The Future of Food Security in India: Can Farmers Adapt to Environmental Change?

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Co-PIs David Lobell, Ram Fishman. Collaborators: Balwinder Singh, Ashwini Chhatre

Postdocs: Nishan Bhattarai, Sukhwinder Singh. Associate: Preeti Rao, Undergraduate: Adrienne Pollack

Cropped Area LCLUC team: Ruth DeFries, Pinki Mondal, Gillian Galford


Google earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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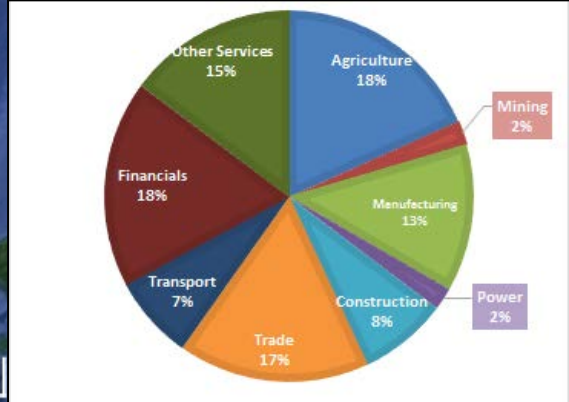
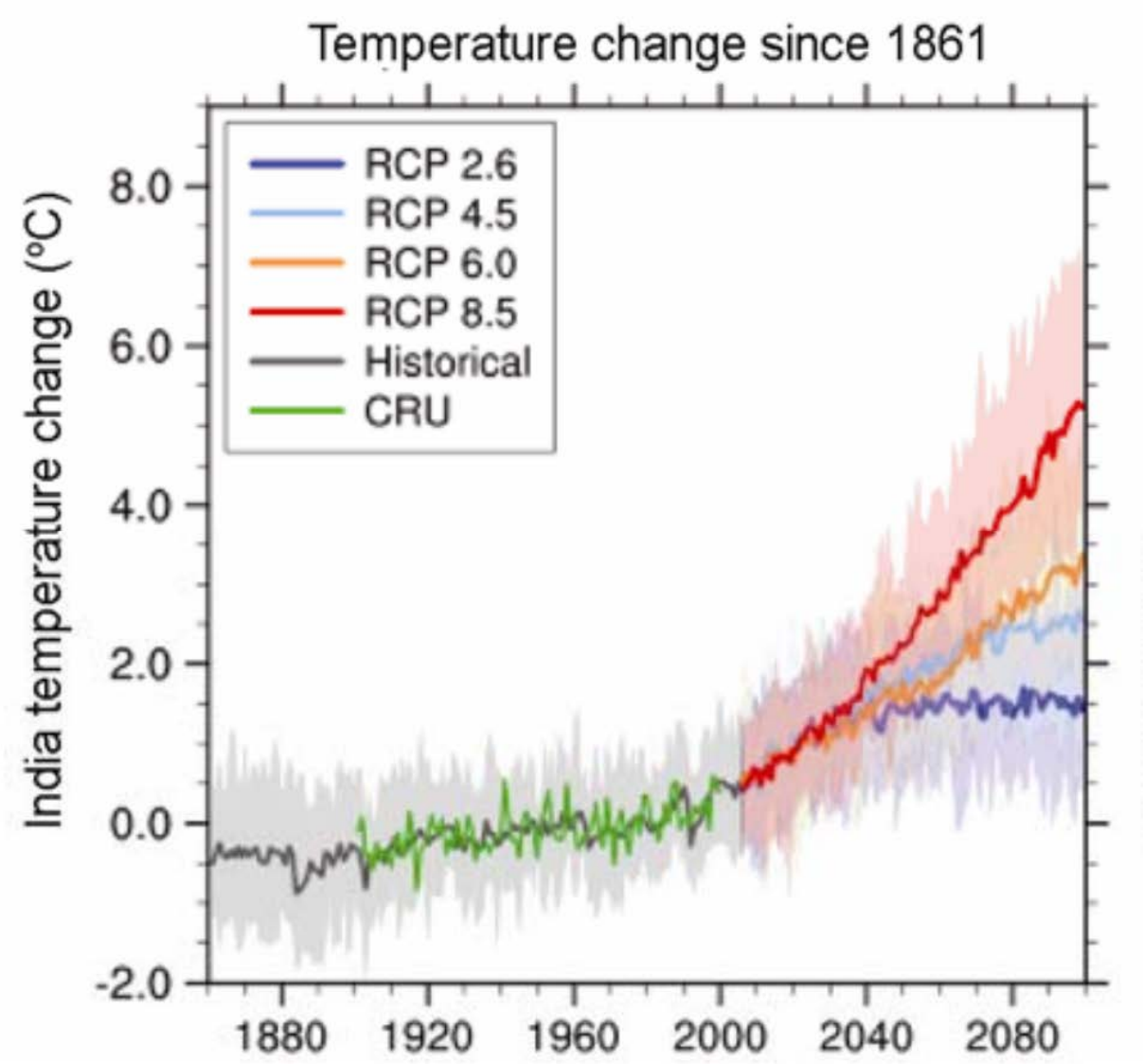
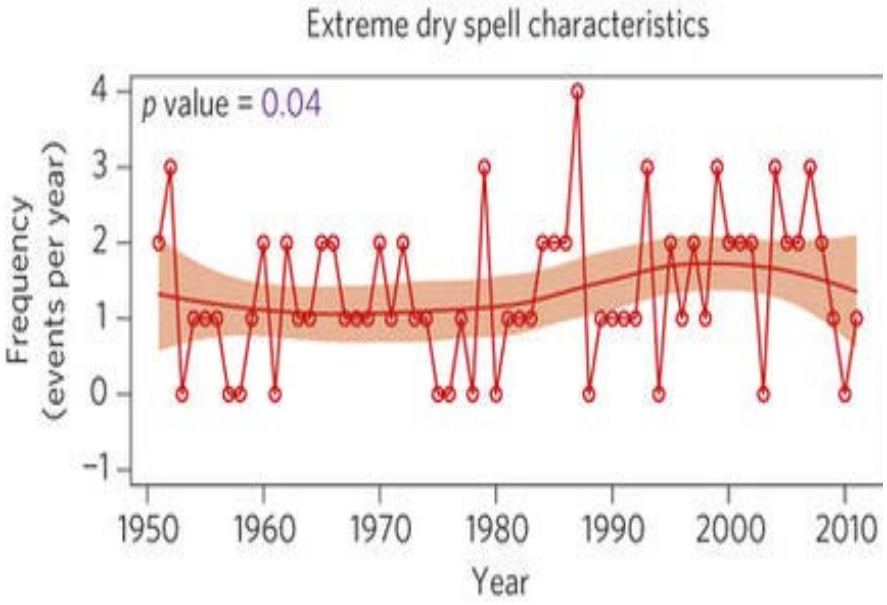

Other Services 15%
Agriculture 18%
Mining 2%
Financials 18%
Manufecturing 13%
Transport 7%
Construction 8%
Power 2%
Trade 17%

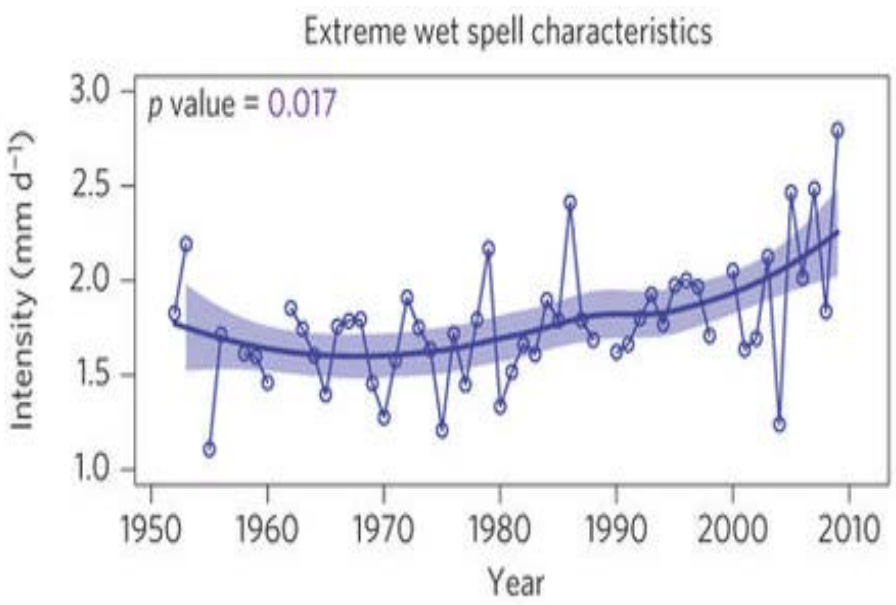
Temperatures are warming



Chaturvedi et al. 2012

Monsoon rainfall has increasing break periods & intense events





Modified from Singh et al. 2014

Water tables are falling

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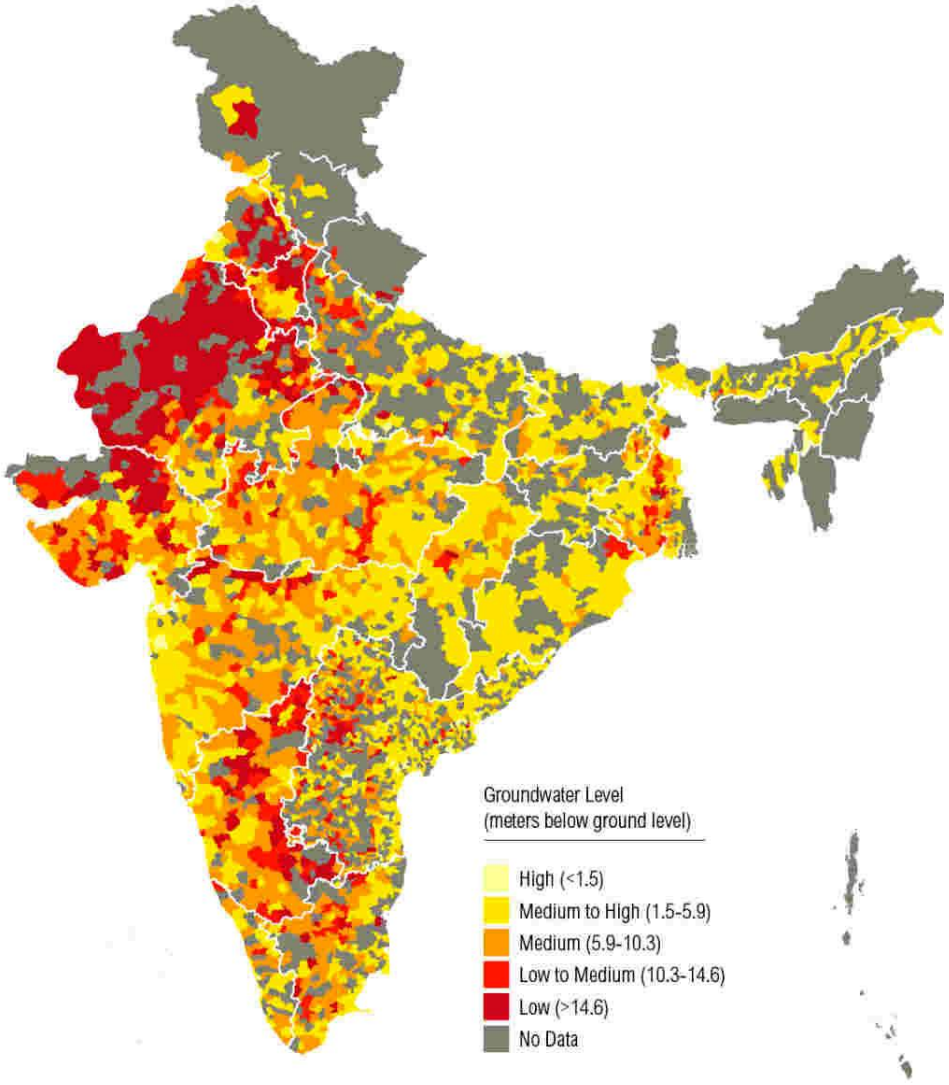

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Main Research Questions

- How are farmers adapting to multiple environmental changes?

