Does Weather Sensitivity of Rice Yield Vary Across Regions? Evidence from Eastern and Southern India

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Background

- To assess climate change impacts at the regional (sub-national) level, past studies employing statistical models have largely followed the approach of uniformly applying the climate response function estimated at the aggregate (national) level to extrapolate/interpolate the impacts for the region(s) of interest.
- Impact estimates based on this approach only loosely indicating the magnitude (or direction) of regional impacts could, however, result in significant overestimation or underestimation of true regional impacts.
- This issue is examined through the assessment of historical impacts of climate change on rice yield across Indian sub-regions.
- This study examines whether an aggregate (all-India) response function represents well the regional impacts on rice yield . Comparison is made between regional impacts simulated using the all-India yield response function and impacts simulated using the region-specific yield response functions.
- It has implications for regional adaptation policy.

Methodology & Data

Estimation

Econometric Modeling to estimate the crop yield weather relation

(1) $$\ln(y_{it}) = \boldsymbol{X}_{it}\boldsymbol{\beta}^{R} + \boldsymbol{W}_{it}\boldsymbol{\gamma}^{R} + \alpha_i + \delta_t + \lambda_i t + \varepsilon_{it}$$

Simulation

Monte Carlo Simulation to estimate climate change impacts on yield

(2) $$\frac{\tilde{y}_{it}}{\hat{y}_{it}} = \left[\prod_j \left(\frac{\tilde{w}_{ijt}}{w_{ijt}}\right)^{\hat{\gamma}_j^R} - 1\right] \times 100$$

Key Highlights

- Uses fine-scale disaggregated data to undertake region-specific assessment of the historical impacts of climate change on Indian agriculture
- Follows crop-phenology literature, and uses region-specific crop calendar to empirically estimate crop yield-weather relationship and examines sensitivity of rice yield to weather at various stages of rice development across regions
- Undertakes statistical simulation to project the impacts
- Examines the nature of within-region distribution of impacts

Variables

Dependent Var: Yield,
Independent Vars:
T_{min}, T_{max}, Rain, Radiation (for Vegetative, Reproductive and Ripening phases)
Labour, Fertilizer, Irrigation, HYV seeds, FE

Data

Weather Variables:
Daily ($1^0 \times 1^0$) data mapped into Indian districts
Source: IMD (2006; 2009)
Non-weather Variables:
World Bank; ICRISAT
Years: 1969-2007

Results

Estimation Results

- Rice yield sensitivity to climate parameters (T_{min}, T_{max} , rain, radiation) vary across plant growth stages and across regions
- Effects of T_{min}, T_{max} on yield vary across regions. T_{max} during reproductive/ripening phase plays most detrimental role and are statistically significant.
- Model fit (R^2 ~ 80%) for both regions (East and South)

