Climate Sensitivity of Winter Cropping in India

LCLUC Regional Team Meeting, Yangon, Jan 13-15, 2016

R. DeFries, Columbia University
G. Galford, University of Vermont
M. Jain, Stanford University
P. Mondal, Columbia University

How can smallholder farmers reduce their vulnerability to climate variability in South Asia?

Multiple Drivers

~~Climate Sensitivity~~ of Winter Cropping in India

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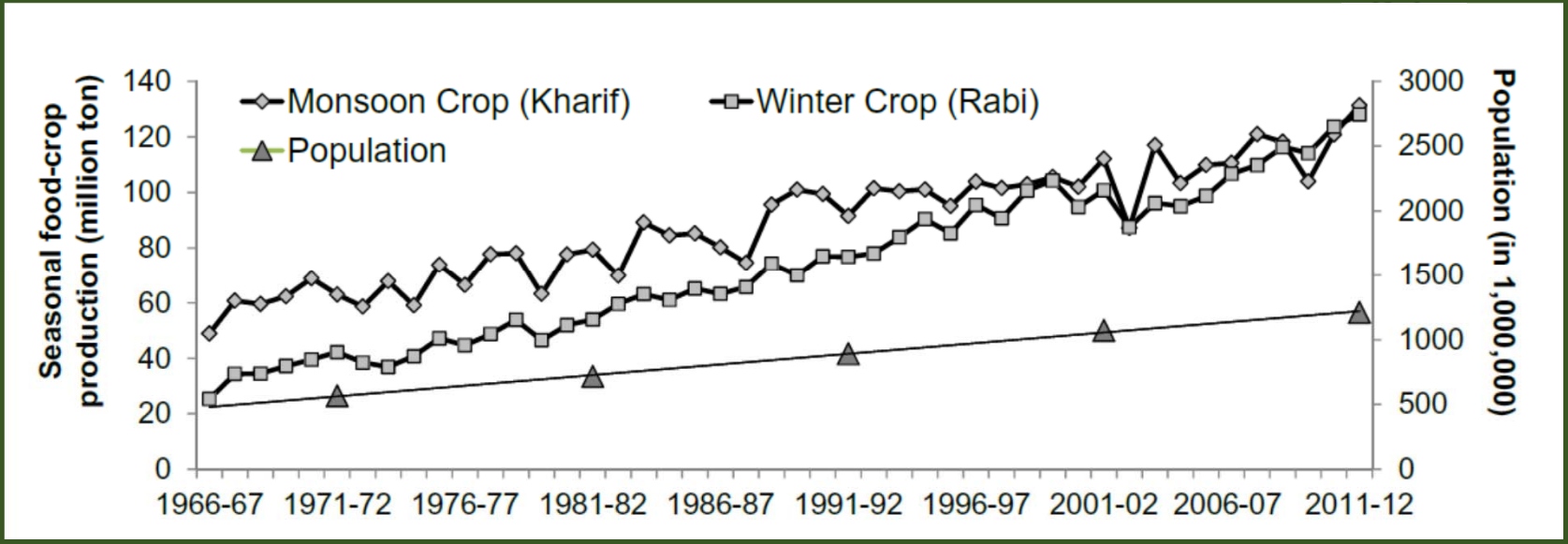
Agricultural intensification in India has occurred largely through increasing winter crop

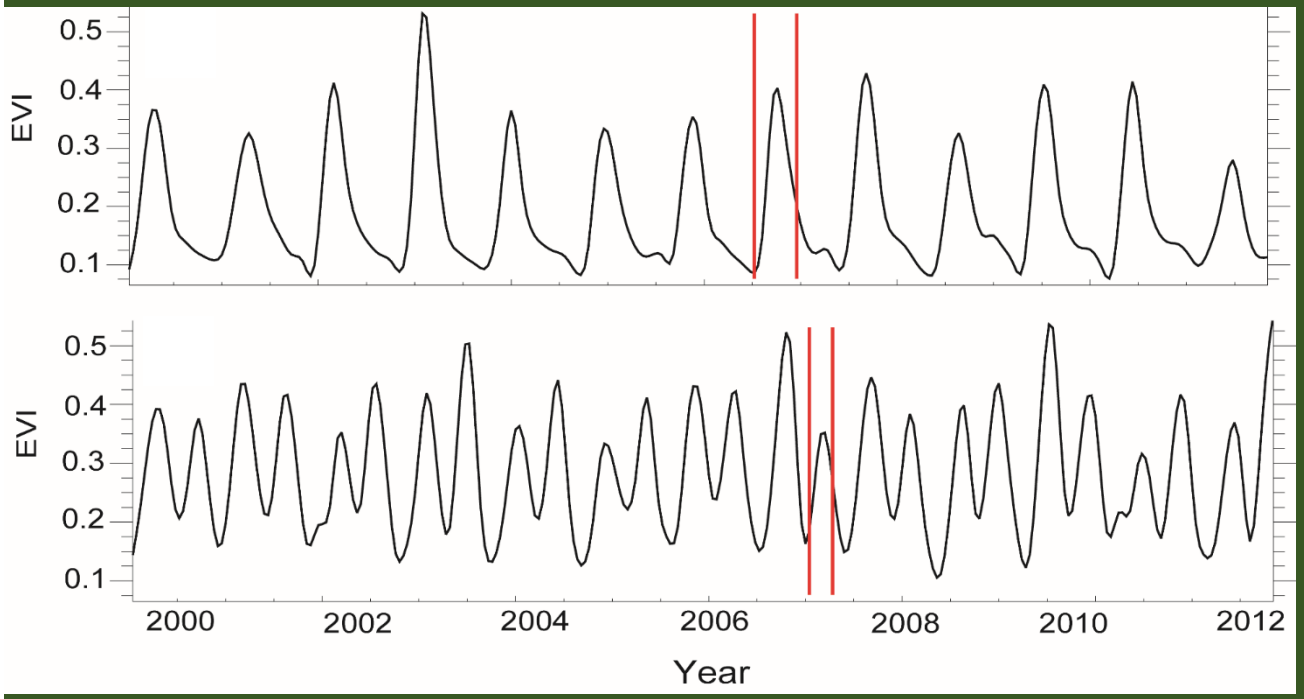


(Mondal et al., 2014)