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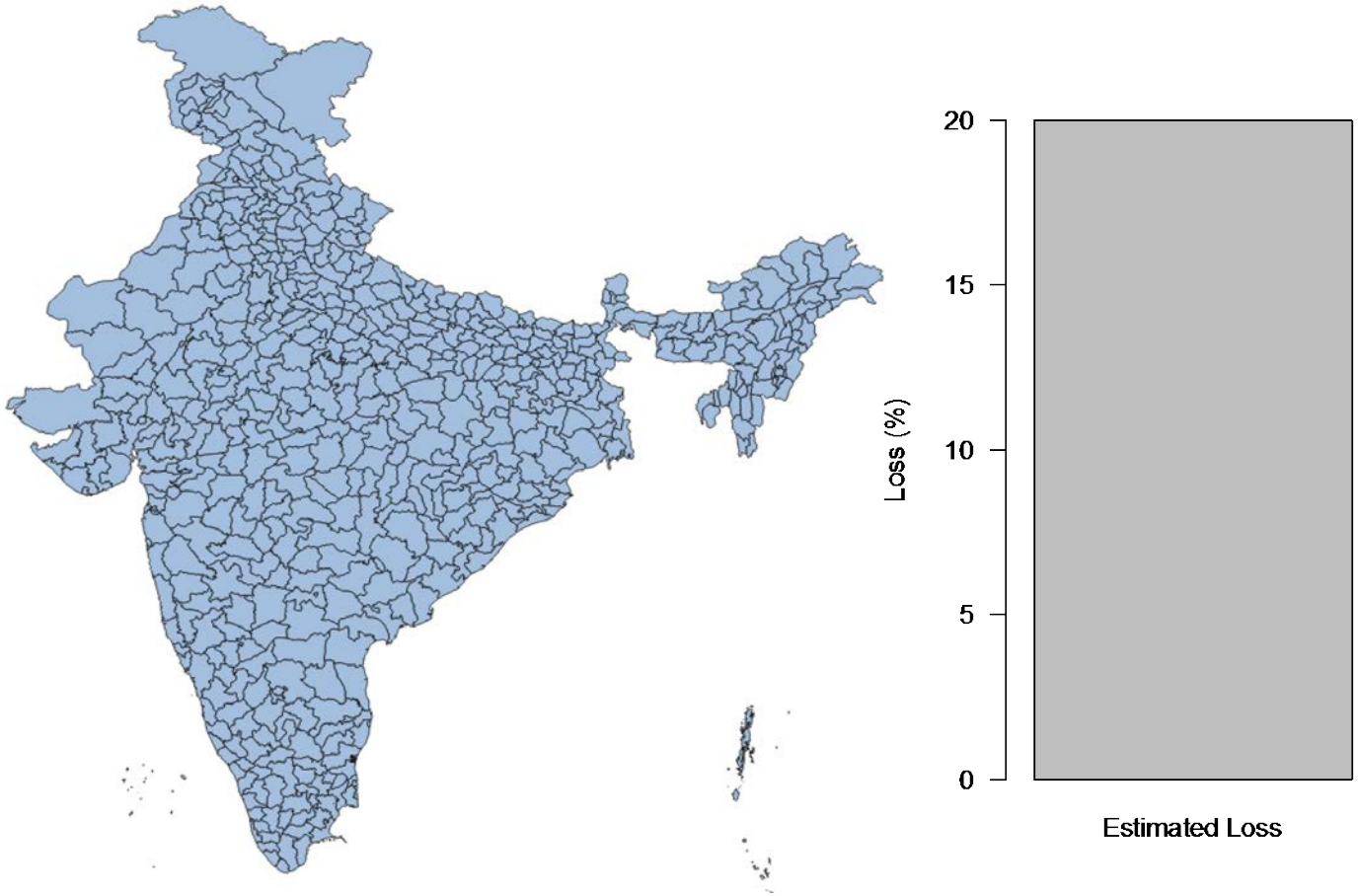
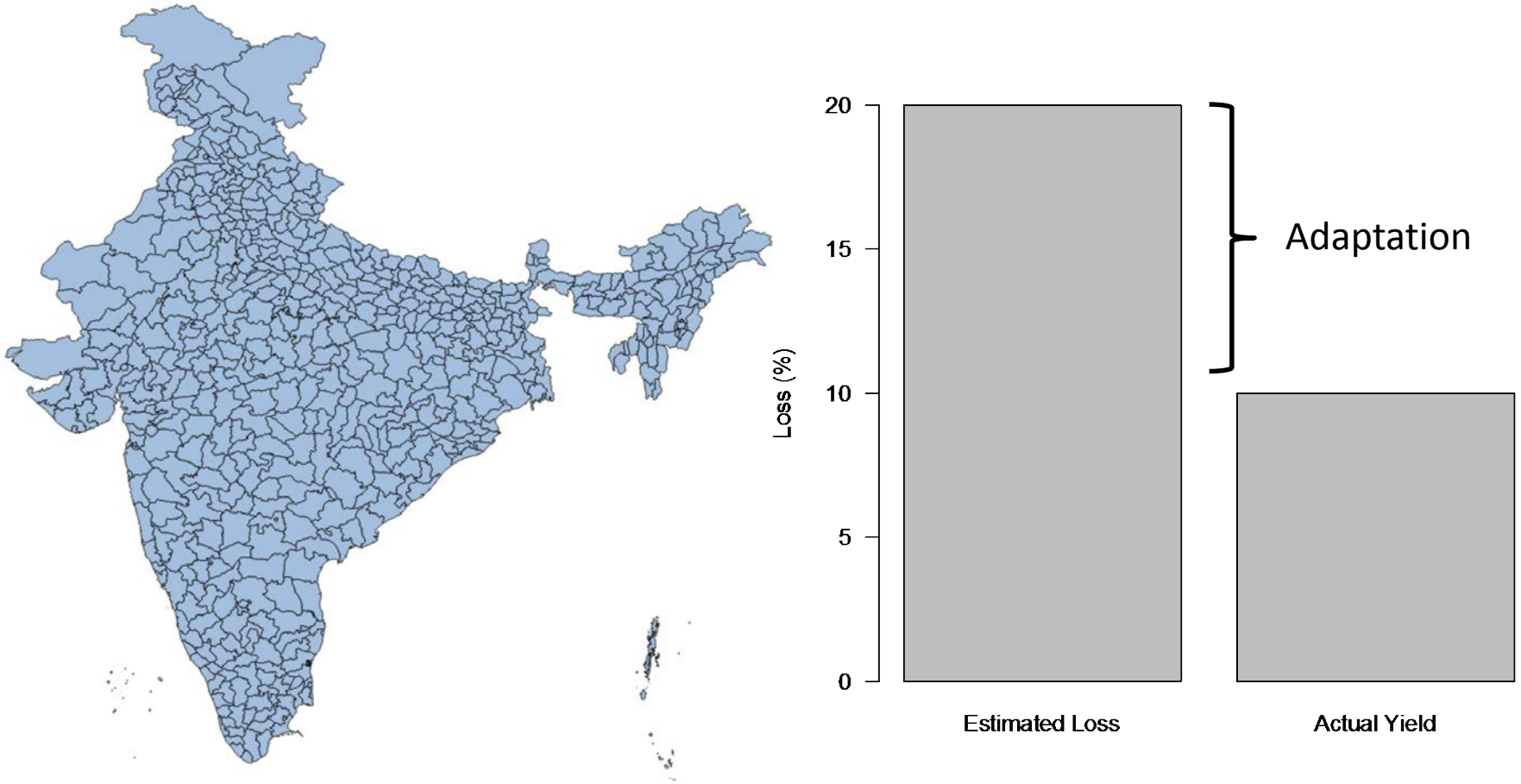
- How effective are these adaptation strategies in reducing long-term negative impacts?
- Which socio-economic & biophysical factors constrain or enhance adaptation?
- Can satellite data be used to prioritize adaptation interventions?



Approach 1. Examine adaptation at large spatio-temporal scales using coarse scale census data



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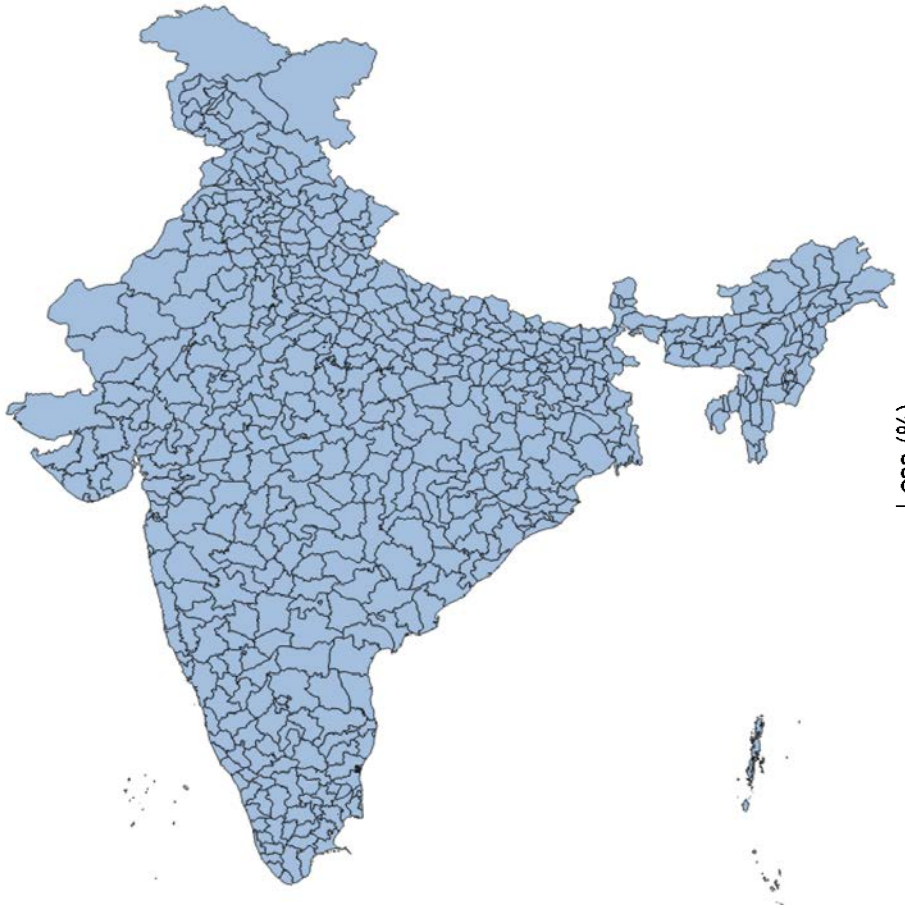

