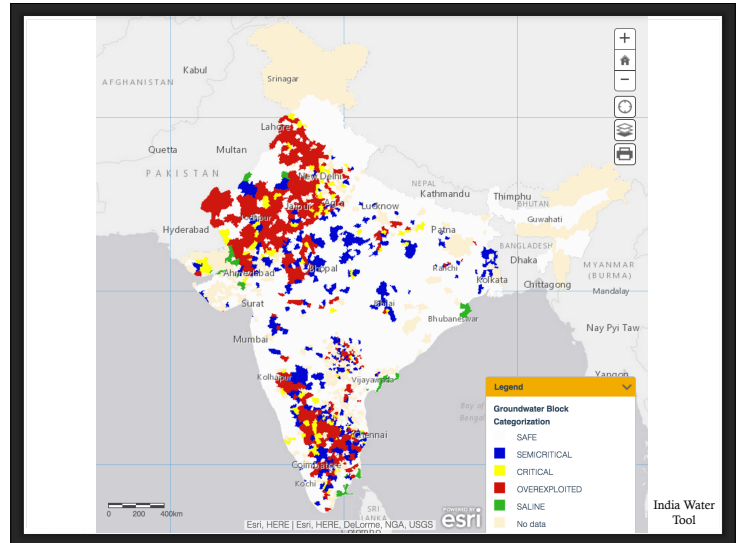


The Relative Influence of Groundwater and Canal Irrigation on Winter Crop Production in India



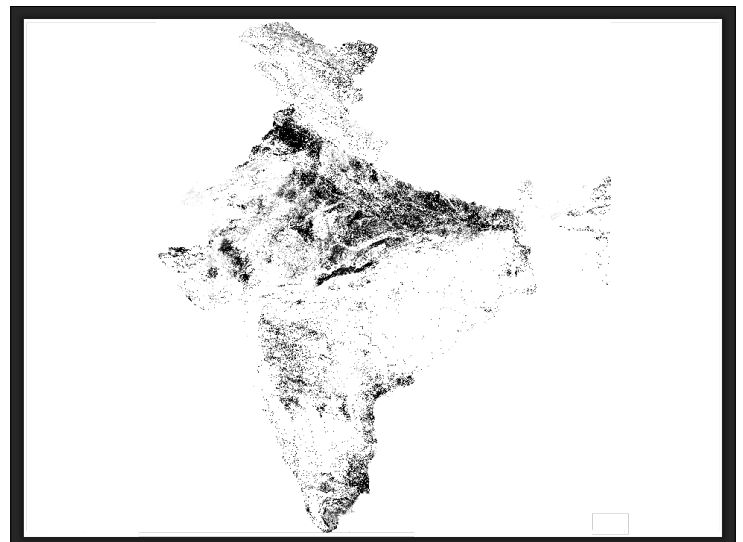
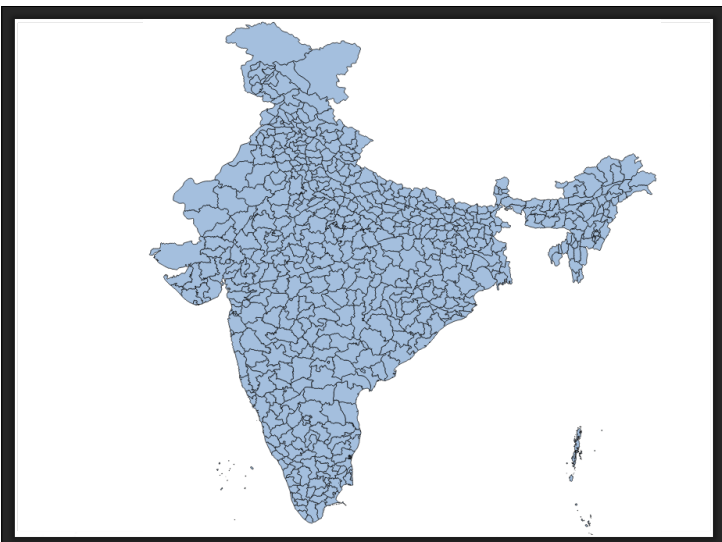
M. Jain*, R. Fishman, P. Mondal, G. Galford, S. Naeem, R.S. DeFries
 *Department of Earth System Science, Stanford University
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Question

- How do different types of irrigation influence winter cropped area and reduce its sensitivity to rainfall variability across India?
 - Deep, shallow, and dug wells
 - Surface flow and lift canals

