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Climate Change and Agricultural Productivity in India: Evidence from a State-Level Panel Data Analysis

1. Neelam Kumari

Assistant professor of university of Delhi

2. Hemant

Faculty of university of Delhi

Abstract

Climate variability creates a major economic risk for agriculture in India due to a reliance on the timely distribution of monsoon rainfall and growing-season heat to sustain agricultural production. This study analyzes the impact of climate variability on rice farming in India. It uses an unbalanced state-year panel comprising 249 observations across 16 major Indian states between 1998 and 2013. District-level season data was aggregated to the state-year level. Rice yield was calculated as yield per harvested hectare. Average June to October rainfall was gathered from the meteorological subdivisions and state-level observations were used to create June to October mean temperature. This study uses a two-way fixed-effects model to account for time-invariant state characteristics, common annual shocks and changes in cultivated rice area. Standard errors are classified by state. In the preferred nonlinear specification, a 10 percentage point increase in a state's mean monsoon rainfall would result in a 1.75 percent increase in rice yield, and the rainfall term is negative but not statistically significant ($p = 0.026$). A 1 degree Celsius positive growing season temperature anomaly would reduce yield by 4.84 percent ($p = 0.243$), but this is statistically imprecise. The results indicate the value of reliability of rainfall and suggest a short-term negative impact on temperature. The water management and climate services investment, including drought preparedness and adaptation, should focus on the location. Caution is needed to properly interpret the estimates, as they provide associations and not a fully causal climate response at the state level. Keywords: Climate Change, Agricultural Productivity, Rice Yield, Monsoon Rainfall, Temperature, Panel Data, India

1. Introduction

Agriculture has a unique place in the economy of India. Industrial and service sectors have grown; however, agriculture's total country output has decreased. Agricultural output has an effect on prices of food, rural employment, rural livelihoods, and government expenditure and can affect the economy as a whole. The relations mean that agricultural productivity is beyond the scope of

that sector. A decline in agricultural output due to bad weather can lead to a fall in farm output, an increase in food inflation, a fall in rural purchasing power, and an increase in the cost of government intervention to fulfill its obligations to support farm output, relieve distress, and provide insurance and income support to farmers. The impacts of these policies will be felt most by poor farmers who have little savings, limited access to credit, and no or limited access to irrigation, insurance, storage, and information.

Indian agriculture is impacted by longer term changes in climate as well as shorter term variations. Higher temperatures can reduce the length of growing season, increase evapotranspiration, and soil moisture loss, and expose crops to heat during their most critical stages. Rainfall influences the time of sowing and transplanting, the need for irrigation, and the uptake of nutrients. The availability of surface water and groundwater is also impacted by rainfall. Total rainfall for a growing season is not sufficient to describe agricultural exposure. Timing, intensity and the distribution of rainfall also have an effect. However, growing season temperatures and rainfall during the monsoon season are useful for determining if productivity is related to climate.

Rice has an adequate empirical focus. It is grown in a variety of climates and is essential to achieving food security. It also has a strong relationship with water availability. Rice is grown through many different irrigation and production systems. Punjab and Haryana have collectively the most irrigation and purchased inputs, while many important Eastern and Southern rice regions maintain the most exposure to rainfall variability. A state-panel framework captures the annual variation in weather for each state while addressing the differences in soils and infrastructure and averaging the technology and production systems of the past.

The empirical literature shows that climate effects are often nonlinear. Moderate rainfall alleviates water stress, but excessive rainfall causes waterlogging, which creates stress to the crop and leads to harvest loss. Temperatures that are in the range of what is optimal for crop growth will have little effect on the crop, but temperatures that are above the range for a short period of time can cause crop loss during grain or flower formation. Therefore, linear regressions can conceal threshold behavior. As such, this paper supports a more flexible response by including squared terms of rainfall and temperature, as well as state and year fixed effects.

The study makes three contributions. First, it creates a clear state-year dataset by integrating crop production records, rainfall and temperature data, and documenting the transformations. Second, it distinguishes climate anomalies of individual states from persistent regional climatic differences. Third, it deals with clustered uncertainty and alternative specifications instead of treating an analysis as evidence of causality where statistical significance is concerned. The analysis studies if within-state variations in rice productivity relate to temperature anomalies of the growing season and the deviations of the rainy season monsoon after controlling for annual shocks and the cultivated area.