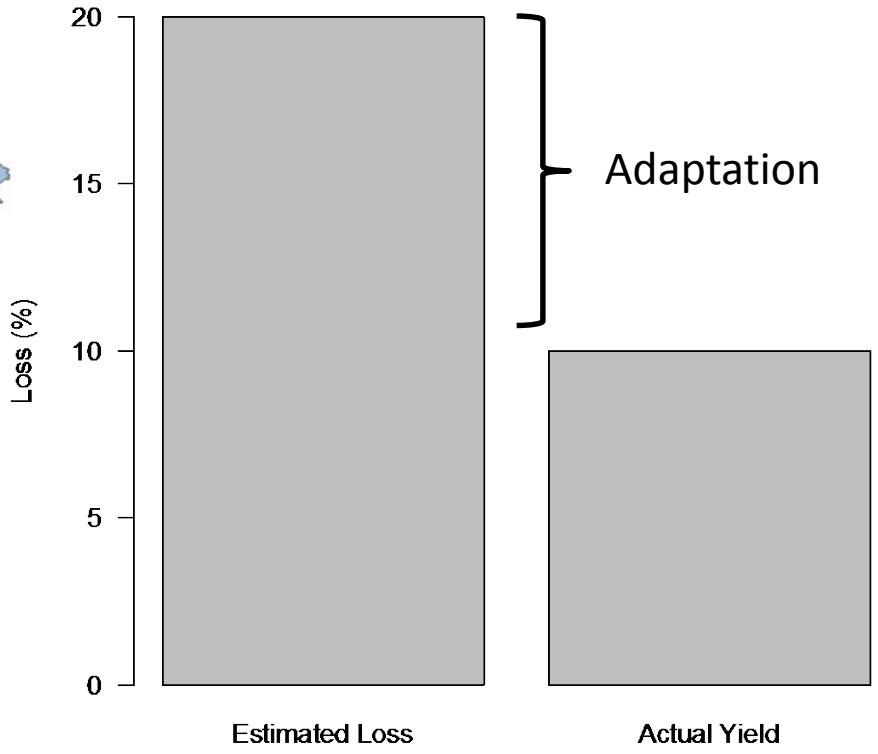

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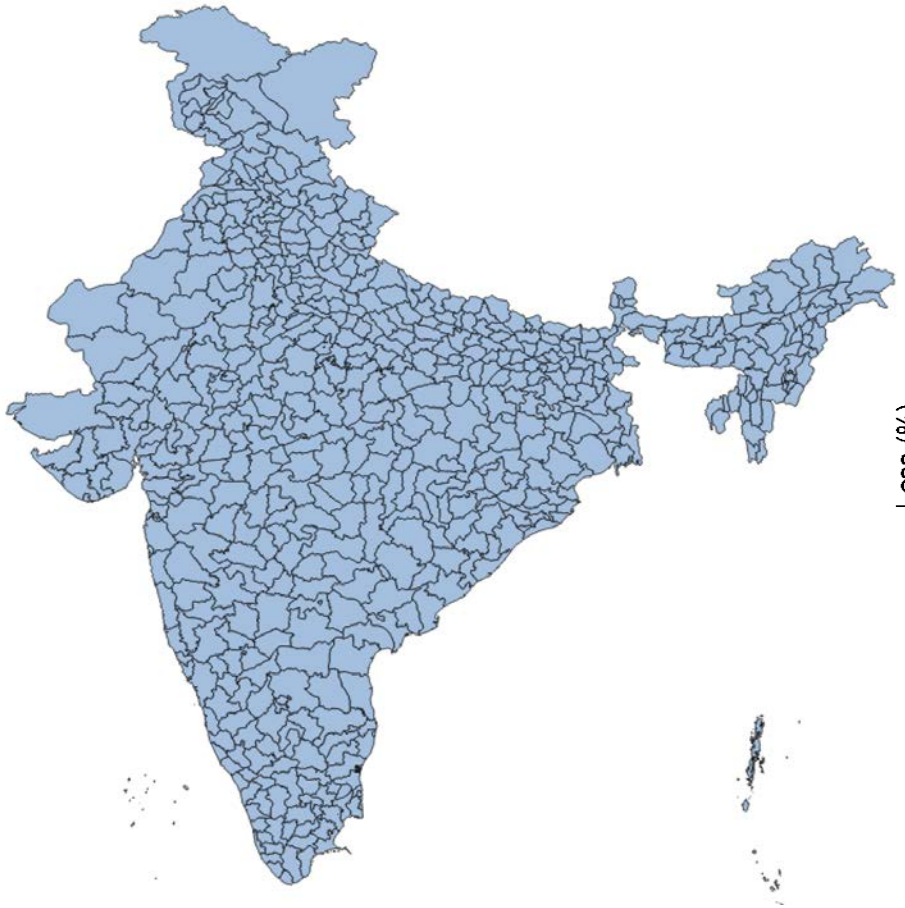
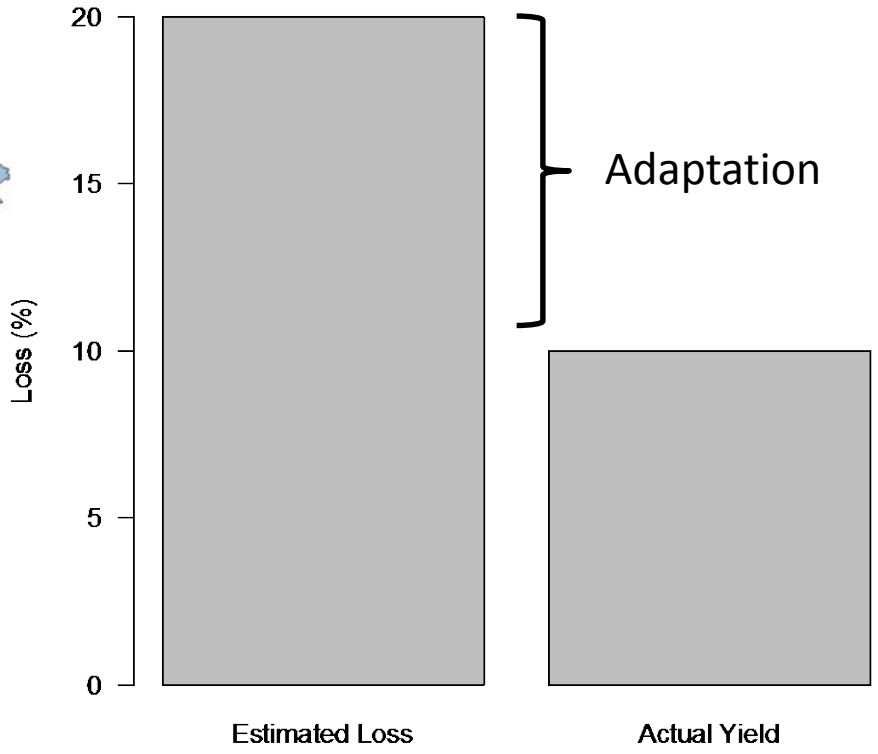
+ empirical estimates of adaptation
+ examine adaptation at large spatiotemporal scales





Approach 1. Examine adaptation at large spatio-temporal scales using coarse scale census data
+ empirical estimates of adaptation
+ examine adaptation at large spatiotemporal scales
- actual adaptation decisions and drivers of decision-making are unclear

Approach 2. Examine adaptation using household surveys and ask farmers how they have adapted

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+ identify adaptation decisions and drivers of decision-making