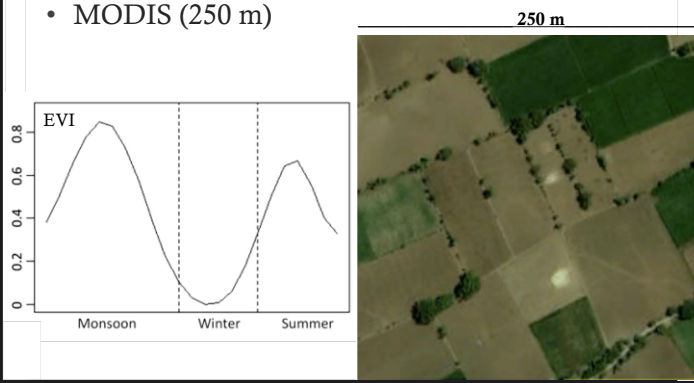


Remote Sensing

- Satellite imagery is available globally since the 1970s (Quarmby et al. 1992, Maxwell et al. 2004)
- Current remote sensing methods may not map smallholder agriculture accurately (Sakamoto et al. 2009, Birader and Xiao 2011)
- Develop a method to map cropped area of smallholder farms using free and readily-available imagery (e.g. MODIS, Landsat)

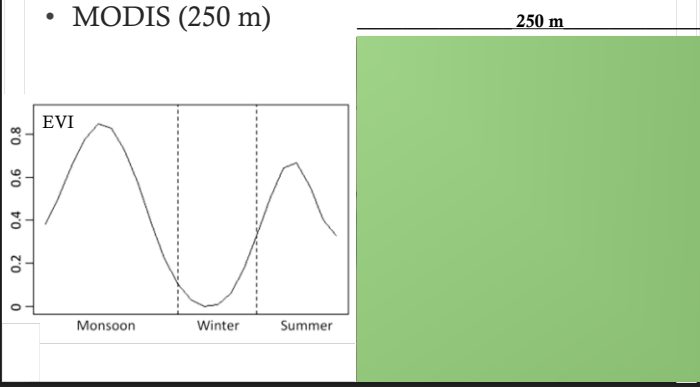
Methods

- MODIS (250 m)



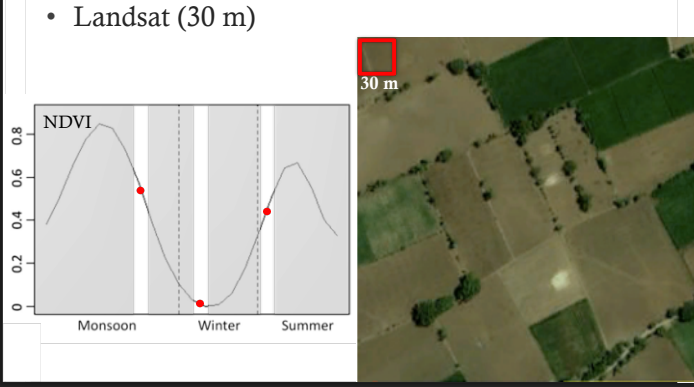
Methods

- MODIS (250 m)



Methods

- Landsat (30 m)



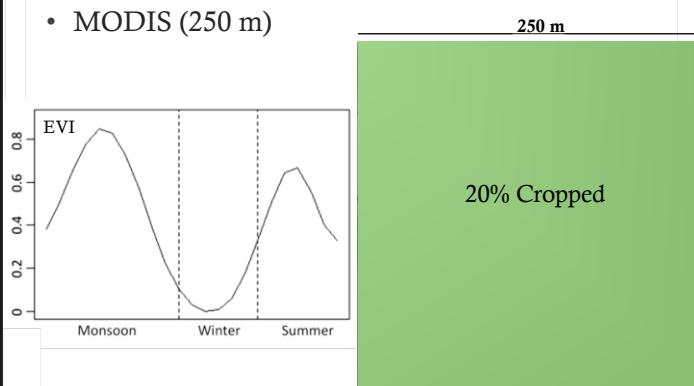
Best Methods: Landsat (≤ 1 km) and Hierarchical (>1 km)