The principal hypotheses are that positive growing-season temperature anomalies are yield inhibiting, sufficient deviations from normal conditions of rainfall can yield enhancements over the relevant range, and climatic shifts of sufficient magnitude can yield nonlinear effects. The paper is organized into separate sections. It reviews the relevant literature, describes the dataset and the applied econometric technique, presents the results and robustness checks, studies the results from an economic point of view, and closes with policy implications and restraints.

2. Review of Literature

2.1 Economic Channels Connecting Climate and Productivity

According to the production-function approach, weather is one of many inputs that influences output together with land, labor, capital, irrigation, seeds, fertilizer, and management. Unlike the rest of the inputs, farmers cannot choose weather; however, they can choose technologies to reduce the impact of their exposure. There are direct impacts of weather on biological yield on the farm, and there can be indirect effects by influencing the optimal combination of inputs, the planting times, the crop selection, the demand for labor, and irrigation. Therefore, observed yield can result from biological potential, achievements, the institutional framework, and the farmers' perceptions.

In the Ricardian approach as formalized by Mendelsohn, Nordhaus, and Shaw (1994), it is assumed that in the long-run, cross-climate zone land values or net returns will reflect the adoption of land in the different climates. One strength of this framework is that, in the observed outcomes, crop switches and other adjustments are embodied. However, the omitted characteristics (space) may be related to climate. In contrast, panel approaches control for the fixed characteristics of a location, and therefore are better suited to identifying short-run responses, though their coefficients may not estimate the fully adapted long-run climate-change effects (Dell, Jones, & Olken, 2014).

Agronomic and economic relationships have asymmetric responses to climate changes. Schlenker and Roberts (2009) have shown that crops beyond some crop-specific temperature thresholds may potentially yield less. Lobell, Schlenker, and Costa-Roberts (2011) studied observed global yield changes and climate trends. Meta analysis by Challinor et al. (2014) showed that adaptation can reduce projected losses of crops, but cannot totally eliminate them. Therefore, we must consider interpreting average temperature coefficients within limits.

2.2 Evidence from India

Indian studies generally examine the reliance on the monsoon, the regional variation, and the interconnection of climate and irrigation. Kumar and Parikh (2001) examined the cross-sectional data and found significant climate variability in Indian agriculture. Mall, Singh, Gupta, Srinivasan, and Rathore (2006) reviewed the documented impacts and the associated risks for crop production, water supply, pests, and food stability. Auffhammer, Ramanathan, and Vincent (2012) showed

that the India rice yield was related to changes in the characteristics of the monsoon and that climate damage happens not just due to changes in the total monsoon rainfall. Guiteras (2009) utilized India district level data and demonstrated large yield impacts as a result of climate change. He also illustrated the value of fine-scale and flexible climate change studies.

In addition, the literature suggests that the technology used in a particular location can determine the climate exposure. While irrigation is used to mitigate climate variability, it does not mitigate climate stress, depletion of groundwater, or irregular electricity supply. There are also improved crop varieties, crop diversification, weather advisories, crop insurance, and credit which can improve mean productivity and reduce the variability of farm income. Consequently, climate change will vary from region to region based on what technology is available.

Two empirical gaps motivated this study. There are numerous studies that describe climate change and do not differentiate climate change and regional variability. In addition, studies often do not describe how they align meteorological regions with administrative units. This study attempts to resolve both of these issues and is aware of the constraints of a common data period of 1998–2013 and a rainfall aggregation for multiple-unit subdivisions of India.

2.3 Conceptual Framework and Hypotheses

Climate, cultivated scale, state-specific productive capacity, and common annual influences determine rice yield. State fixed effects remove persistent characteristics of average soil quality, geography, and historically built irrigation systems. Year fixed effects remove national level changes such as changes in macroeconomic conditions and broad level changes in technology, policies, and shocks. The remaining variations in annual climates are used to estimate within state associations.