RESEARCH QUESTIONS

- ***Can satellite data capture seasonal cropping patterns for complex landscapes of South Asia?***
- ***How much and where are farmers switching between single and double cropping?***
- ***Which climatic, biophysical and demographic variables are associated with variability in winter cropping?***

Phenology with MODIS Enhanced Vegetation Index (EVI) to map cropping intensity



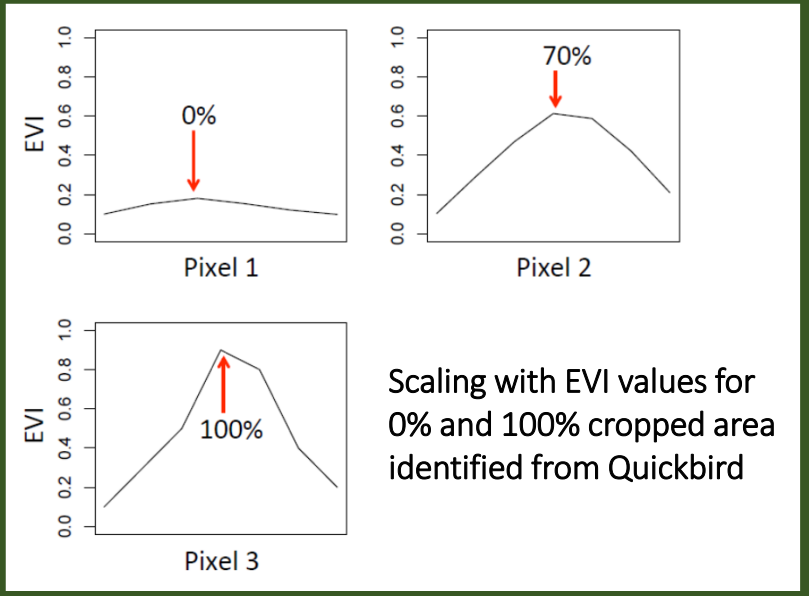
Single crop: monsoon only

Double crop: monsoon and winter

Mondal et al, in review

The challenge of small field size

The challenge of small field size

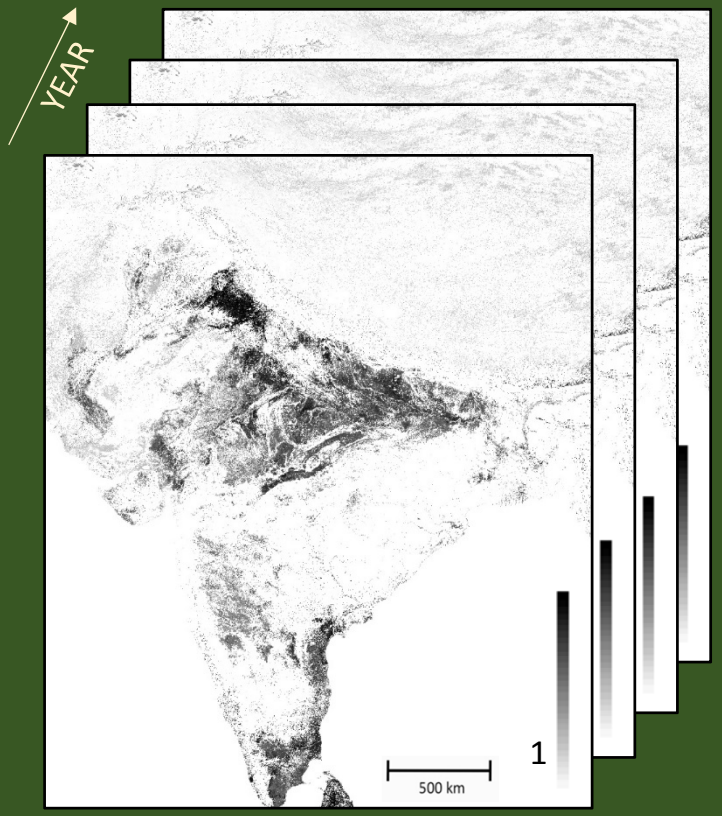


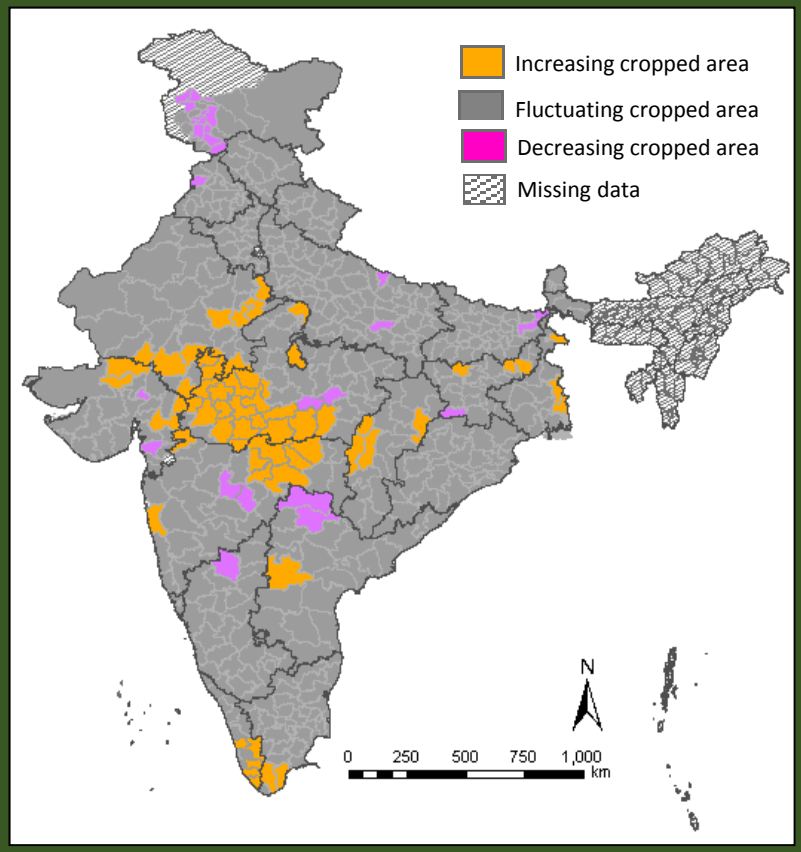
Scaling with EVI values for 0% and 100% cropped area identified from Quickbird

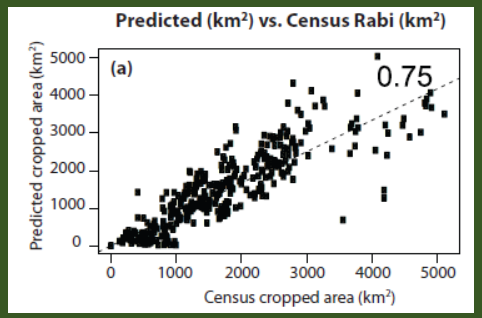
Method	250 × 250 m			1 × 1 km			5 × 5 km		
	R^2	RMSE	Rank	R^2	RMSE	Rank	R^2	RMSE	Rank
Landsat	**0.85**	**0.11**	**0.92**	**0.93**	**0.08**	**0.96**	0.97	0.07	0.98
MODIS Peak	–	–	–	0.71	0.41	0.90	0.96	0.29	0.98
TMA	0.16	0.44	0.41	0.46	0.40	0.68	0.60	0.43	0.80
Hierarchical	0.59	0.19	0.78	0.86	0.07	0.93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

