheic vegetation mean share (all)
non-photosyntheic vegetation mean share (all)
All rangelands mean fractional cover shares
fractional cover share (all)
bare ground mean share (high)
photosyntheic vegetation mean share (high)
non-photosyntheic vegetation mean share (high)
High forage quality rangelands mean fractional cover shares
fractional cover share (high)
bare ground mean share (low)
photosyntheic vegetation mean share (low)
non-photosyntheic vegetation mean share (low)
Low forage quality rangelands mean fractional cover shares
fractional cover share (low)
huc-level mean precipitation (mm)
mean precipitation (milimeters)
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

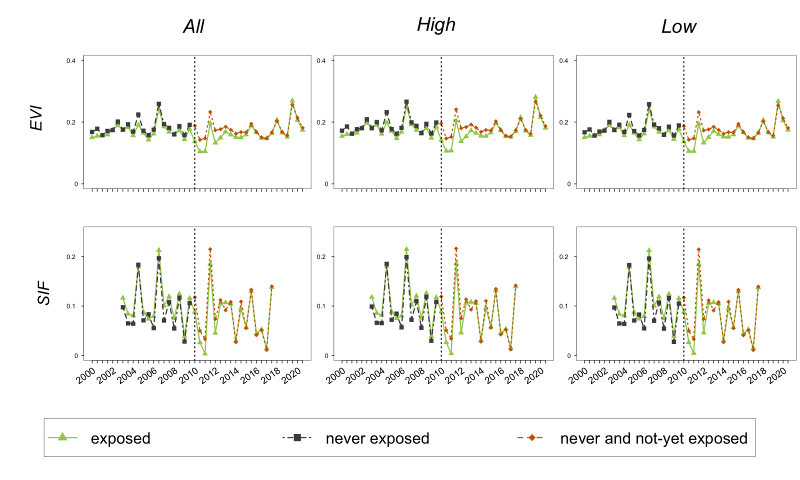
back


EVI mean (all)
SIF mean (all)
All rangelands mean vegetation indices
EVI mean (high)
SIF mean (high)
High forage quality rangelands mean vegetation indices
EVI mean (low)
SIF mean (low)
Low forage quality rangelands mean vegetation indices
mean vegetation index
huc-level mean precipitation (mm)
mean precipitation (milimeters)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

back

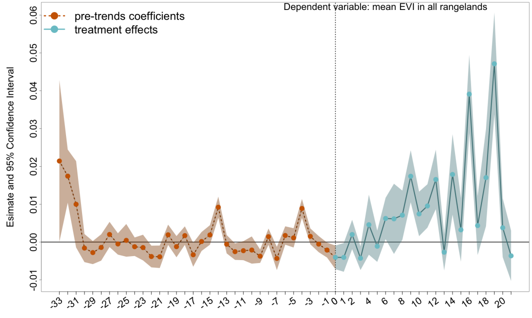

All
High
Low
Proportion BG
Proportion PV
Proportion NPV
1
0.8
0.6
0.4
0.2
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020

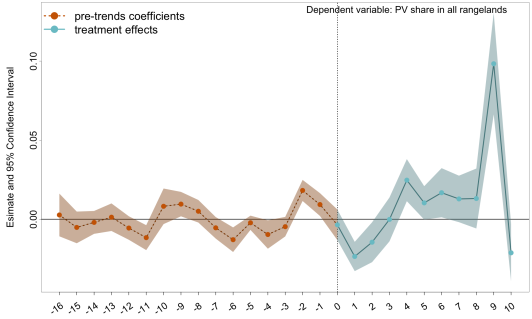
back



All
High
Low
EVI
SIF
0.4
0.2
0
0.1
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
exposed
never exposed
never and not-yet exposed

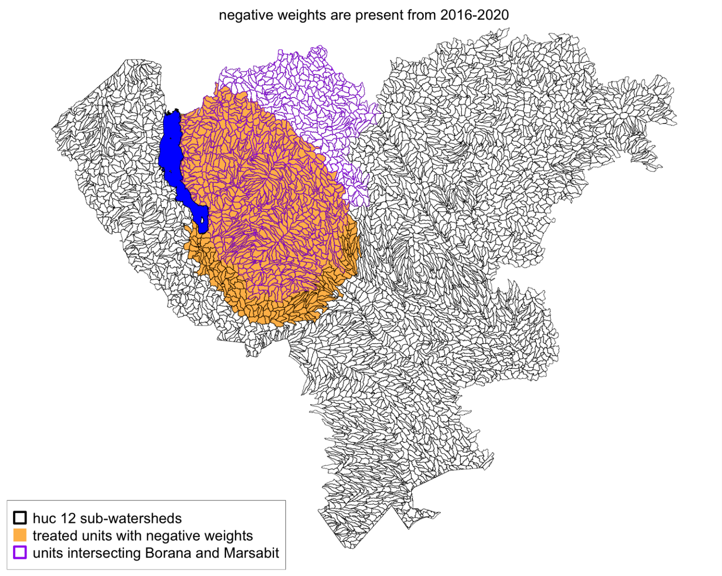
back


pre-trends coefficients
treatment effects
Dependent variable: mean EVI in all rangelands
Esimate and 95% Confidence Interval
-0.01
0.00
0.01
0.02
0.03
0.04
0.05
0.06
-33 -31 -29 -27 -25 -23 -21 -19 -17 -15 -13 -11 -9 -7 -5 -3 -1 0 1 2 4 6 8 10 12 14 16 18 20