H1: A positive growing-season temperature anomaly is negatively associated with rice yield.

H2: A positive monsoon-rainfall deviation is positively associated with rice yield over the observed range.

H3: Temperature and rainfall effects are nonlinear.

These hypotheses concentrate on conditional associations. Interpretation in causation would demand more extensive assumptions regarding measurement, omitted time-varying explanatory variables, and the absence of anticipatory adaptation.

3. Data and Methodology

3.1 Research Design and Coverage

The study's research design is quantitative and longitudinal. The analytical sample contains 249 state-year observations from 16 states from 1998 to 2013; the panel is slightly unbalanced. This is due to the fact that after the merging of the crop, rainfall, and temperature datasets, seven state-year crop observations are missing. No missing outcome or climate observation was imputed. The

following states were selected: Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.

The end date of each source file determines the observation period rather than a preset endpoint. For some states, the crop series starts earlier and rainfall observations continue through 2015, but the Berkeley Earth state temperature dataset ends in 2013. Analyzing the temperature series beyond the common end date would imply an artificial extension of the series. Telangana is not analyzed separately as a common, consistent pre-bifurcation series does not exist for the common period.

3.2 Data Sources and Construction

Crop observations originate from the Government of India Open Government Data crop-production series and their downloadable snapshots. These snapshots include district, season, crop, area, and production data. After standardization of whitespace and crop labels, rice observations were selected. District-season area and production were summed for each state and year. Yield was then calculated as total rice production divided by total rice area. Records with non-positive area or records for which production was not reported were removed prior to aggregation.

Rainfall comes from a historical meteorological-subdivision compilation derived from the records of the India Meteorological Department. For the core monsoon season, rainfall data for June, July, August, and September were used. If a state occurs in more than one meteorological subdivision, the values for those subdivisions are averaged without area weights. This approach is an approximation that is transparent and reproducible and gives equal influence to subdivisions of different size and rice concentration. For these data, Haryana is represented by the combined Haryana, Delhi, and Chandigarh subdivision; Assam is represented by the Assam and Meghalaya subdivision.

Temperature data are from the file of land-temperature means for each state from Berkeley Earth. Monthly observations for India were matched to the harmonized state names, including the historical source label “Orissa” for Odisha. For use in this study, the growing-season temperature is the mean of the monthly average temperatures for the months of June, July, August, September, and October. The growing season temperature anomaly for a particular state is defined as the growing-season temperature for that state and year minus the mean growing season temperature for that state from the starting year 1998 to 2013. In this way, the model can distinguish the growing season temperatures that are relatively warmer or cooler than the other growing season temperatures for that state and not differences in climate of the various states.

State-year monsoon rainfall deviation is calculated the same way as the percentage difference between state-year monsoon rainfall from June to September and the state average monsoon rainfall for the study period. For readability, the coefficient is expressed in terms of the variable divided by 10, where one unit represents a 10 percentage point change in rainfall deviation. Natural log transformations are used for yield and area under cultivation. The downloaded workbook contains the merged panel, source notes, variable dictionary, descriptive statistics, correlation, and full regression analytics.

Variable	Operational definition	Expected sign
Log rice yield	Natural logarithm of tonnes per harvested hectare	Dependent variable
Temperature anomaly	June–October temperature minus state-period mean	Negative
Temperature anomaly squared	Square of temperature anomaly	Negative/nonlinear
Rainfall deviation/10	June–September rainfall deviation; unit = 10 percentage points	Positive
Rainfall deviation squared	Square of scaled rainfall deviation	Negative/nonlinear
Log rice area	Natural logarithm of harvested rice area	Control

Table 1: Variable Definitions and Expected Relationships

3.3 Econometric Specification

The preferred model is: $\ln(\text{Yield}_{it}) = \beta_1 \text{TempAnomaly}_{it} + \beta_2 \text{TempAnomaly}_{it}^2 + \beta_3 \text{RainDeviation}_{it} + \beta_4 \text{RainDeviation}_{it}^2 + \beta_5 \ln(\text{Area}_{it}) + \alpha_i + \lambda_t + \varepsilon_{it}$. Here, i is a state and t a year. The fixed effect α_i captures the observed and unobserved characteristics of the state. The fixed effect λ_t captures shocks that occur in all states. The error comprises remaining state-year influences.