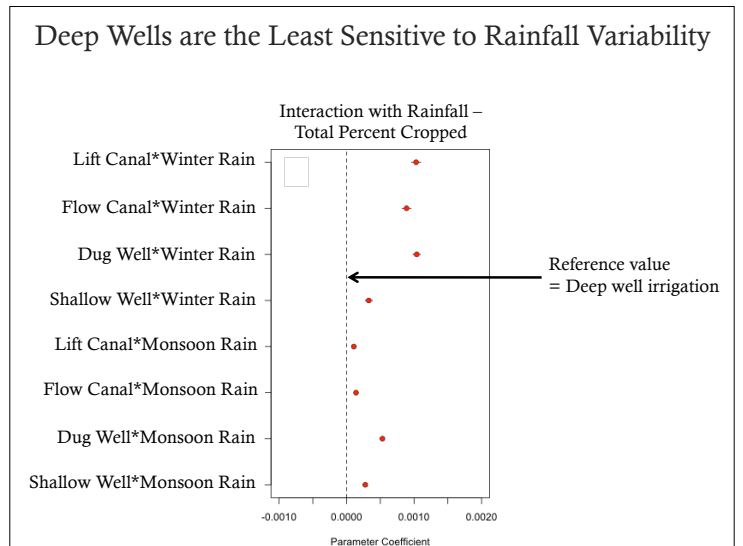
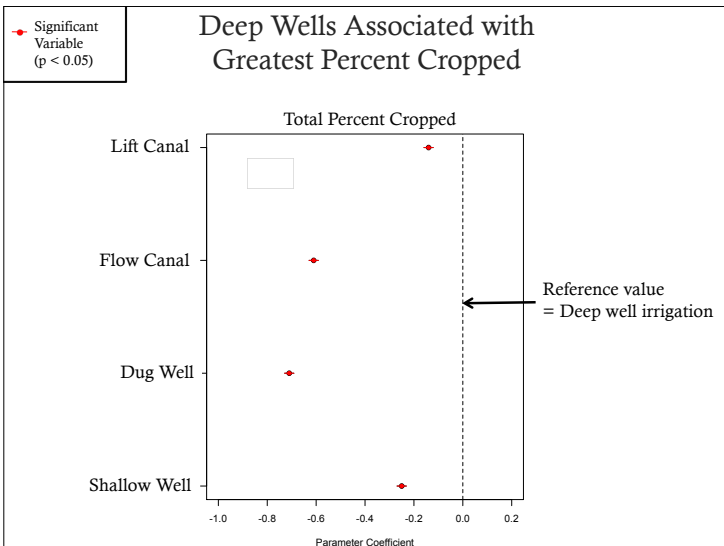
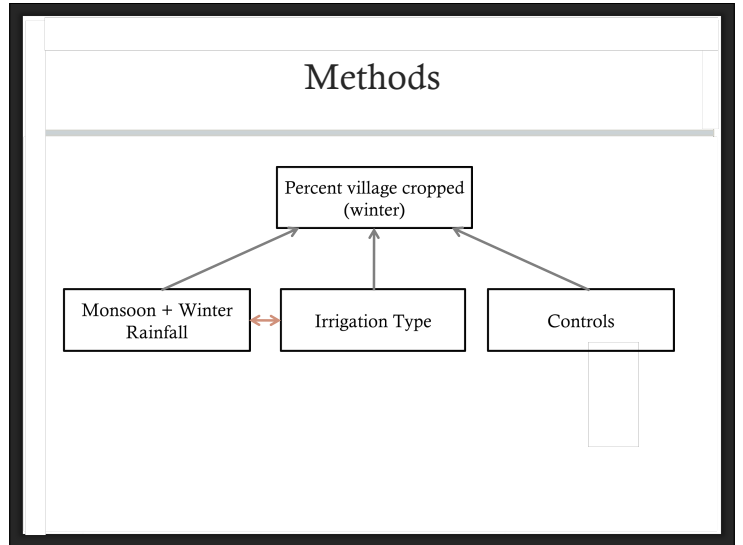
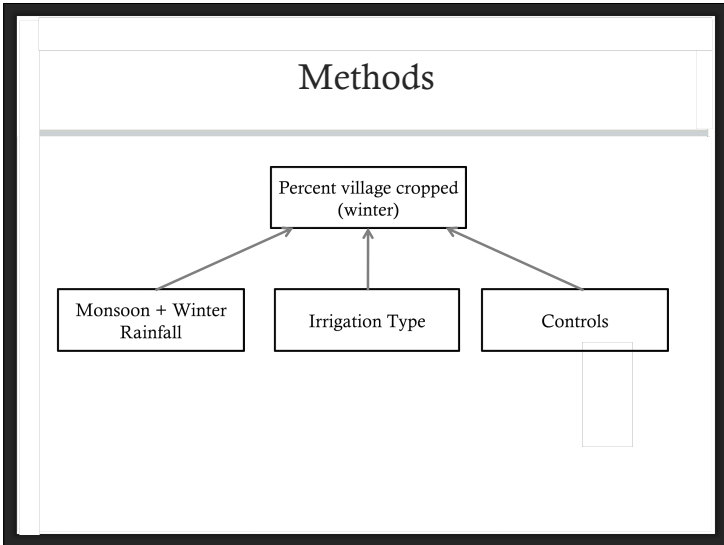
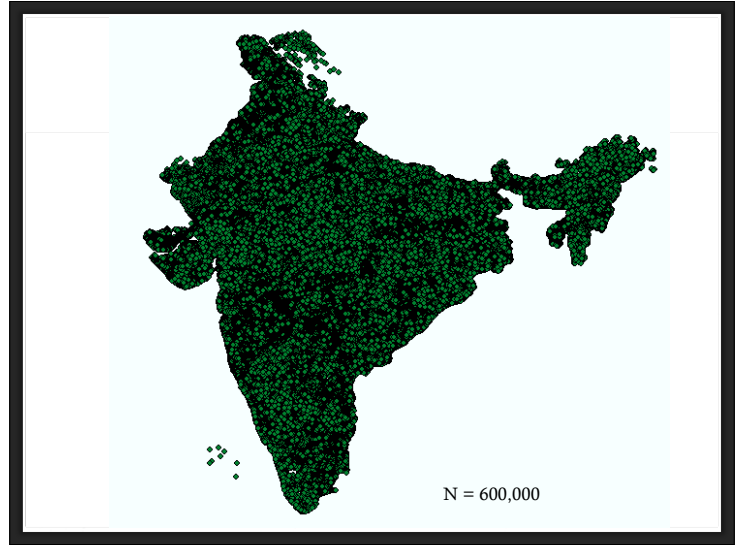
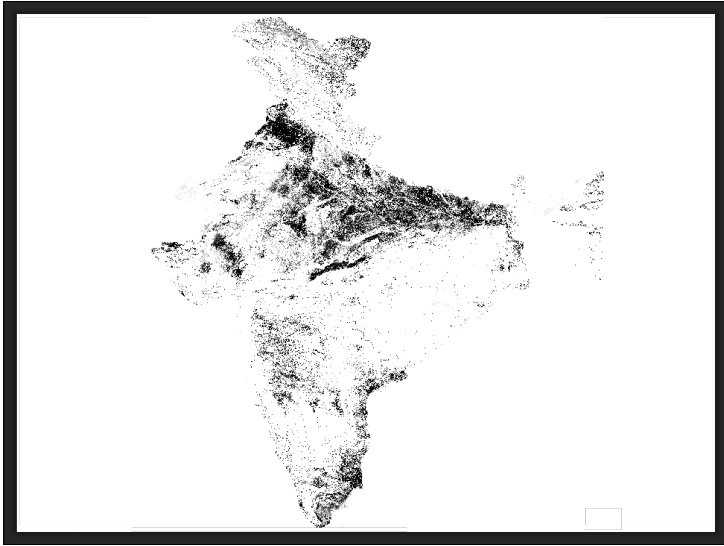
Method	250 × 250 m			1 × 1 km			5 × 5 km		
	R ²	RMSE	Rank	R ²	RMSE	Rank	R ²	RMSE	Rank
Landsat	0.85	0.11	0.92	0.93	0.08	0.96	0.97	0.07	0.98
MODIS Peak	-	-	-	0.71	0.41	0.90	0.96	0.29	0.98
TMA	0.16	0.44	0.41	0.46	0.40	0.68	0.60	0.43	0.80
Hierarchical	0.59	0.19	0.78	0.86	0.07	0.93	0.97	0.01	0.99