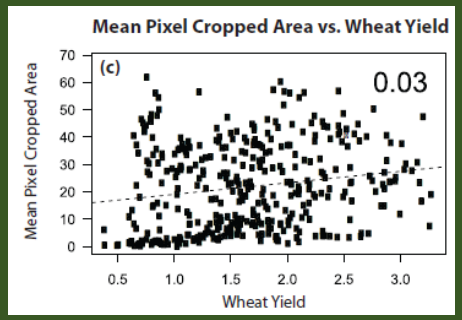
Jain et al, 2013

Winter productive crop area from 2000 to present



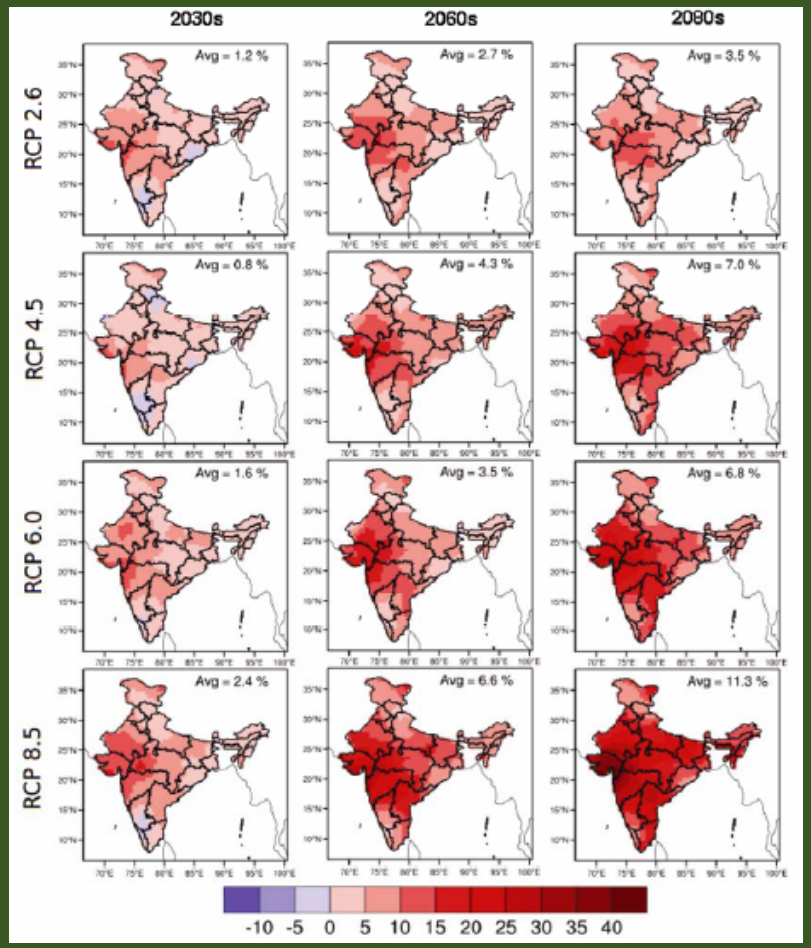




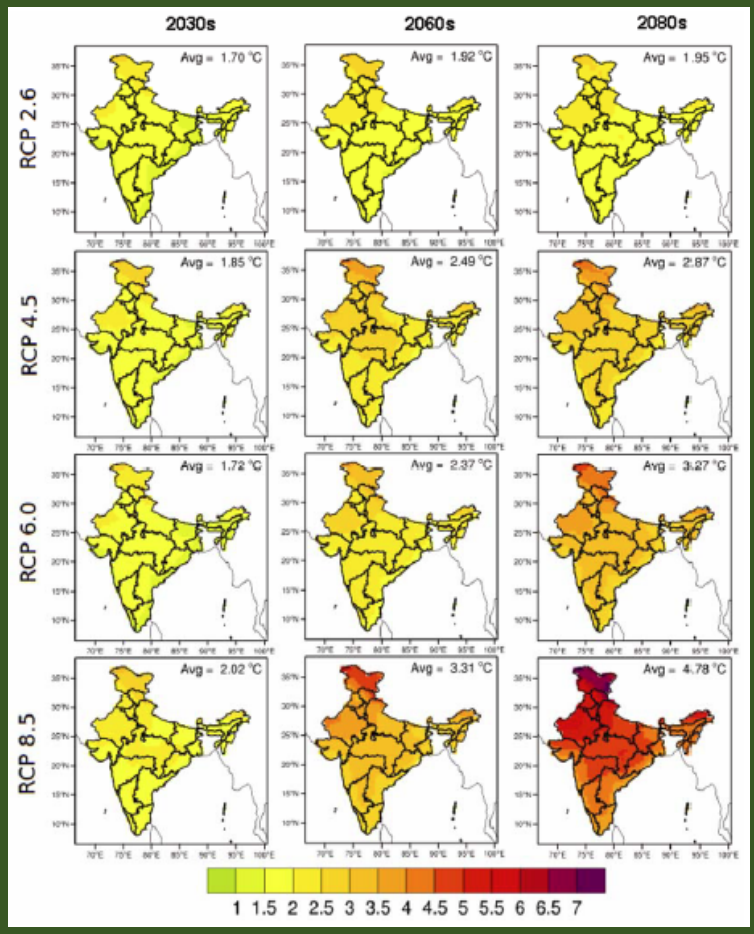


Mondal et al, in review