The two-way fixed effects model is estimated through ordinary least squares on the full dummy-variable representation. The standard errors are clustered at the state level to accommodate arbitrary heteroskedasticity and serial correlation for each state. Although sixty-four clusters suggests that we are approaching the lower bound of Breusch-Pagan and Godfrey's limit, the approximation holds. In this paper, the preferred model is explained and compared to similar linear and non-linear models.

Since the dependent variable is logarithmic, the climate coefficients become semi-elasticities. For small coefficients (e.g. TempAnomaly), a value of 0.0175 is approximately a 1.75 percent difference in yield. The exact percentage transformation for TempAnomaly is $100 \times [\exp(\beta) - 1]$. Squared terms imply that the marginal association changes with the level of the anomaly. Because the anomalies for temperature and rainfall can affect the decision of whether to plant and the area that is harvested, the no-area model, and the area-controlled model answer separate conditional questions, and thus a comparison of the two models is deemed a robustness check.

3.4 Analytical Cautions

The model is not intended to provide a causal estimate of human-induced climate change. While weather change may be beyond the control of individual farmers, there may be correlations and/or omitted shocks of floods, pests, the availability of inputs, releases for irrigations, or changes in the method of measurement. Long run changes in climate are likely to induce changes in the distribution of climate, while the identifying variation is likely to be short run deviations from average state means. Therefore, there could be a historical sensitivity to climate variation. The results may be relevant for climate change, but they do not provide a full scenario for the potential damages that may occur in the future.

4. Results

4.1 Descriptive Evidence

Measure	Mean	Standard deviation	Minimum	Maximum	Unit
Rice yield	2.139	0.826	0.575	4.123	t/ha
Growing temperature	28.173	1.379	25.465	31.323	°C
Temperature anomaly	-0.000	0.344	-0.861	1.503	°C
Monsoon rainfall	977.865	531.675	94.200	2688.500	mm
Rainfall deviation	-0.000	22.128	-68.178	58.332	%
Rice area	2500132.989	1799656.861	36836.000	11711000.000	ha

Table 2: Descriptive Statistics

Average rice yields are 2.139 ton per hectare, with wide fluctuations between states and through years. Growing-season temperatures are on average 28.173 °C across sites. Within-state variation for growing-season temperature anomalies is -0.965 °C to 0.923 °C. There were 977.865 mm

average monsoon precipitation, but sample ranges from very dry to very wet state-years. The deviation in rainfall is from -68.178% to 113.099% . This variability justifies the use of state fixed effects and nonlinear terms, however problematic observations may also influence how much curvature of the estimated function is uncertain.