Jain et al. (2013)
Remote Sensing of Environment

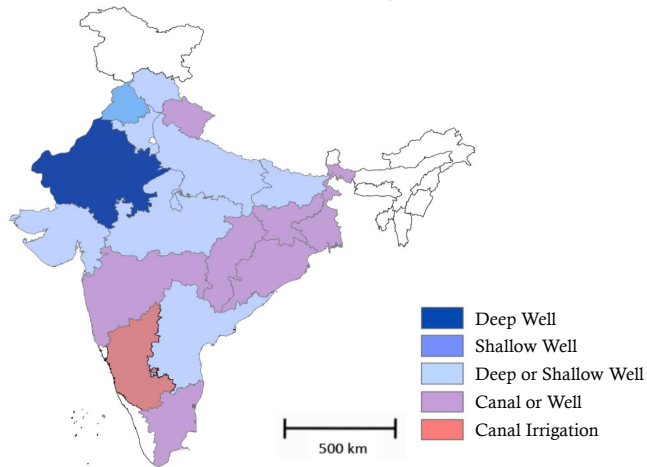
Hierarchical Method

- MODIS (250 m)





Groundwater is Associated with Greater Crop Cover and Reduced Sensitivity



Conclusions

- Groundwater irrigation is associated with increased percent winter crop and reduced sensitivity to rainfall, particularly in regions with the greatest levels of groundwater depletion
- Need to identify ways to more efficiently use groundwater (e.g. drip, less water-intensive crops) or improve canal irrigation

Future Work

- Improve cropped area estimates by using Landsat data (with Pinki Mondal, Gillian Galford, and Ruth DeFries)
- Link cropped area estimates with groundwater levels we have from 2000 to the present (with Aaditya Dar and Ram Fishman)
- Produce estimates of yield at 30 meter resolution using satellite data and link these with irrigation data (with David Lobell)