How might future climate change affect winter cropping?



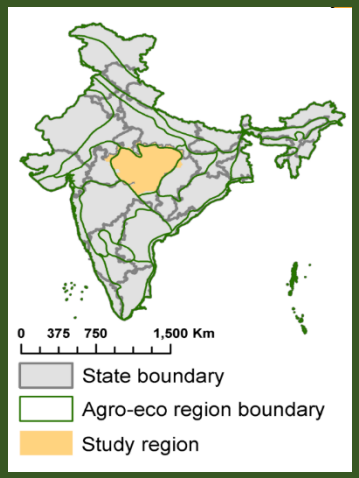
PROJECTED PRECIPITATION

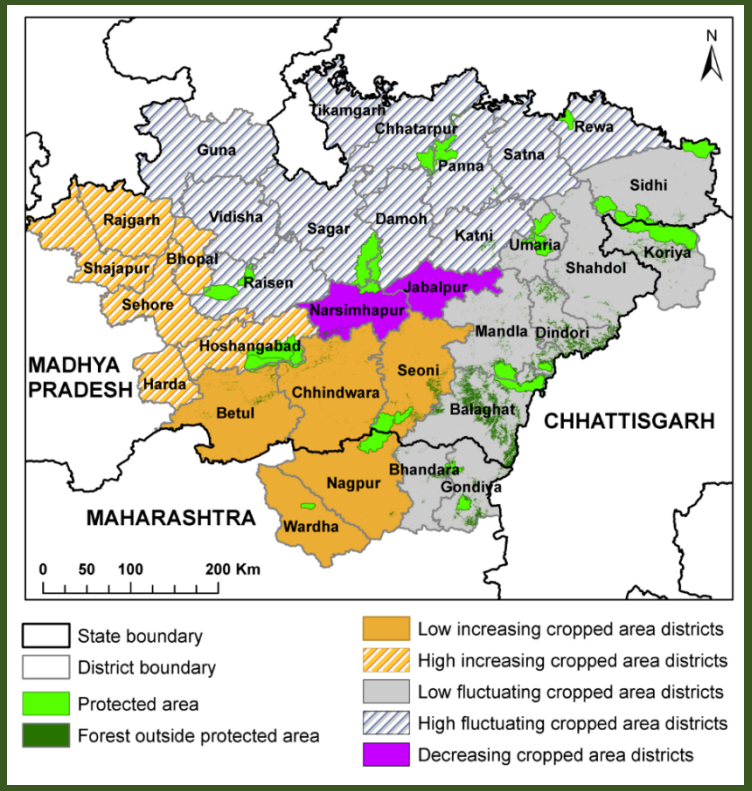


PROJECTED TEMPERATURE

[Source: Chaturvedi et al. 2012]