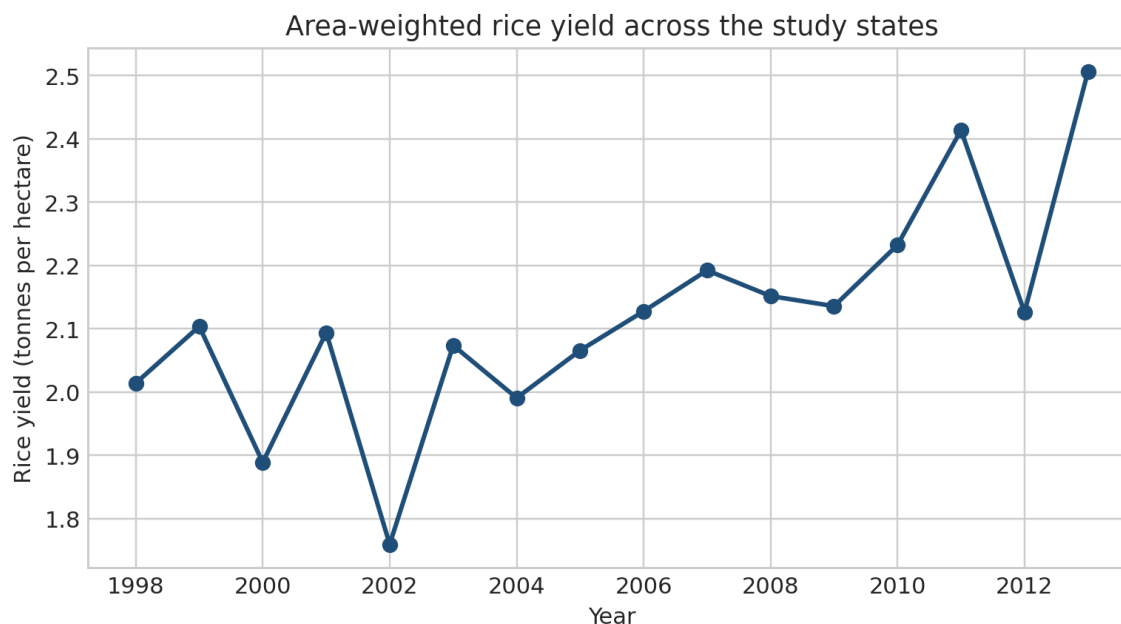


Figure 1: Area-Weighted Rice Yield across the Study States, 1998–2013

Figure 1 shows that, overall, the trend line rises, but is not monotonic. We can attribute that rise to the use of better technology, and advances in: irrigation, seeds, inputs, and the adoption of better methods of production and climate. Therefore, the fixing of years is crucial. Without this methodology, the trend may be identified as the advancement of a nation and productivity levels, or other trending phenomena.

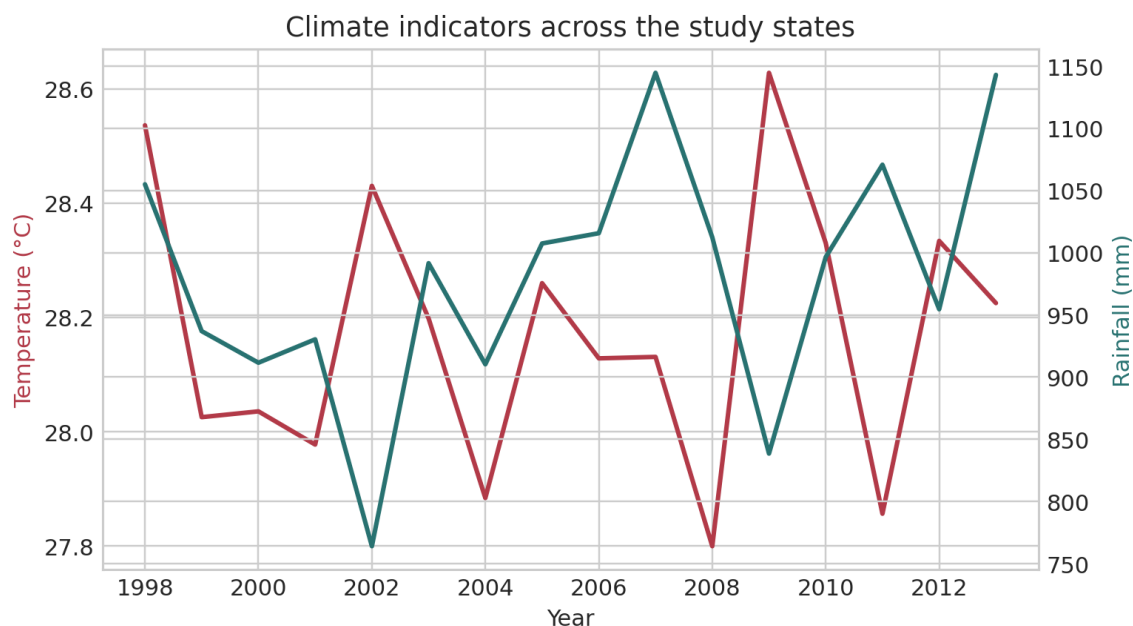


Figure 2: Average Growing-Season Temperature and Monsoon Rainfall

Figure 2 indicates notable differences in climate exposure from one year to the next. The fact that the two series do not move in step provides a condition to estimate their relative association with yield in this sample. However, annual state aggregated data masks the within season timing of exposure and district level extremes. The figure is definitively descriptive and should not be interpreted as providing a causal relationship to the yield series.