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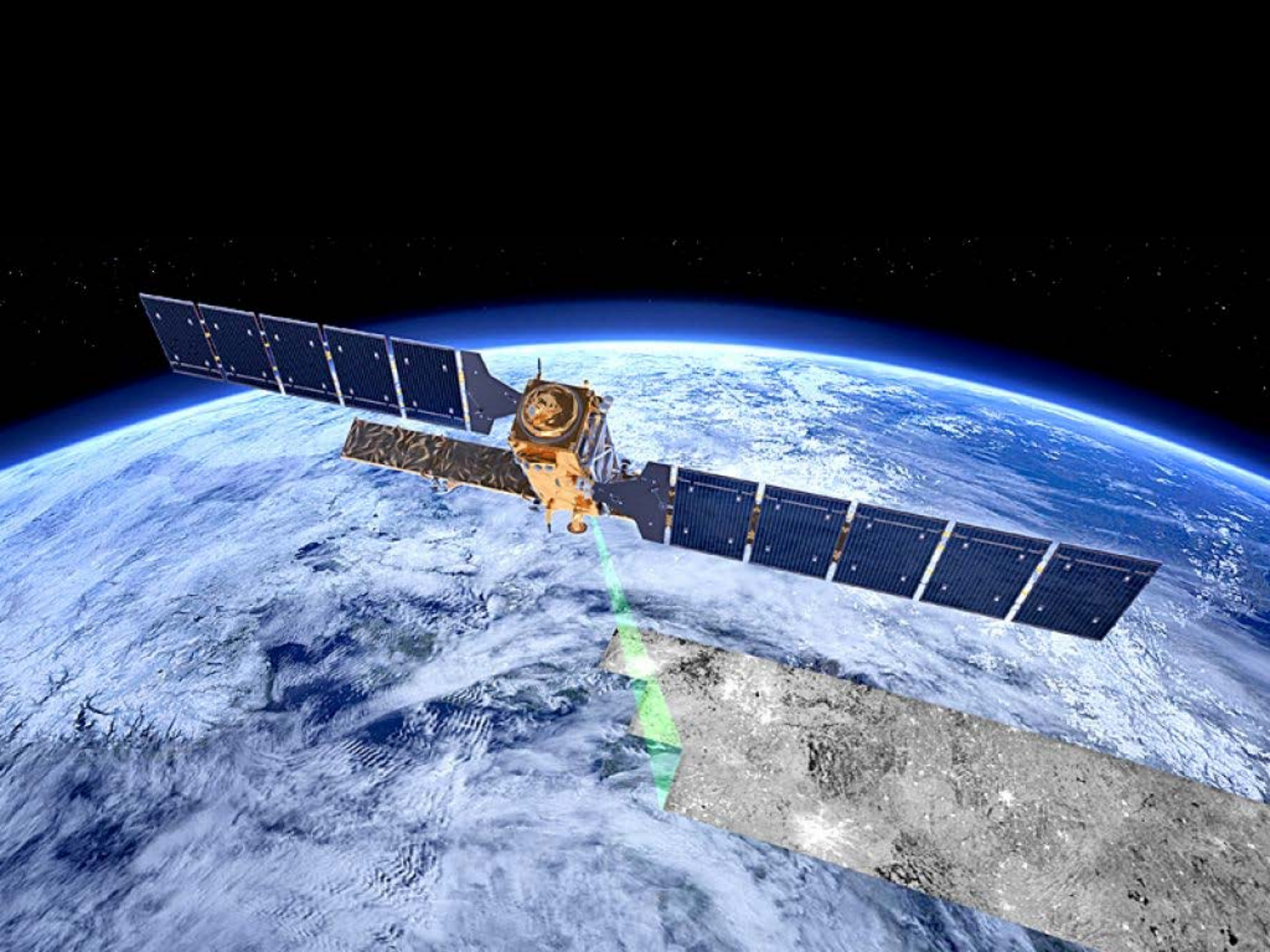
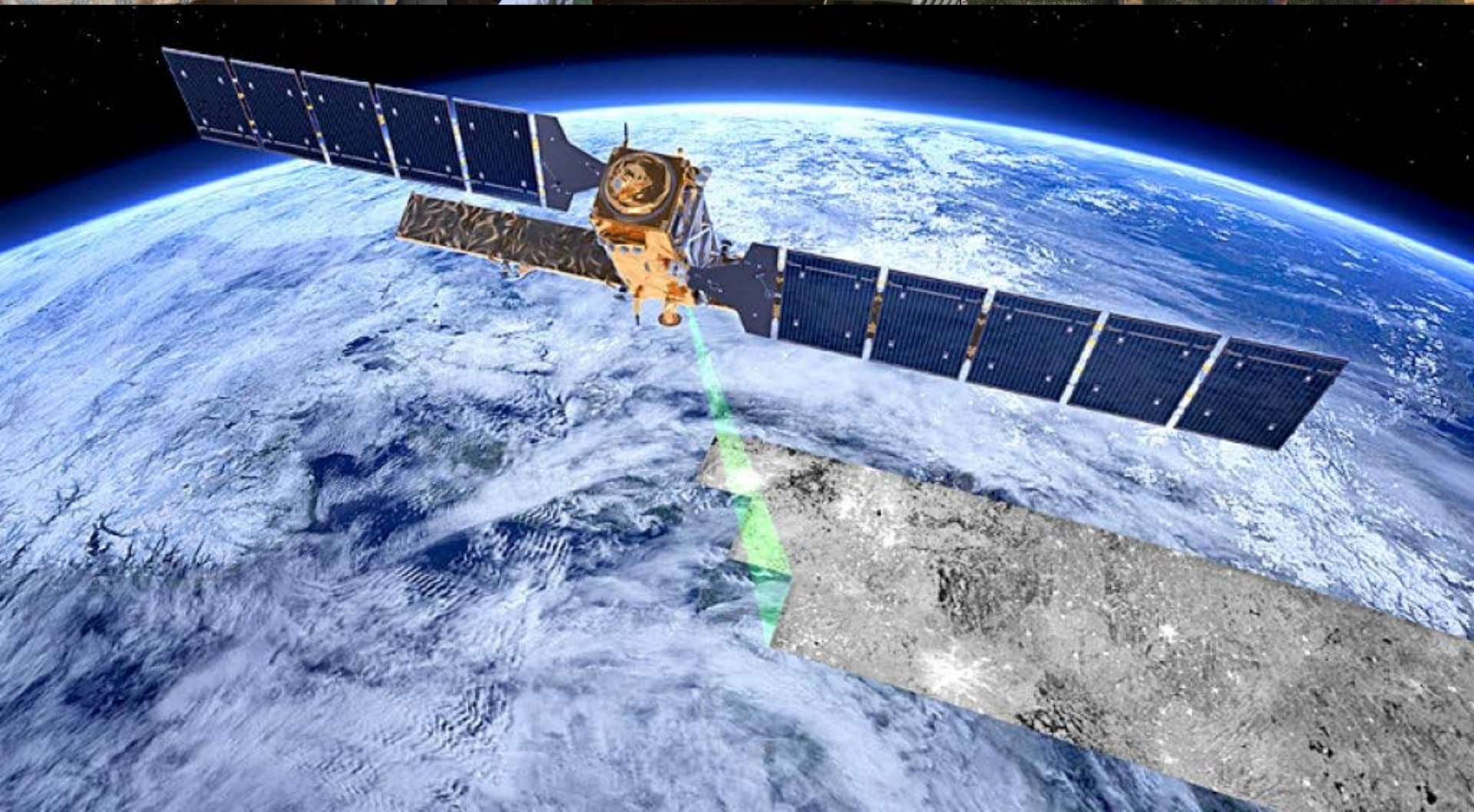
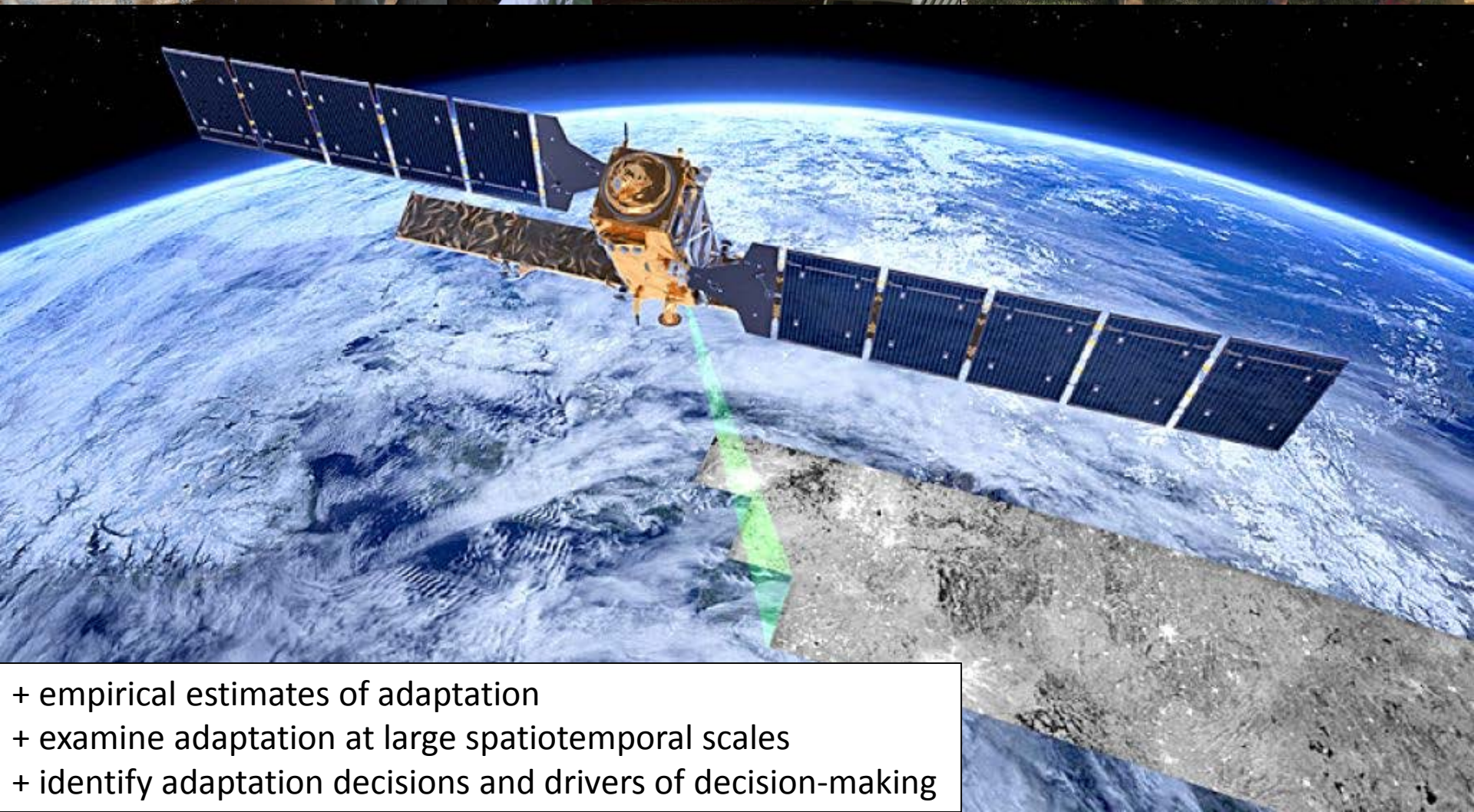
+ identify adaptation decisions and drivers of decision-making