Winter cropping trends in central Indian highlands





Mondal et al., in review

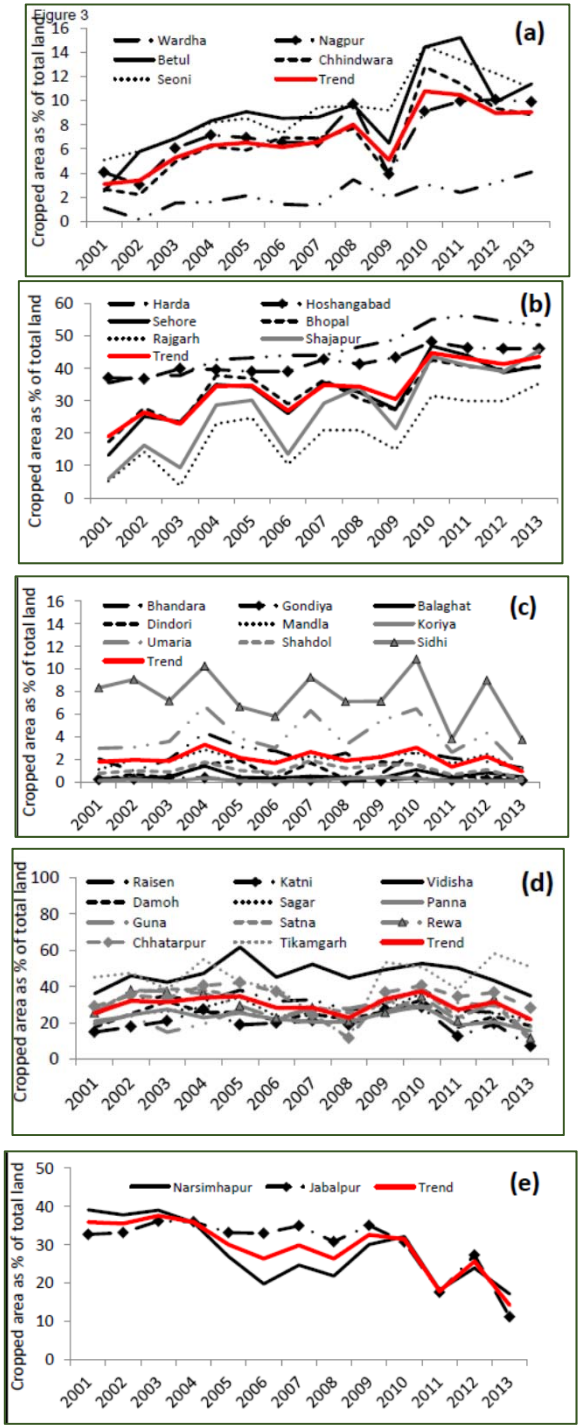
Low increasing

High increasing

Low fluctuating

High fluctuating

Decreasing

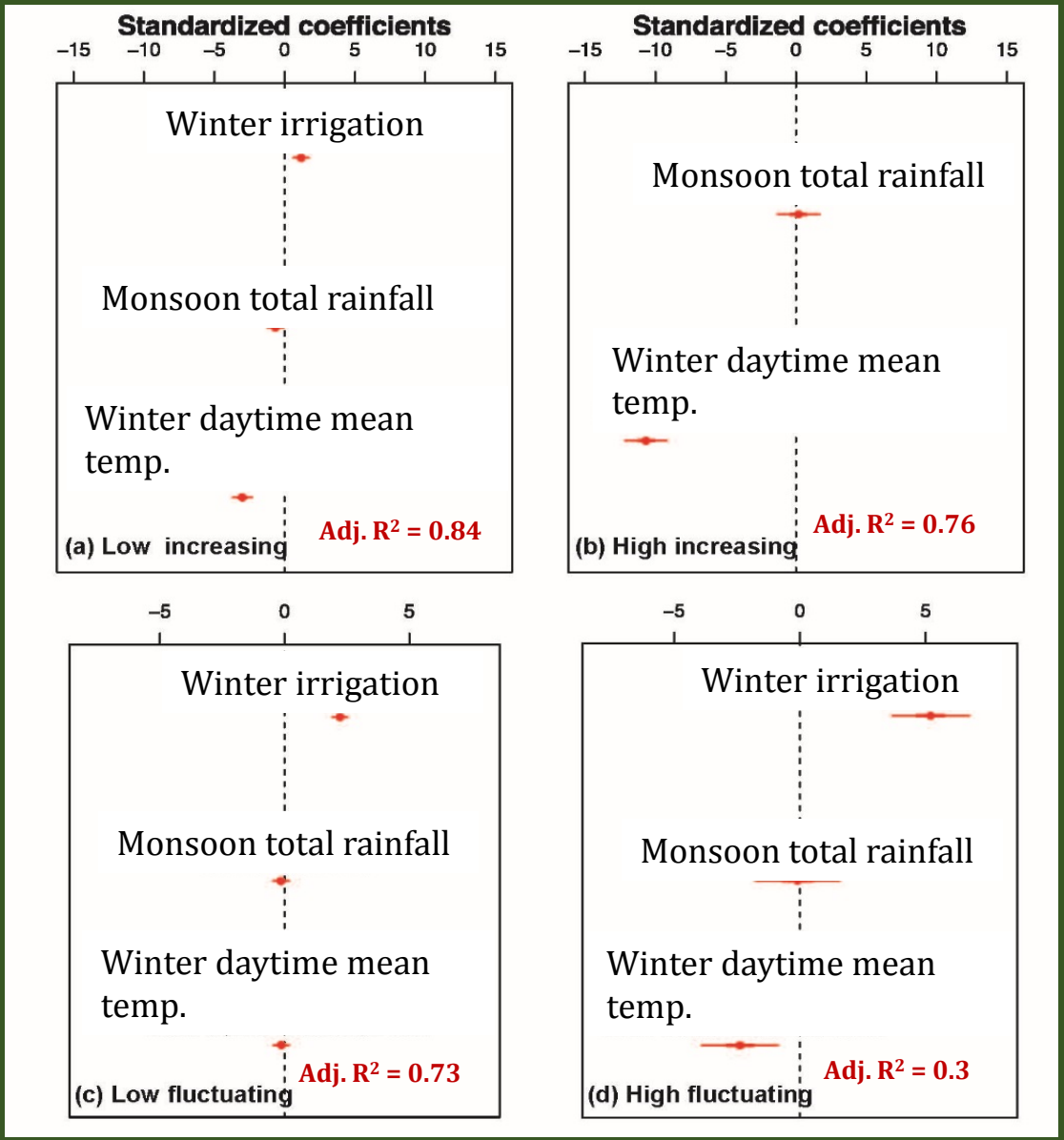


Soil and irrigation are key factors for winter cropping

PULSES
(chickpea, pigeon pea, lentil, moong)