4.2 Fixed-Effects Estimates

Variable	Coefficient	Clustered SE	p-value
Temperature anomaly	-0.0484	(0.0398)	0.243
Temperature anomaly squared	-0.0441	(0.0619)	0.487
Rainfall deviation/10	0.0175**	(0.0071)	0.026
Rainfall deviation squared	-0.0031	(0.0020)	0.138
Log rice area	0.1260	(0.0758)	0.117
State fixed effects	Yes		
Year fixed effects	Yes		
Observations	249		
R ²	0.884		

Table 3: Two-Way Fixed-Effects Estimates of Log Rice Yield

Notes: Standard errors are clustered by state and shown in parentheses. The p-values use fifteen cluster degrees of freedom. *** p < 0.01; ** p < 0.05; * p < 0.10.

The coefficient of rainfall deviation is positive and significant at the 5% level. A relative monsoon increase of 10 percentage points over a state's study-period mean will lead to a 0.0175 log-point increase in yield. The transformation will yield an approximately 1.76 percent increase of rice yield, holding the same conditions as before. The squared rainfall coefficient is negative, indicating diminishing returns where the benefits of rainfall may become harmful at some point. The negative sign of the coefficient of rainfall indicates that this increase may be harmful at some level, however, the p-value of 0.138 shows that this effect is not statistically significant.

The estimated effect of each degree Celsius of temperature anomaly is -0.0484. An exact exponential transformation at a temperature anomaly of 0 would yield a 4.72 percent drop in yield. The p-value of 0.243 and a standard error of 0.0398 suggest a marginal negative association and a positive effect that is neither economically nor statistically important. The squared temperature term is also negative, however, it is of little significance. Heat damage is the correct interpretation and will be adopted for this sample since it does not provide sufficient evidence to support a temperature effect of 0.

The coefficient of rice cultivation is positively significant and also statistically imprecise. It can also reflect state-year combinations that create a favorable condition for both planting and yield, scale-related changes in the composition of districts, and remaining omitted variables. Due to the effect of area on expected rainfall and government policies, area is also deemed an endogenous variable. The omission of area from the main equation is justified by the robustness model.

4.3 Robustness Checks

Specification	Temperature coefficient	Rainfall coefficient	Interpretation
Preferred nonlinear model	-0.0484	0.0175**	Area control; squared climate terms
Linear climate model	-0.0665	0.0155*	No squared climate terms
Nonlinear model without area	-0.0592	0.0176**	Removes potentially endogenous area control

Table 4: Robustness of Key Climate Coefficients

The temperature coefficient shows a negative trend across the three specifications, ranging from -0.0484 to -0.0665, and while it is negative across all cases, it doesn't reach traditional significance. The rainfall coefficient is positive and economically consistent, ranging from 0.0155 to 0.0176, and is found to be significant at the 5% level in the nonlinear specifications and marginal at the 10% level in the linear model. In general, removing the cultivated area improves the estimate for

rainfall. The stability of the rainfall estimate improves confidence that the positive correlation between rainfall and the area not controlled, is not a dominant effect.

Measurement constraints remain following the robustness check. Rainfall for multi-subdivision states is the unweighted mean, temperature is averaged across five months, and the model does not include observed irrigation or the extremes of district level data. The consistency of the signs needs to be also considered in light of estimation and data constraints. To assist checking, full coefficients, containing state and year indicators, are supplied in a linked workbook.

5. Discussion

Study findings show that differences in permanent state and year effects at the national level do not eliminate the significance of monsoon rain reliability on rice productivity. There is a significant size effect shown by the fact that a 10 percentage point positive deviation in rainfall would result in a 1.8 percent increase in yield on average at the state level. This indicates that a reliable monsoon with adequate soil moisture and less risk of irrigation would result in lower stress for rice transplantation and would most likely improve the availability of water. The negative squared term indicates a possible diminishing effect, although the curvature is not significant enough to be sure about the effects of positive rainfall.