- challenging to do across large spatio-temporal scales

- challenging to quantify adaptation







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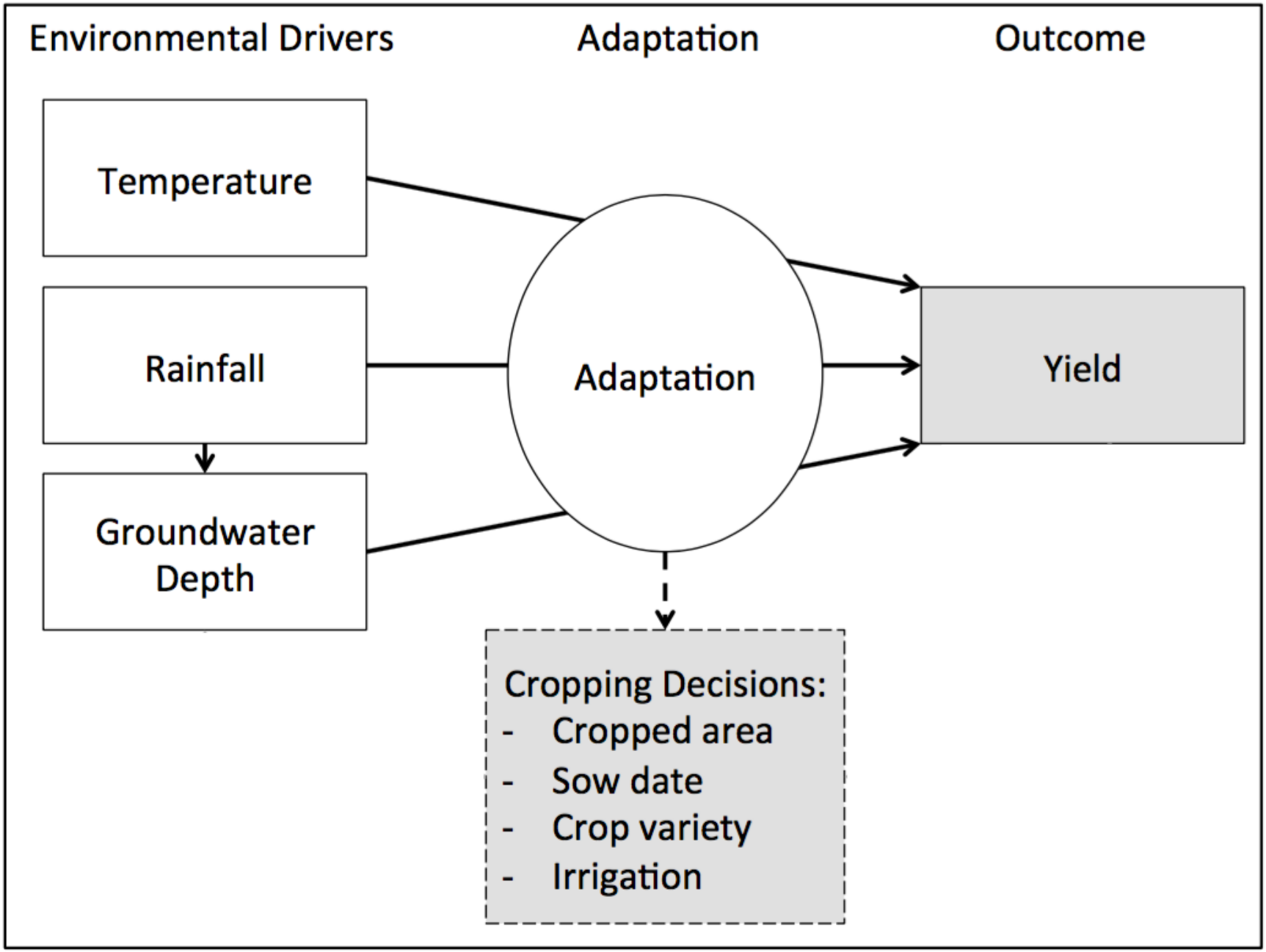
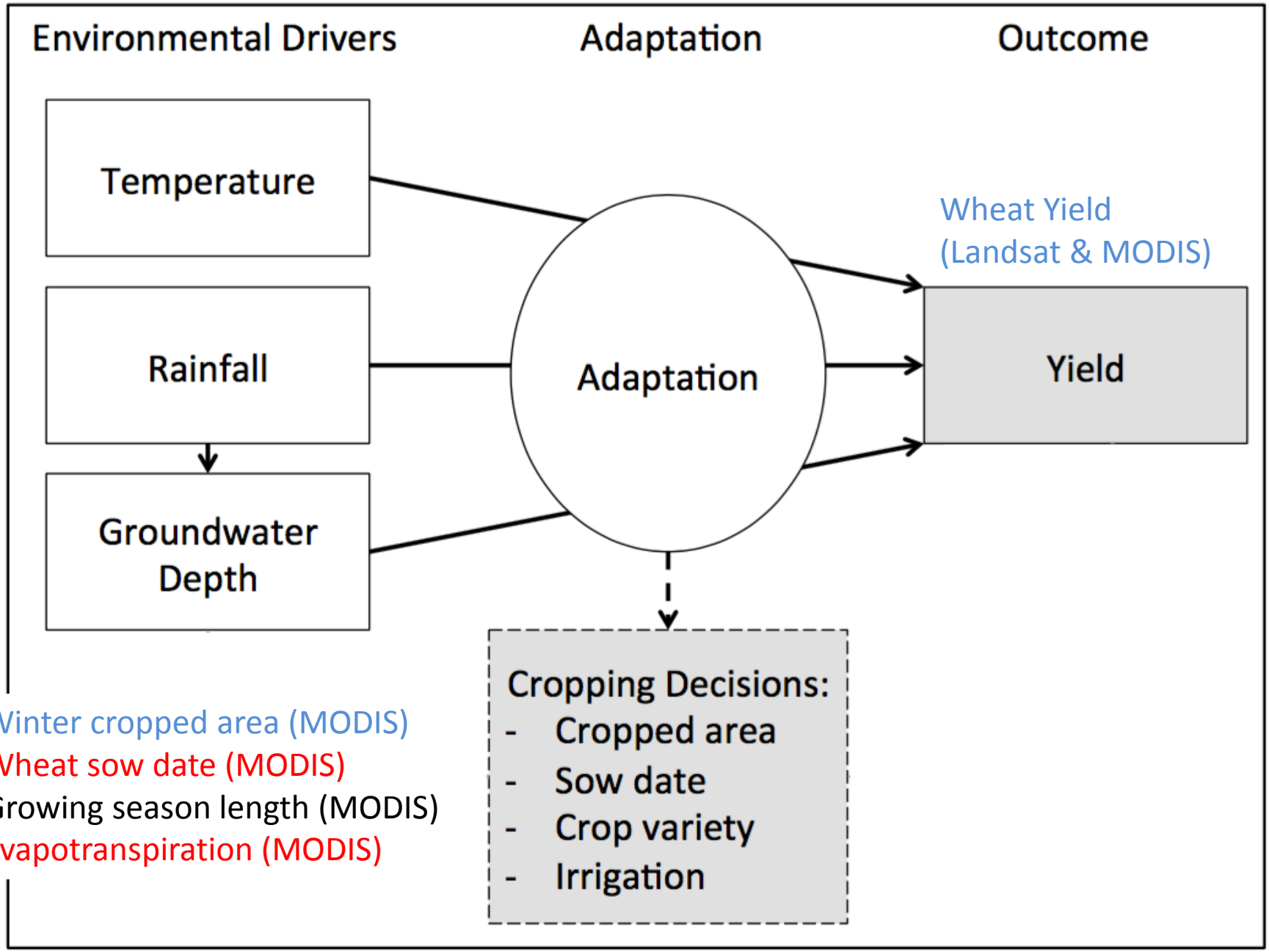
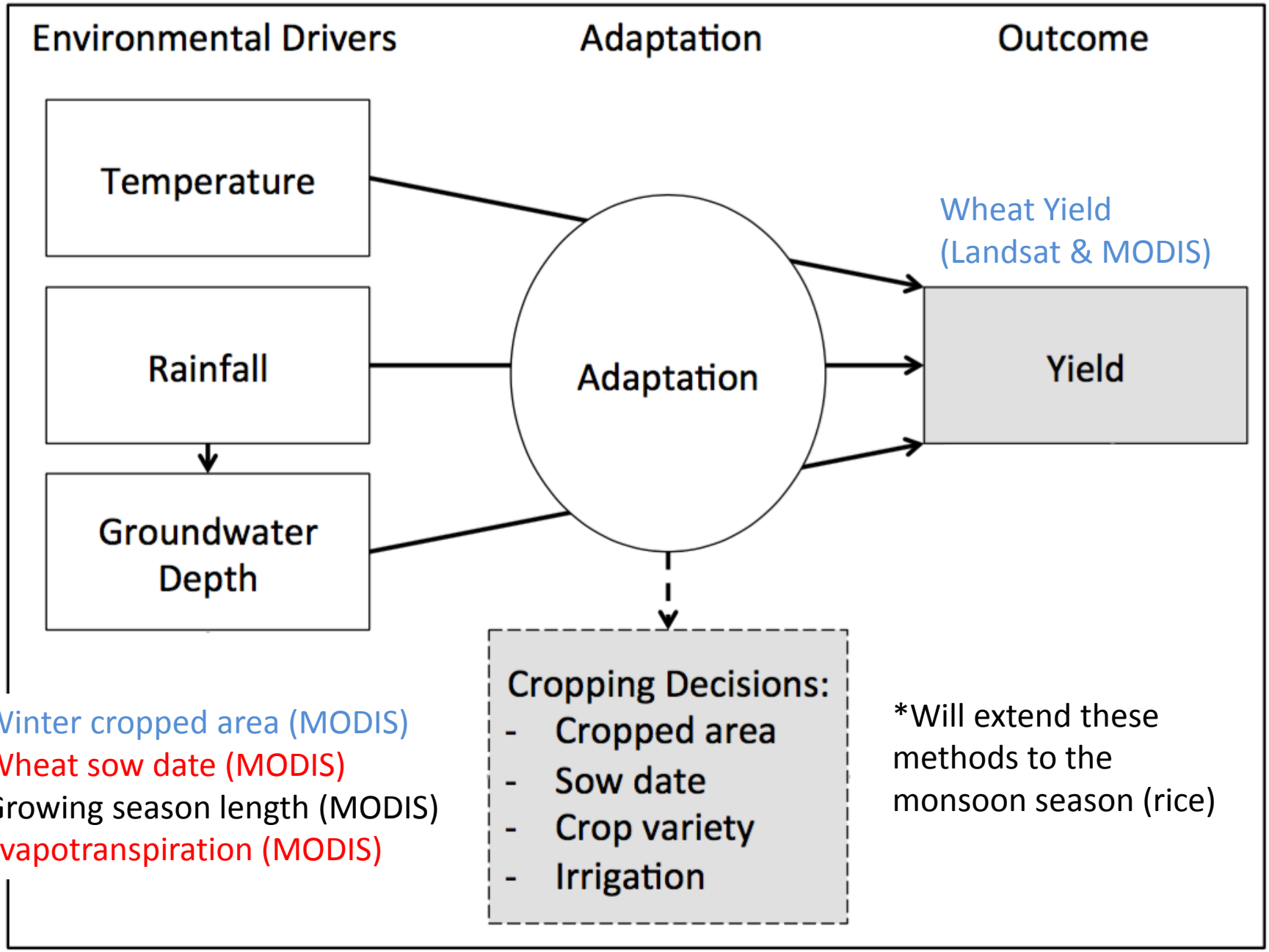

Environmental Drivers
Adaptation
Outcome
Temperature
Rainfall
Groundwater Depth
Adaptation
Yield
Cropping Decisions:
- Cropped area
- Sow date
- Crop variety
- Irrigation



Winter cropped area (MODIS)
Wheat sow date (MODIS)
Growing season length (MODIS)
Evapotranspiration (MODIS)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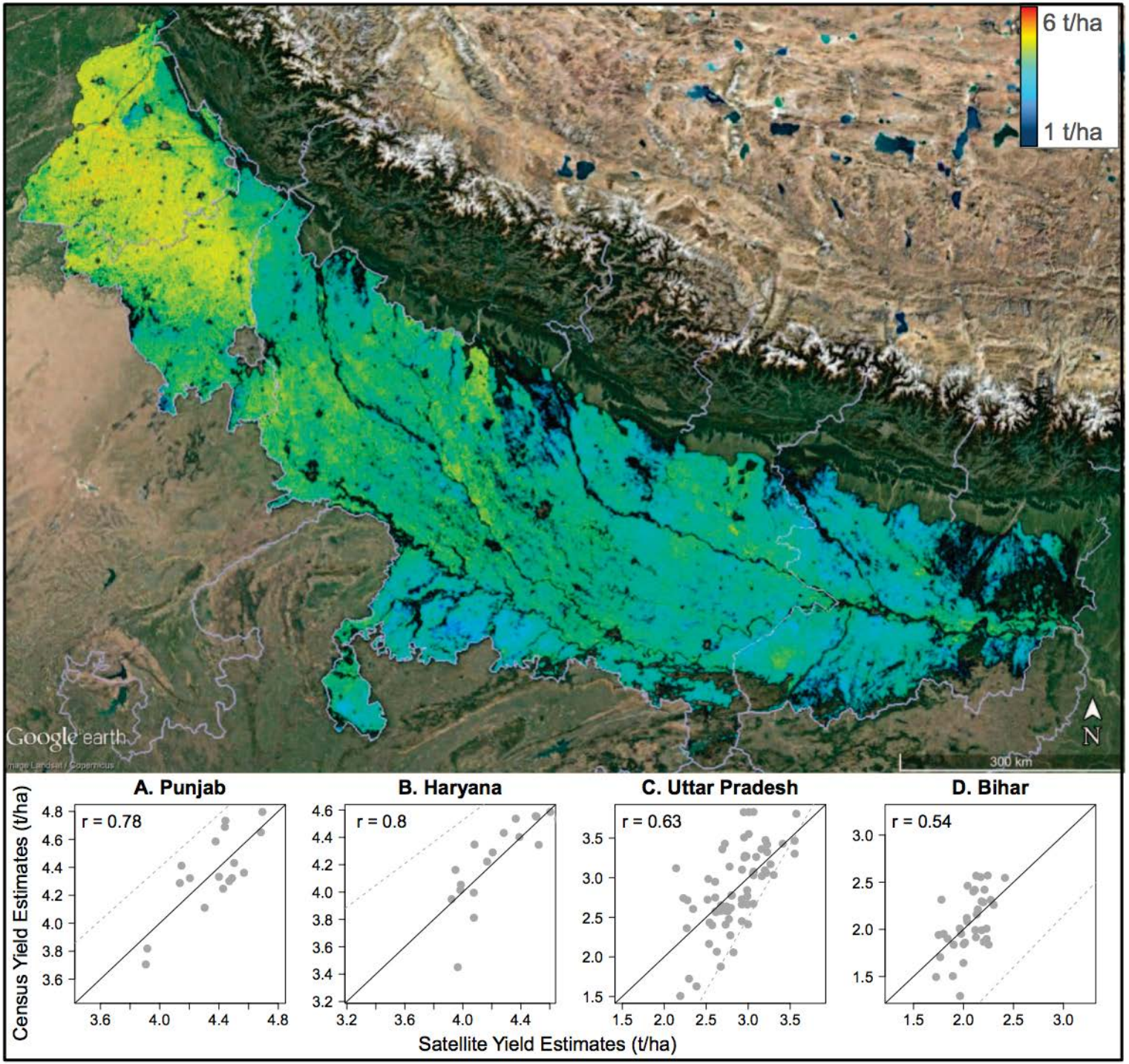
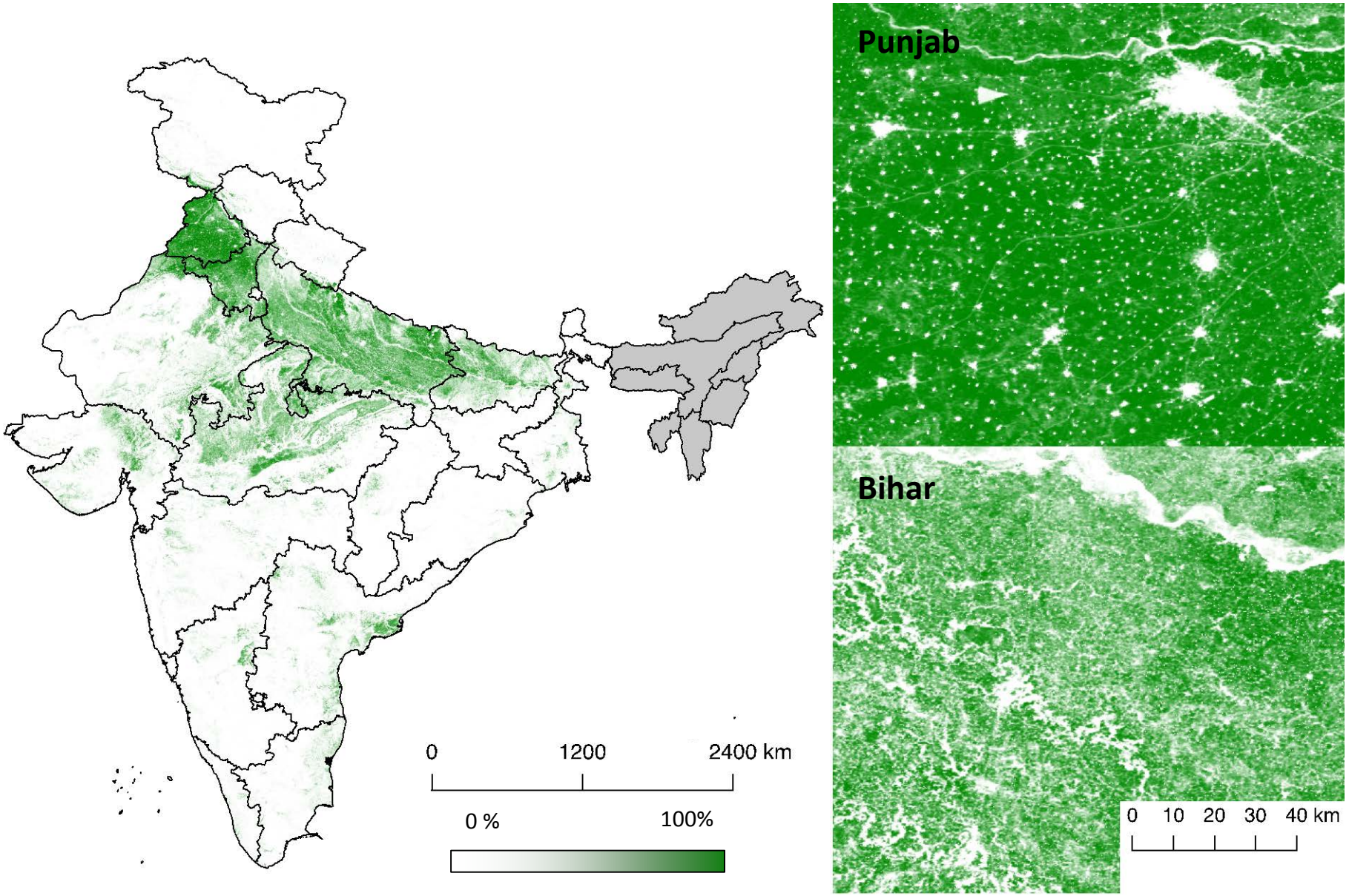
*Will extend these methods to the monsoon season (rice)