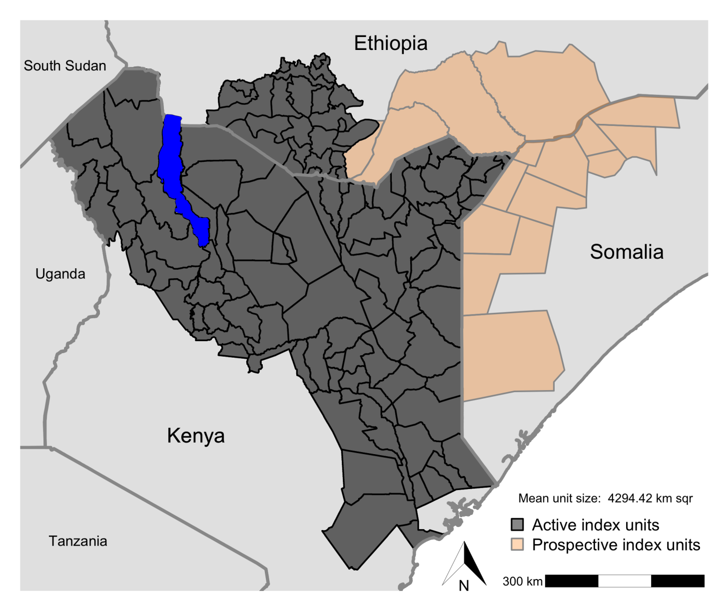

pre-trends coefficients
treatment effects
Dependent variable: PV share in all rangelands
Esimate and 95% Confidence Interval
0.00
0.05
0.10
-16 -15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

back

Results: TWFE



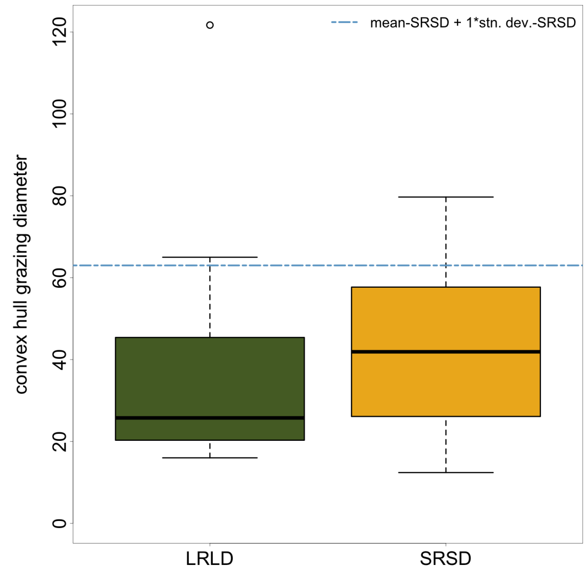
back


Ethiopia
South Sudan
Uganda
Somalia
Kenya
Tanzania
Mean unit size: 4294.42 km sqr
Active index units
Prospective index units
N
300 km

back

Rangelands are often cited as the dominant land type on Earth.

Definition (Pellant et al. 2020): "lands on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly". back


mean-SRSD + 1*stn. dev.-SRSD
convex hull grazing diameter
0
20
40
60
80
100
120
LRLD
SRSD

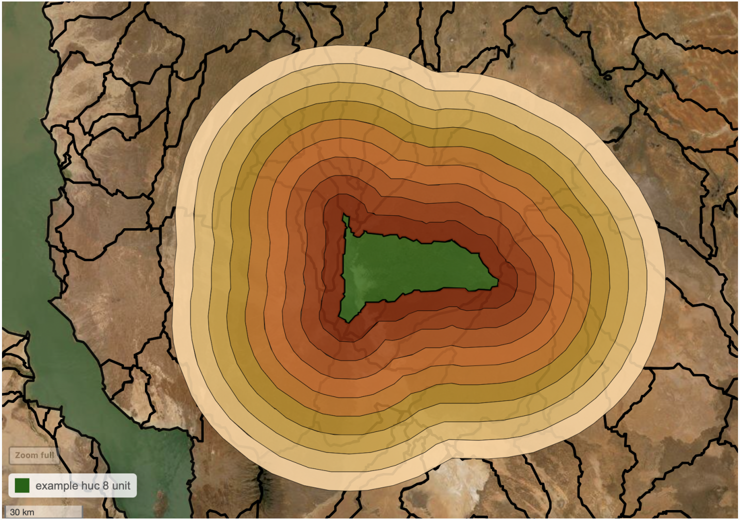
back

figures/aoi_all_91322.png

(only masks out water and impervious cover) back figures/aoi_high_91322.png

(includes grassland, open canopy woodland, sparse scrubland, and figures/aoi_low_91322.png

(includes sparse vegetation, bushland, dense scrubland, close canopy



back