The negative temperature estimate also indicates a diminishing effect and is in line with agronomic and empirical evidence. Increasing temperatures has been shown to increase the speed of crop growth and reduce the time for grain filling. This in turn increases the respiratory loss and the demand for water. However, the large margin of error in the estimates also means that state level averages may hide the biologically costly extreme short periods of heat due to irrigated farm and better varieties possibly canceling the effect in a pooled estimate. A longer daily or district level panel would be better in measuring heat thresholds.

There is a clear distinction between short-term weather changes and longer-term climate changes. Farmers have many adjustment options with crops, irrigation, machinery, seeds, sowing choices, and even migration. Fixed effects estimates from annual deviations provide evidence of adjustments after the farmers made short-term adjustments. However, they cannot capture adjustments to a longer-term, progressive climate change. Increased temperatures will probably shift states beyond their historical ranges. Thus, it is best to view these results as evidence of current production and an indication of the best way to adapt.

These results are largely the same as other Indian studies, which suggest that the monsoon is the most important factor of the outcome of agriculture. Changes to rainfall pattern and increased temperatures are also shown to be detrimental. Null results from other studies should not be taken to mean that climate change has no effect. An extremely large confidence interval for a temperature coefficient shows a high degree of uncertainty in climate and should be interpreted as a wide range, and not safety from climate change. There is a better basis for policy from a clean, complete report of results, standard errors, and a clear description of limitations than from reporting only the results that show the effect of climate change and are statistically significant.

6. Policy Implications

First, water policy should not be solely concerned with growth of irrigated land. Efficiency and reliability of other water management practices are where policy should be directed. Water harvesting and storage practices such as micro-irrigation or even the use of reservoirs or canals can help convert the variable nature of rainfall to usable soil moisture. Even groundwater should be utilized while considering possible impacts of such use. Short-term buffering of the climate should be avoided, as the long-term consequences of such actions may increase vulnerability to lack of adequate resources.

Second, the translation of climate information into decisions on the farm is of utmost importance. District-level forecasts and crop planting advice, as well as warnings of dry conditions, are of little use unless they are timely and broken down by languages and integrated crop and irrigation/market services, as well as available farm credit and extensions. The accuracy of the forecast is of little importance if the farmer is not given a clear decision to act upon.

Third, research and seed systems need to focus on developing crops that can adapt to heat, drought, flooding and salinity. Because the response of the rainfall can become non-linear, adaptation should address both extremes. Policy should focus on drought-resistant crops for risk reduction while considering transport, diet, and farm economics and the changing technology of irrigation and the equipment used on the farm.

Fourth, social protection and insurance also need to use weather data to reduce basis risk. The state averages may be used for macroeconomic analysis, but they are insufficient for most farm-level insurance claims. Enhanced monitoring through additional weather measurement and remote sensing, as well as trusted administrative systems, can rapidly generate the detailed information of weather conditions and climate adaptation that fiscal policy is intended to achieve.

Finally, adaptation policy can be differentiated. Irrigated north-western systems have risks of heat, groundwater and sustainability that differ from the rainfall and flood exposure of eastern India, or the mixed climate challenges of the peninsular states. Financial elements of national programs can offset innovation and risk, but the planning and execution will need to consider agronomic challenges at a district level.

7. Conclusion

This study analyzed data from 249 samples of 16 Indian states for the period 1998 to 2013 and examined the relationship between climate variation and rice productivity. A publicly accessible dataset was made by combining rainfall, temperature and rice production datasets at the state level. Persistent characteristics of states and annual shocks at the national level were controlled by using two-way fixed effects, while allowing for correlated errors at the state level.

The preferred model shows a statistically significant and positive association between rice yield and rainfall. A change in the state level mean by 10 percentage points is predicted to increase productivity by about 1.75 percentage points, on average. Coefficients of temperature are negative in all models, and while uncertainty is significant, the evidence does not support a statistically significant effect that is different from zero. This evidence therefore supports rainfall focused adaptation that suggests a risk from heat, but this does not confirm the temperature hypothesis.