WHEAT

Photos: P. Mondal



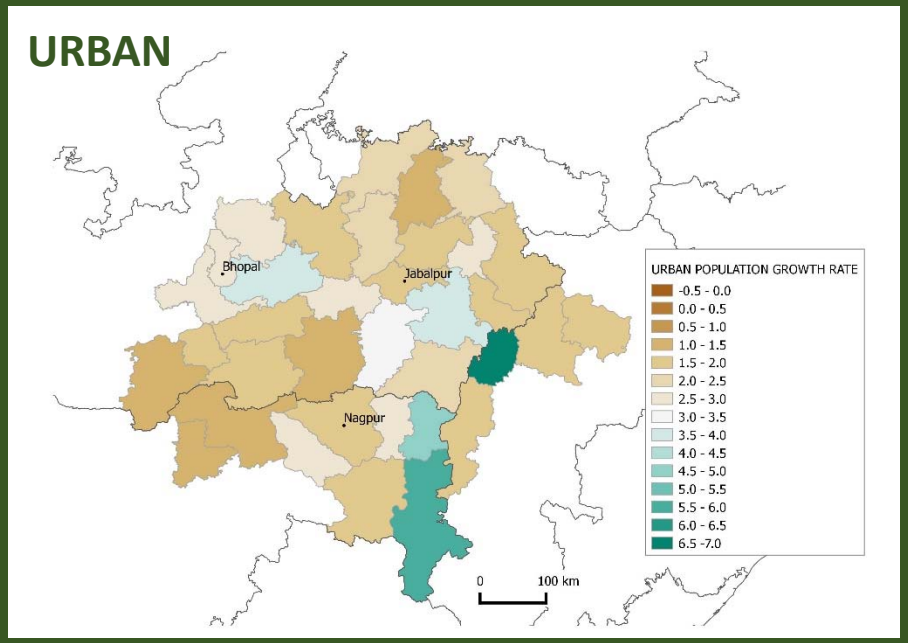
- Winter irrigation has a statistically significant **positive impact** on productive cropped area

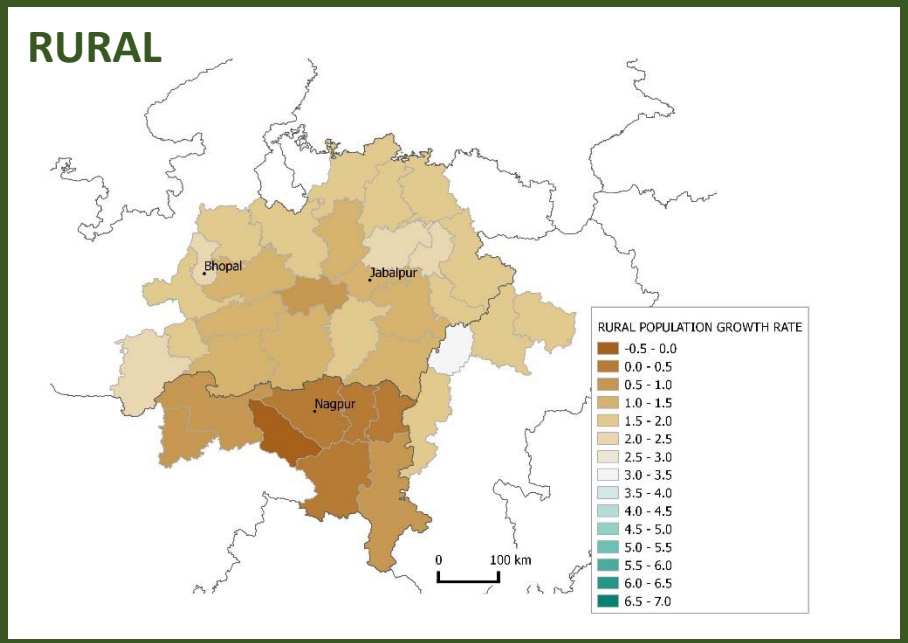
BUT

- Winter daytime mean surface temperature shows a **strong negative** correlation with cropped area