Jain et al. 2017 using methods from Lobell et al. 2015



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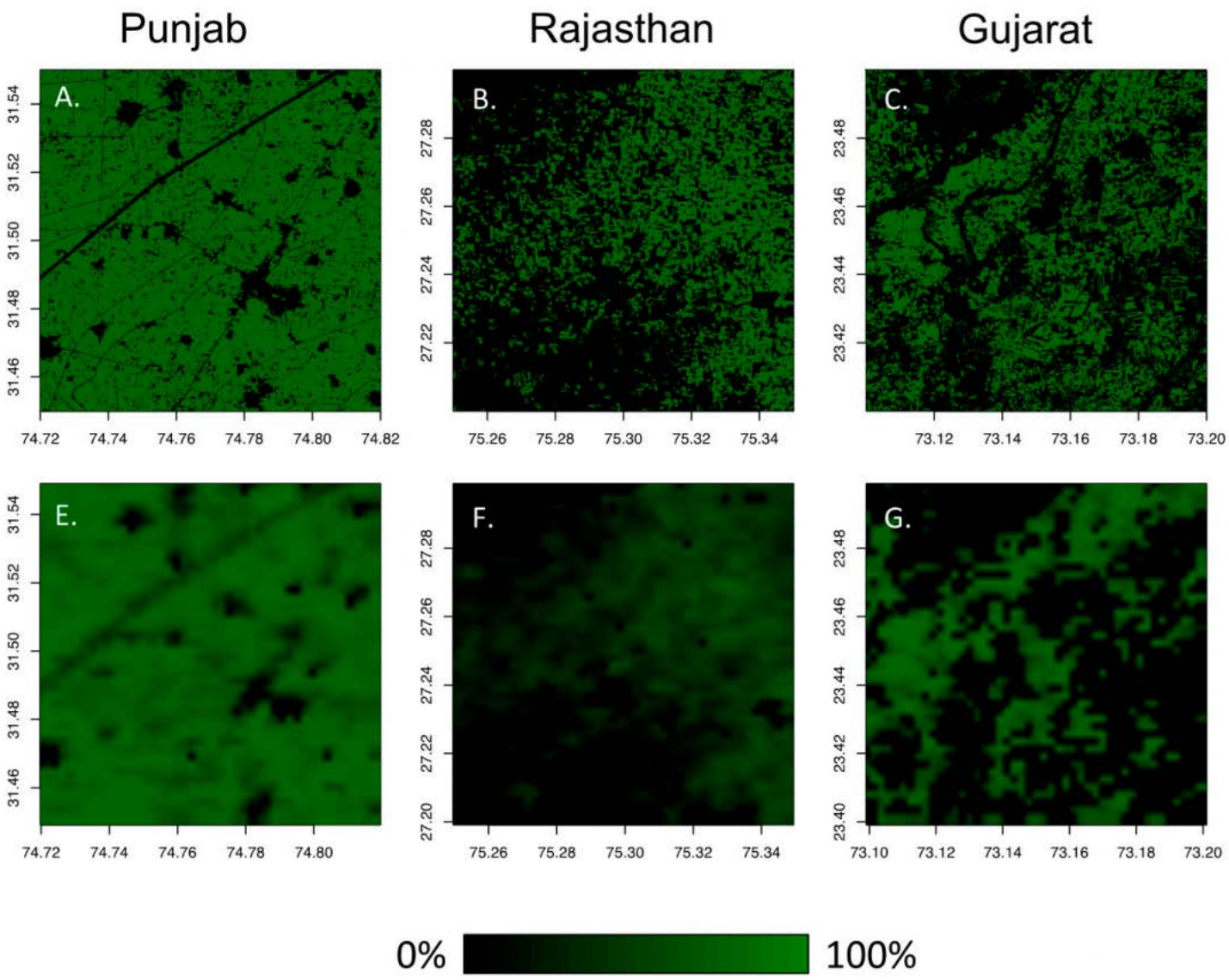
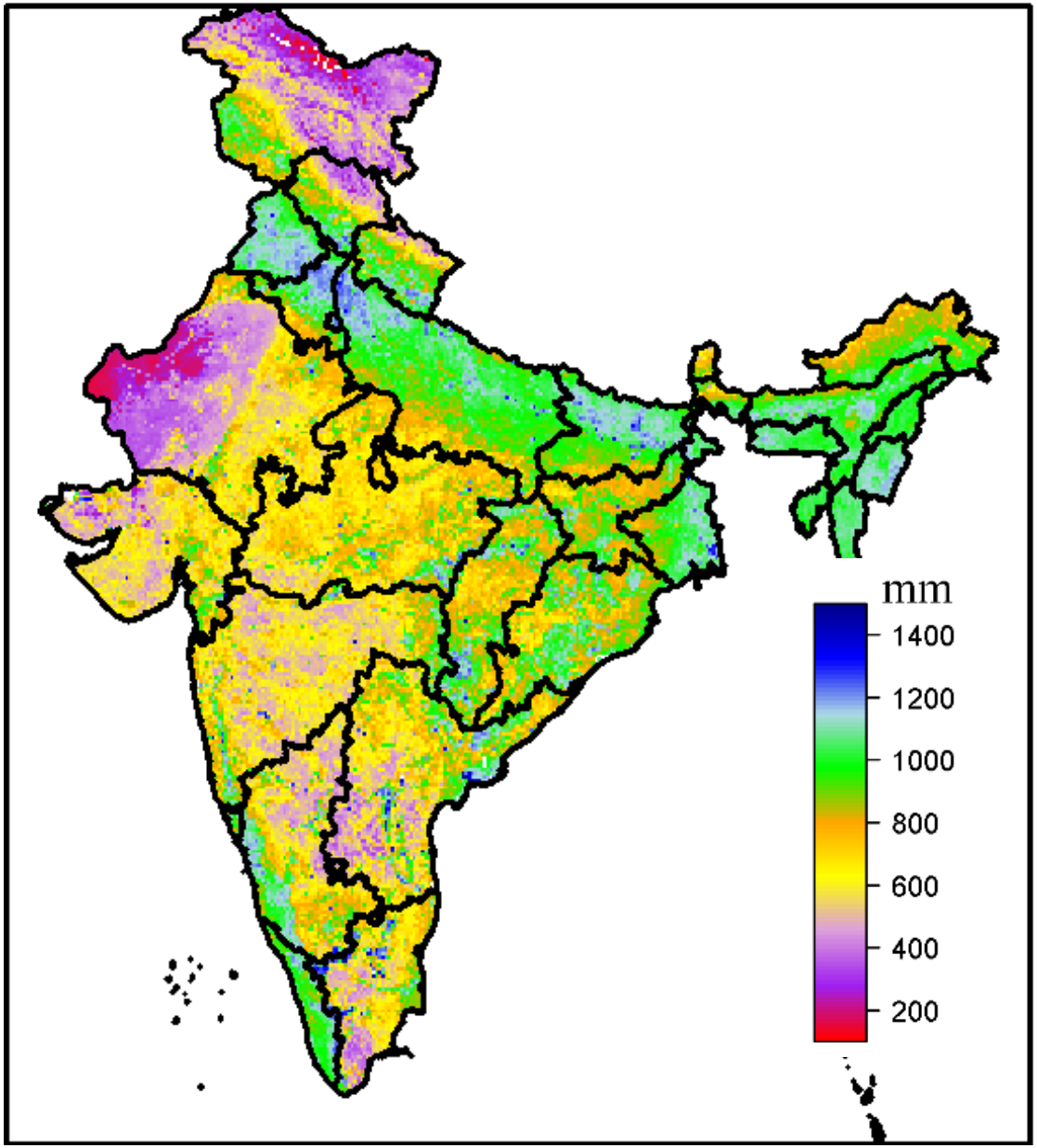
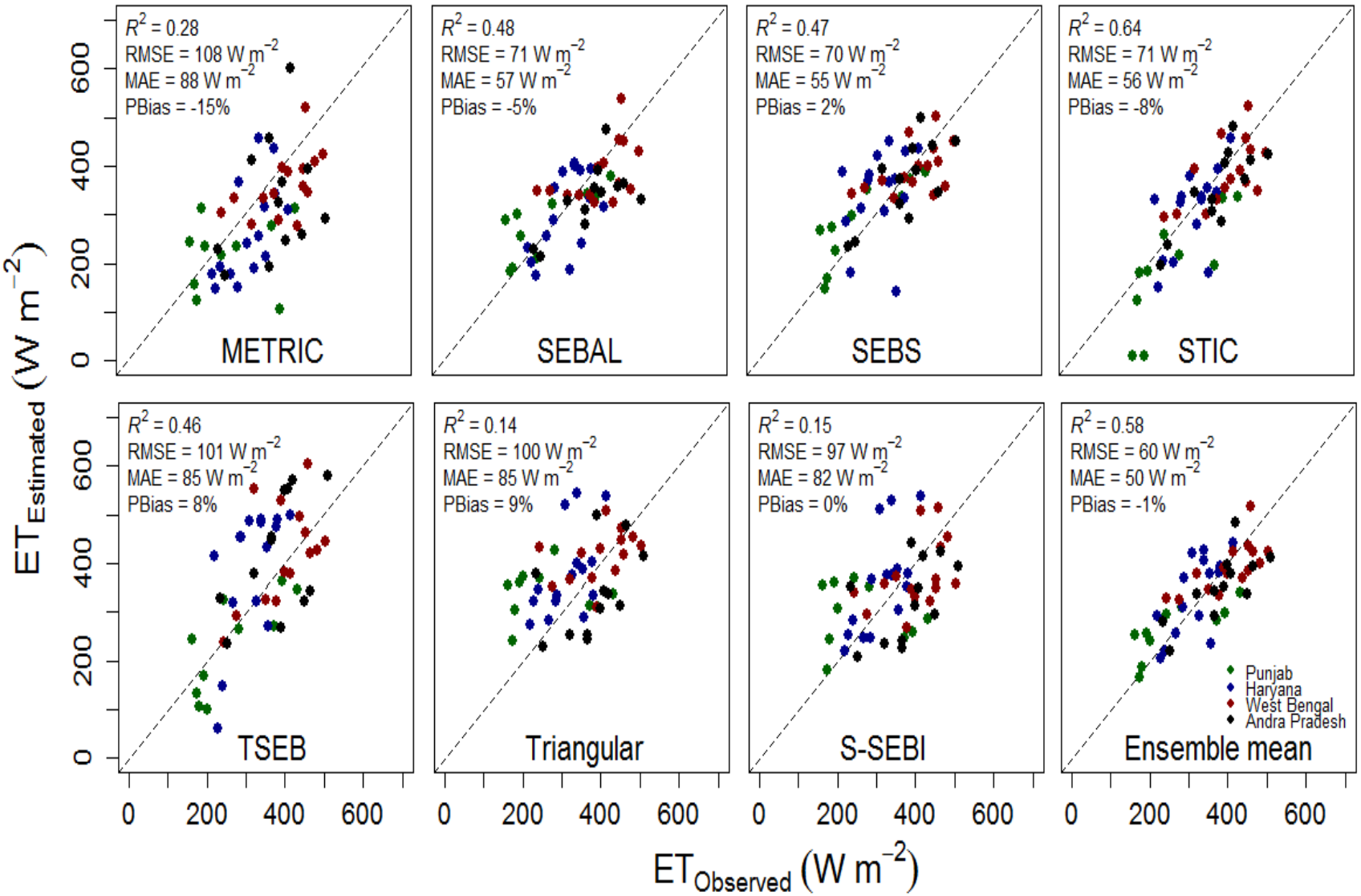