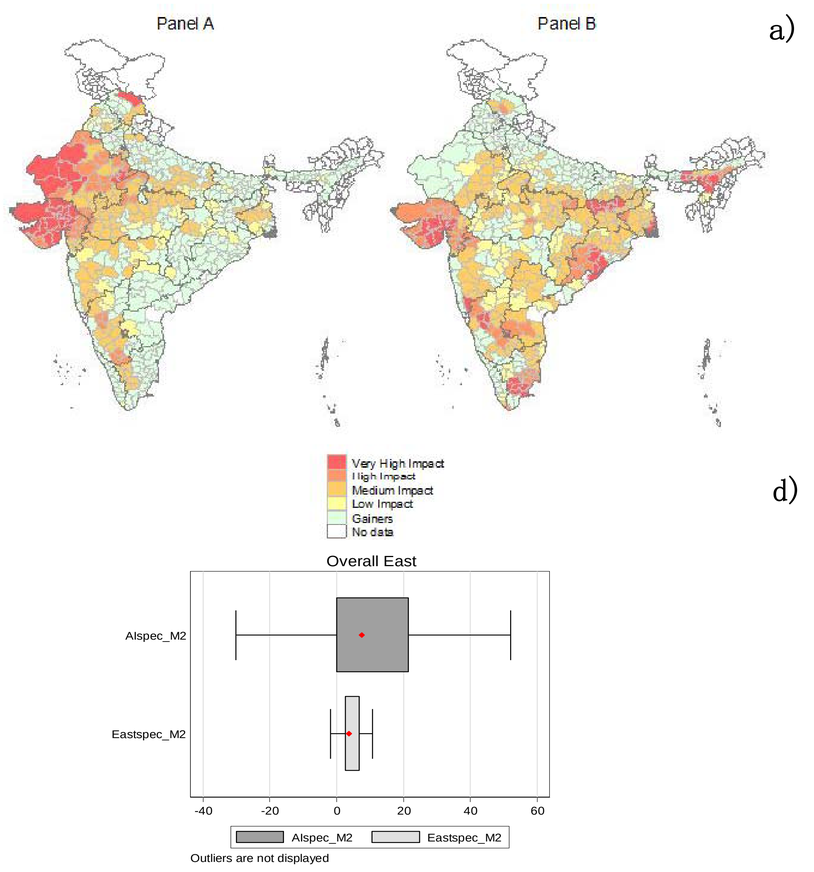
Simulation Results

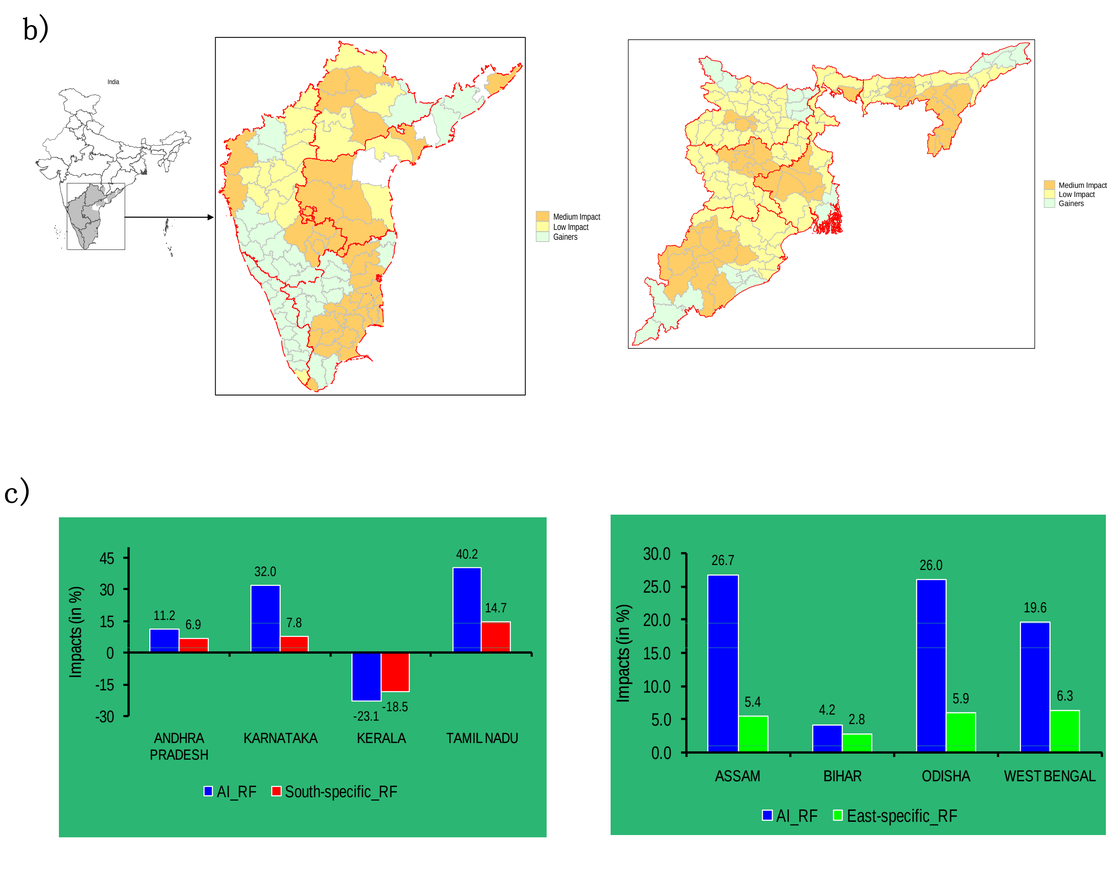
- Rice yield in South (East) would have been ~ 8 % (~ 5%) higher had past changes in climate not occurred
- Impacts are systematically overestimated if All-India response function is used to estimate regional impacts
- Within-region impacts analysis indicate that more number of districts are likely to get adverse impacts

Figure 1

Comparison of impacts estimated using All-India Vs. Regional response functions

a) Simulated impacts using AI RF
b) Simulated impacts for South and East using South- and East-specific RF
c) Comparison of mean impact estimates based on AI and regional RF for each region
d) Comparison of Within-region distribution of impacts based on AI and East RF





Conclusion

The analysis suggests that regional impacts are overestimated when simulated using an all-India yield response function instead of using the region-specific yield response function - yield losses estimated for South and East using national yield response function are ~21.6 and ~15.4 per cent, respectively.

The study highlights the need to conduct regional crop-weather sensitivity assessment using region-specific characteristics to understand regional vulnerability to climatic and non-climatic stressors and for region-level adaptation planning to tackle climate change.

This has significant implications given the high rice dependence of India's poor population.