Mondal et al., in review

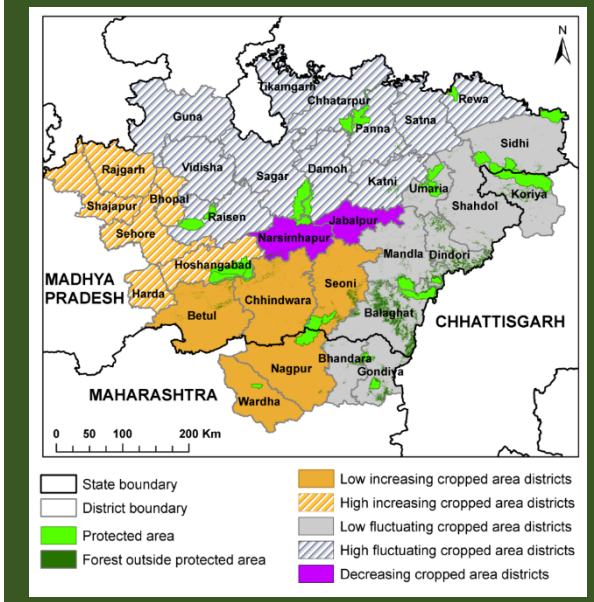
CLIMATE IS ONLY ONE PART OF THE PICTURE: URBANIZATION AND CHANGING LABOR DYNAMICS





Source: India Census Data 2001 and 2011

Dominant decadal trends in demographic variables and their association with winter cropped area (Pearson's r values) in five district categories. Statistically significant ($p<0.05$) correlation coefficients are in red.



District categories	Main cultivators[a] (rural density)		Main agricultural laborers[b] (rural density)		Marginal cultivators[c] (rural density)		Marginal agricultural laborers[d] (rural density)	
	Correlation with cropped area	Dominant decadal trend	Correlation with cropped area	Dominant decadal trend	Correlation with cropped area	Dominant decadal trend	Correlation with cropped area	Dominant decadal trend
Low increasing	-0.49	↓	-0.02	↑	0.29	↓	0.65	↑
High increasing	-0.60	↓	0.36	↑	-0.71	↓	0.02	↑
Low fluctuating	-0.07	↓	0.27	↑	-0.43	+/-	0.36	↑
High fluctuating	0.44	↓	-0.10	↑	0.22	↓	-0.23	↑

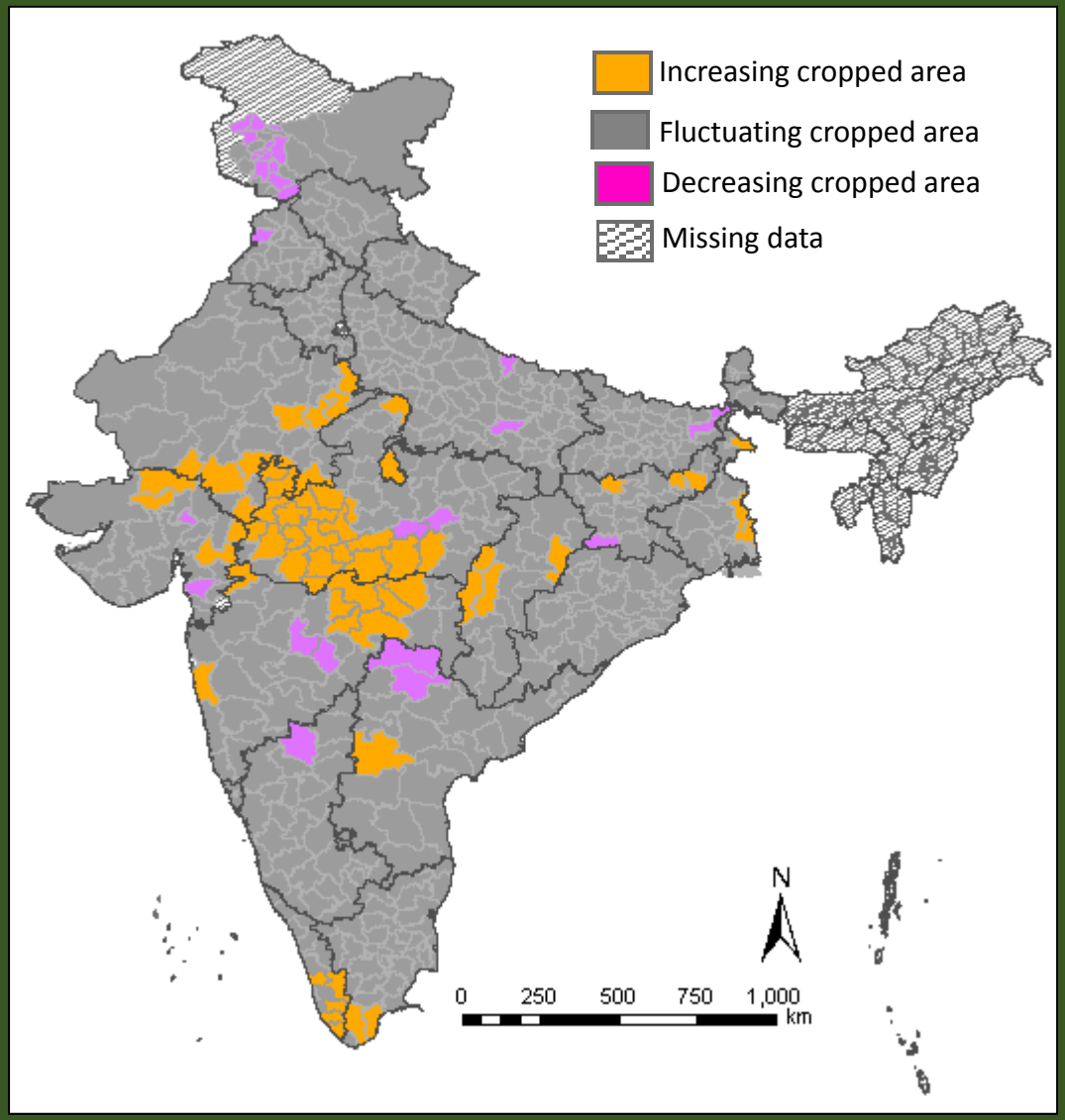
[a]Main cultivators = Main workers (worked for >6 months) who are cultivators (who take farming decisions)
[b]Main agricultural laborers = Main workers who are agricultural laborers (who work for cultivators)
[c]Marginal cultivators = Marginal workers (worked for <6 months)
[d]Marginal agricultural laborers = Marginal workers who are agricultural laborers (who work for cultivators)