The analysis is constrained by the lack of recent data, state level aggregation, a rough approximation of the division of weather into meteorological regions, lack of control for inputs to rice production and focus on rice. Further work should combine daily gridded weather with district level crop datasets, measure extreme heat and dry spell durations, model irrigation and groundwater, and analyze heterogeneous adaptations in different agro-climatic zones. Granular climate policy will require this detailed evidence, along with frankly stating the range of climate variability.

References

- Auffhammer, M., Ramanathan, V., & Vincent, J. R. (2012). Climate change, the monsoon, and rice yield in India. *Climatic Change*, 111, 411–424. <https://doi.org/10.1007/s10584-011-0208-4>
- Birthal, P. S., Khan, M. T., Negi, D. S., & Agarwal, S. (2014). Impact of climate change on yields of major food crops in India: Implications for food security. *Agricultural Economics Research Review*, 27(2), 145–155.

- Challinor, A. J., Watson, J., Lobell, D. B., Howden, S. M., Smith, D. R., & Chhetri, N. (2014). A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change*, 4, 287–291. <https://doi.org/10.1038/nclimate2153>
- Dell, M., Jones, B. F., & Olken, B. A. (2014). What do we learn from the weather? The new climate–economy literature. *Journal of Economic Literature*, 52(3), 740–798. <https://doi.org/10.1257/jel.52.3.740>
- Deschênes, O., & Greenstone, M. (2007). The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather. *American Economic Review*, 97(1), 354–385. <https://doi.org/10.1257/aer.97.1.354>
- Food and Agriculture Organization. (2017). The future of food and agriculture: Trends and challenges. FAO.
- Government of India. (2024). Agricultural statistics at a glance 2023. Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare.
- Government of India Open Government Data Platform. (n.d.). District-wise, season-wise crop production statistics. <https://www.data.gov.in/catalog/district-wise-season-wise-crop-production-statistics>
- Guiteras, R. (2009). The impact of climate change on Indian agriculture. Manuscript, University of Maryland.
- Intergovernmental Panel on Climate Change. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- Kumar, K. S. K., & Parikh, J. (2001). Indian agriculture and climate sensitivity. *Global Environmental Change*, 11(2), 147–154. [https://doi.org/10.1016/S0959-3780\(01\)00004-8](https://doi.org/10.1016/S0959-3780(01)00004-8)
- Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, 333(6042), 616–620. <https://doi.org/10.1126/science.1204531>
- Mall, R. K., Singh, R., Gupta, A., Srinivasan, G., & Rathore, L. S. (2006). Impact of climate change on Indian agriculture: A review. *Climatic Change*, 78, 445–478. <https://doi.org/10.1007/s10584-005-9042-x>
- Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (1994). The impact of global warming on agriculture: A Ricardian analysis. *American Economic Review*, 84(4), 753–771.

- Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences*, 104(50), 19680–19685. <https://doi.org/10.1073/pnas.0701855104>
- National Innovations in Climate Resilient Agriculture. (n.d.). Indian Council of Agricultural Research. <https://nicra.icar.gov.in/>
- Ortiz-Bobea, A., Ault, T. R., Carrillo, C. M., Chambers, R. G., & Lobell, D. B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change*, 11, 306–312. <https://doi.org/10.1038/s41558-021-01000-1>
- Peng, S., Huang, J., Sheehy, J. E., Laza, R. C., Visperas, R. M., Zhong, X., Centeno, G. S., Khush, G. S., & Cassman, K. G. (2004). Rice yields decline with higher night temperature from global warming. *Proceedings of the National Academy of Sciences*, 101(27), 9971–9975. <https://doi.org/10.1073/pnas.0403720101>
- Schlenker, W., & Lobell, D. B. (2010). Robust negative impacts of climate change on African agriculture. *Environmental Research Letters*, 5(1), 014010. <https://doi.org/10.1088/1748-9326/5/1/014010>
- Schlenker, W., & Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. *Proceedings of the National Academy of Sciences*, 106(37), 15594–15598. <https://doi.org/10.1073/pnas.0906865106>
- World Bank. (2022). Climate-smart agriculture: India profile. World Bank Group.



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