Jain et al. 2017

Mean annual Evapotranspiration (2001-2016)



Bhattarai et al. in prep.



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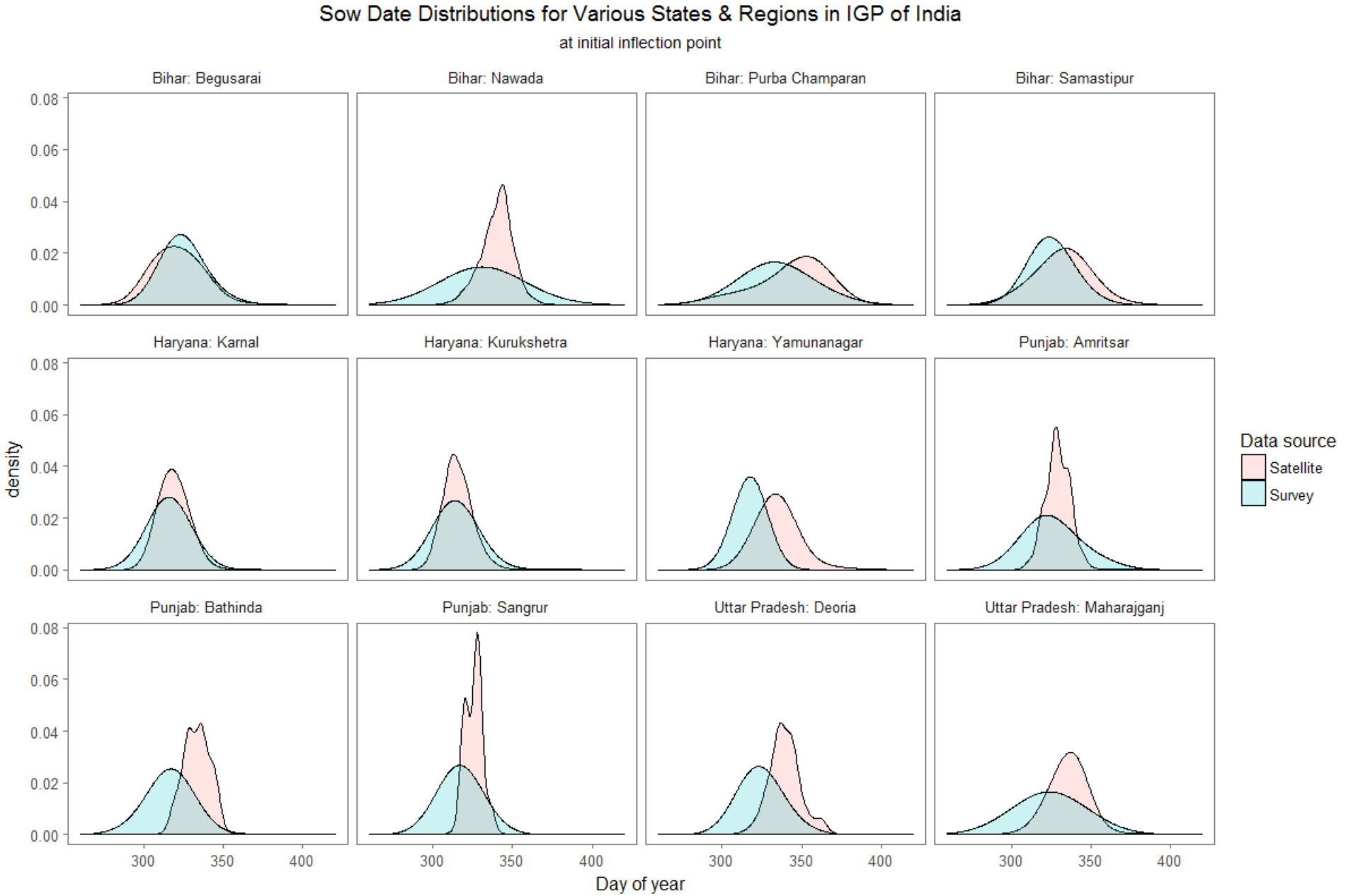

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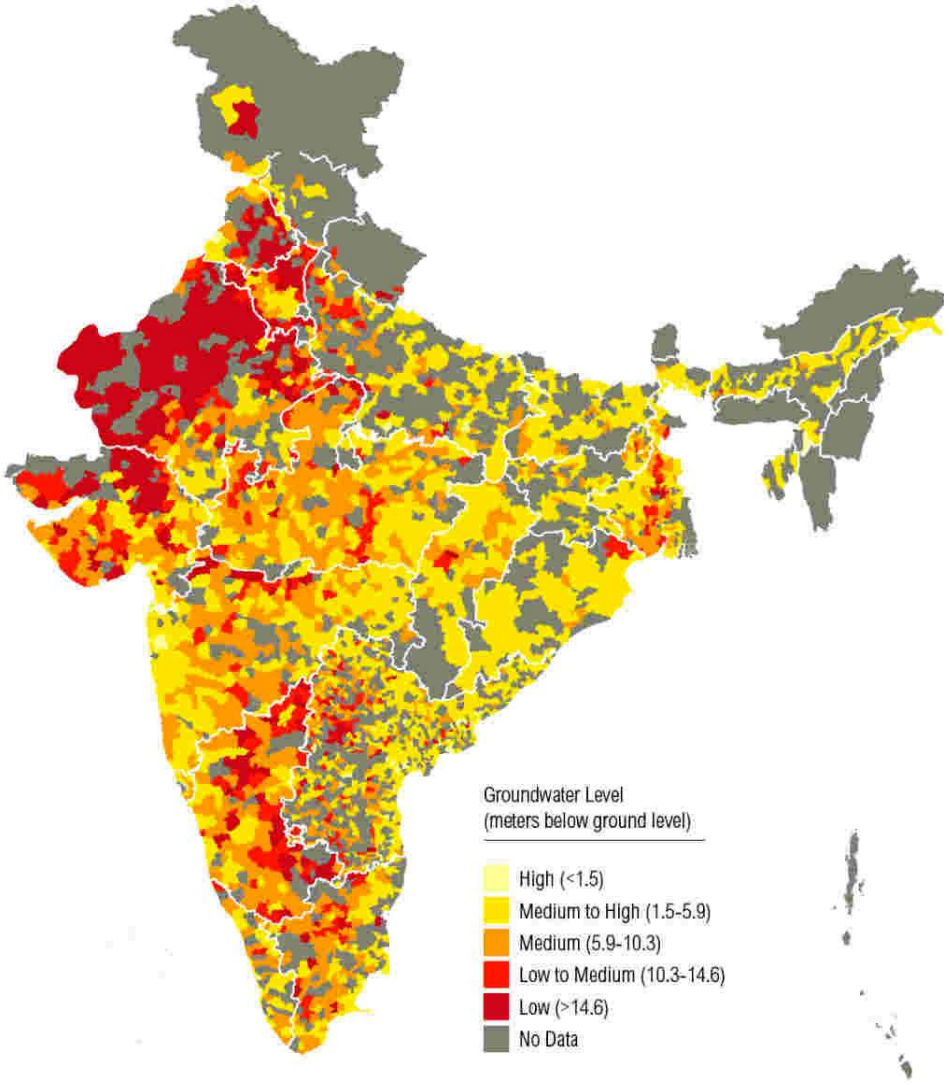

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- Is switching to canal irrigation a viable long-term adaptation strategy?

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	Ensem ET
Ground water Level (m)	-9.134***
	(0.858)
Precipitation (mm)	0.007*
	(0.004)
District FE	Yes
Year FE	Yes
Observations	3024
R^2	0.05
Note:	*p<0.1; **p<0.05; ***p<0.01

Bhattarai et al. in prep.