SUMMARY

- Winter cropping is key aspect of agricultural intensification and food security in South Asia
- Mapping winter cropping of smallholder farms with remote sensing allows region-specific analyses
- Region-specific analysis needed to understand drivers: labor dynamics critical
- SARI research needs to address complexity of changing economics, labor and climate

Next steps

- Dynamics in other agro-ecological zones
- Impacts of changing winter cropping patterns on nutrition
- Impacts of winter cropping on fires and air quality



Publications

Mondal, P., Jain, M., Robertson, A., Galford, G., Small, C., DeFries, R. 2014. Winter crop sensitivity to inter-annual climate variability in central India. *Climatic Change* 126, 61-76.

Mondal, P., Jain, M., DeFries, R., Galford, G., Small, C. 2014. Sensitivity of crop cover to climate variability: Insights from two Indian agro-ecoregions. *Journal of Environmental Management*. 148, 21-30.

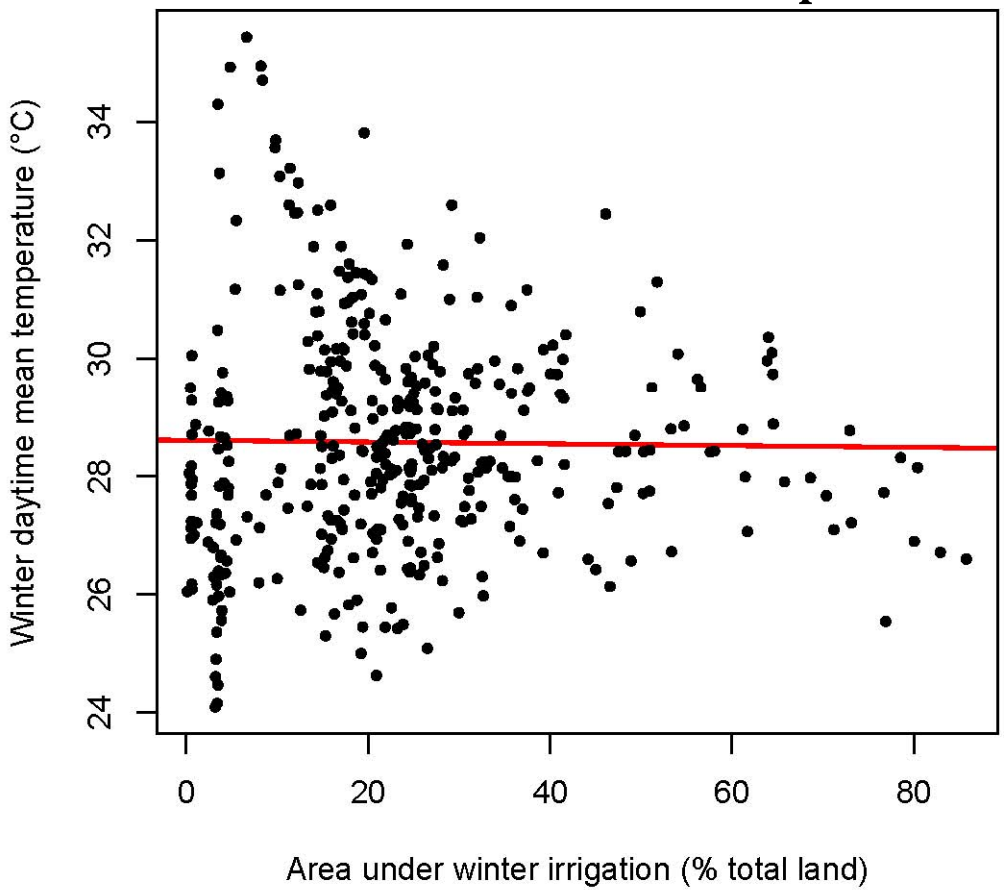
Jain, M., Mondal, P., DeFries, R., Small, C., Galford, G. 2013. Mapping cropping intensity of smallholder farms: a comparison of methods using multiple sensors. *Remote Sensing of Environment* 134, 210-223.

Mondal, P., Jain, M., Zukowski, M., Galford, G., DeFries, R., in review, Quantifying fluctuation in winter cropped area in central Indian highlands, *Regional Environmental Change.*

THANK YOU

Irrigation vs. Temperature

All 33 districts in the central Indian landscape



We did not find any significant correlation between irrigation and land surface temperature, except in one district category