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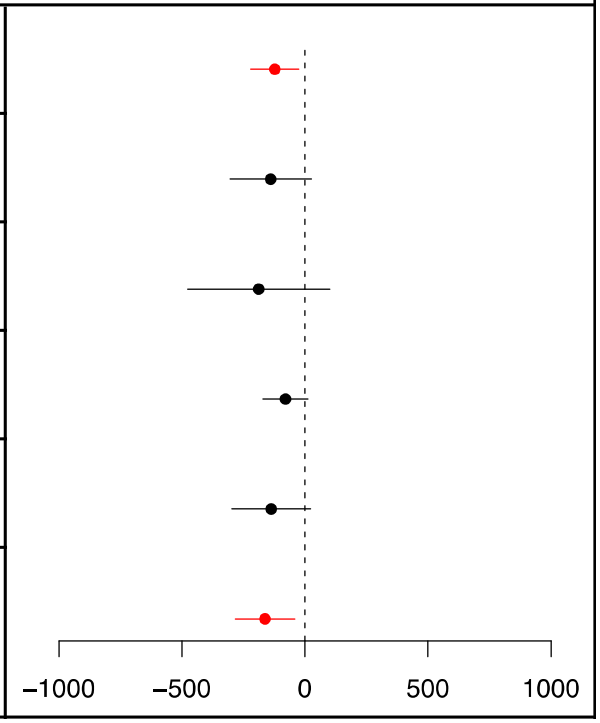
- Is current groundwater depletion associated with yield declines or have farmers been able to adapt?

Regression/ Subset	Change in Yield (kg/ha) per Standard Deviation in Groundwater	
National	Winter Wheat	
	Winter Rice	
	Winter Maize	
	Monsoon Rice	
	Monsoon Maize	
	Monsoon Pearl Millet	

Pollack et al. in prep.

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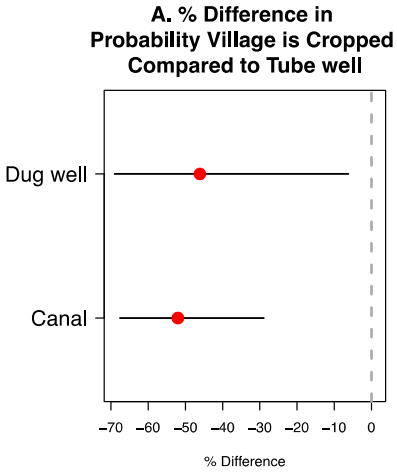
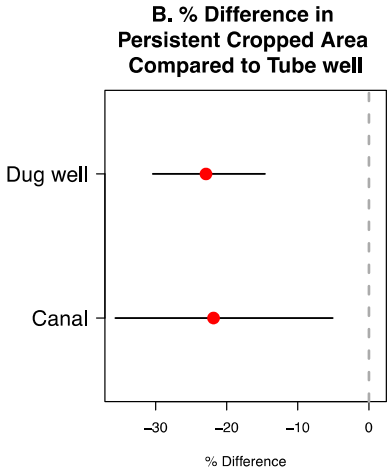
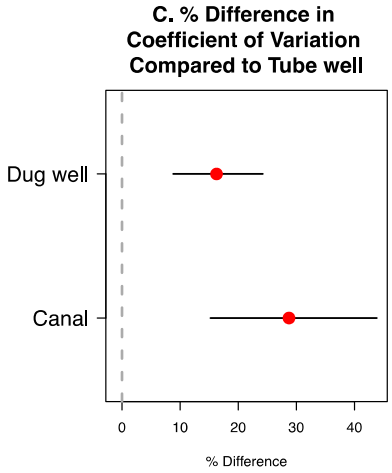
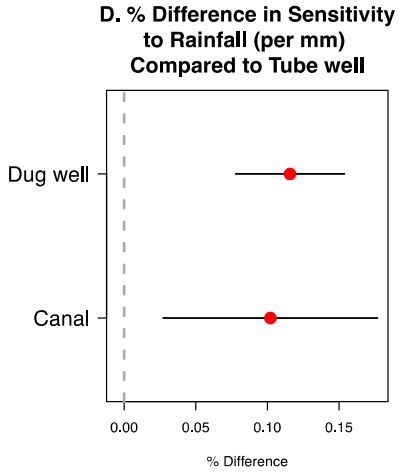


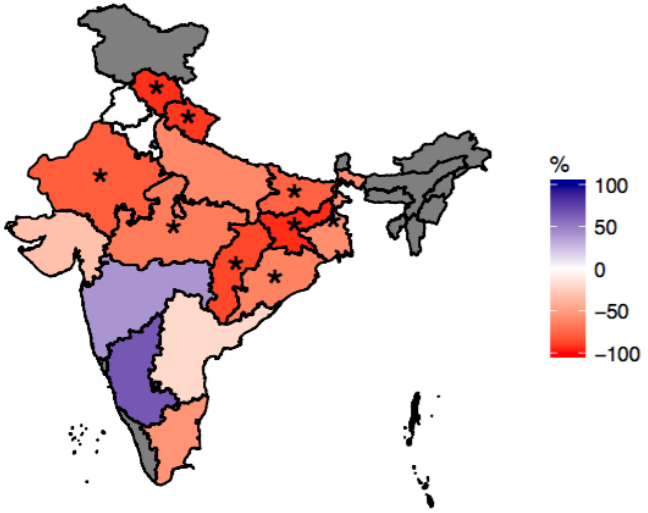




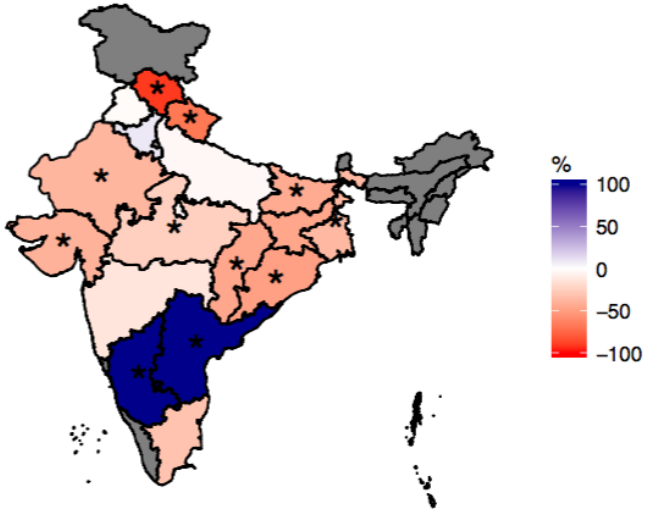


Jain et al. in prep

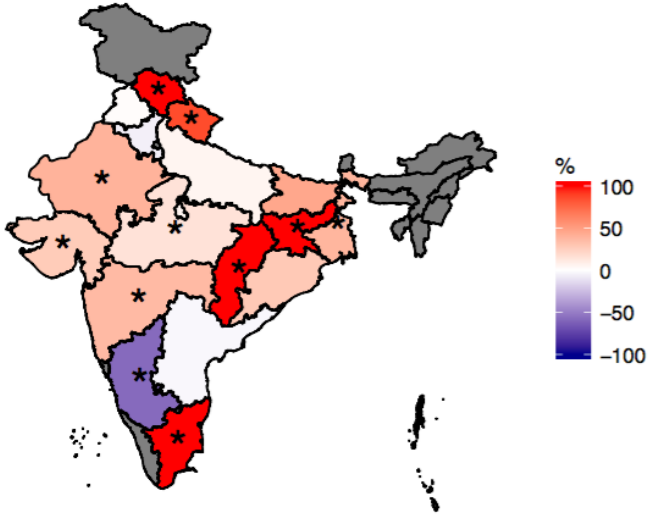
A. % Difference in
Probability Village is Cropped



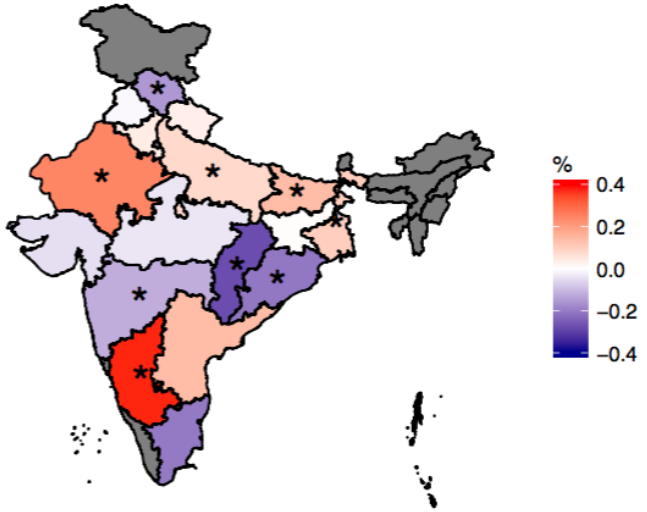
B. % Difference in
Persistent Cropped Area



C. % Difference in
Coefficient of Variation



D. % Difference in
Sensitivity to Rainfall (per mm)



Conclusions

- Groundwater depletion is already reducing irrigation capacity and the yields of some crops (e.g., wheat)
- Switching to canal irrigation when wells run dry will only be able to ameliorate production losses by ~ 50%
- This suggests that additional adaptation strategies that more efficiently use groundwater are needed (e.g., drip irrigation)

Conclusions

- Satellite data allow us to
  - map decision making in response to environmental change at fine spatial resolutions
  - link adaptation with drivers and outcomes at large spatio-temporal scales
  - examine heterogeneity in adaptation efficacy at fine spatial resolution

Informing Interventions & Capacity Building

- Partnering with CIMMYT and IWMI to identify ways our results and satellite data products can be used to target appropriate interventions regionally
- Conducting remote sensing trainings with scientists from CIMMYT and the Mahalanobis National Crop Forecast Centre on using Google Earth Engine

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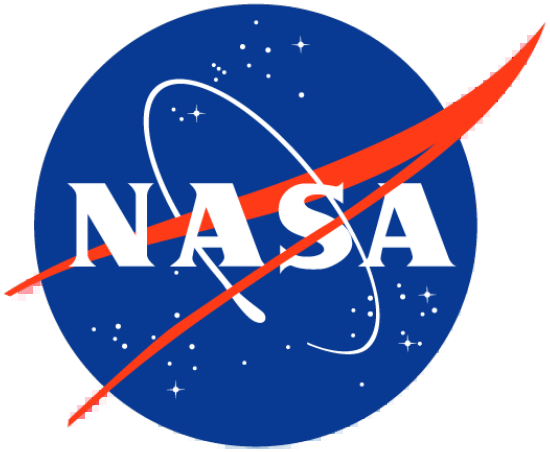
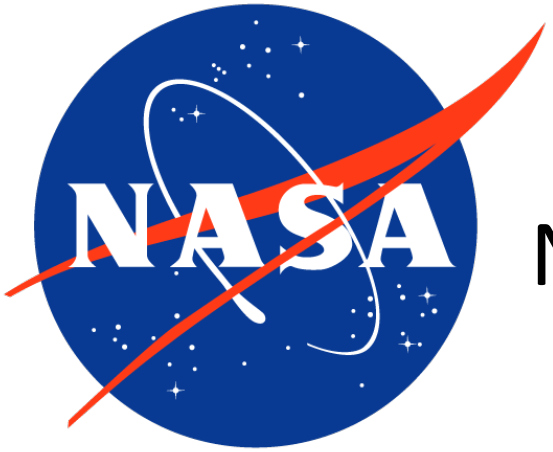


LCLUC

Land Cover/Land-Use Change Program



New Investigator Program (NIP)