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Climate Change and Structural Transformation: Evidence from Indian Towns and Districts

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Abstract

Climate change poses a fundamental challenge to structural transformation in developing economies. Using a panel of 2,655 towns and 292 districts in India (1981-2011) with location, year, and region-year fixed effects, I show that rising temperatures create persistent spatial inequalities in development. A 1°C increase in growing season temperature reduces the share of non-agricultural workers by 21.2% in rural areas but only 4.1% in urban regions of districts, attributable to reduced rural demand for non-agricultural goods and services leading to greater agricultural dependence. At a more granular level within towns, I find a smaller decrease of 3.2% in non-agricultural worker share, alongside a significant growth of 56.9% in seasonal employment, suggesting that urban labor markets adapt to climate stress through temporary work opportunities. Additionally, I find unilateral increases in the share of agricultural labor across districts by 32.8% and in towns by 17.5%. These findings indicate that while climate change may impede rural structural transformation, towns serve as crucial adaptation nodes by facilitating sectoral mobility. This spatial heterogeneity in climate resilience has important implications for policies targeting agriculture and urbanization in developing economies.

1 Introduction

Extreme weather brings significant challenges to developing economies, particularly for agriculture reliant populations. This research studies the historical pattern of structural transformation in India and builds upon prior work by Liu et al. (2023), Somanathan et al. (2021), Jessoe et al. (2017) and Dell et al. (2012). According to the 2011 Census, agriculture is a significant share (54.6%) of employment in India. Studying the effects of climate change on structural transformation is crucial to understanding economic growth and designing urban policy in this context. Jessoe et al. (2017) find that temperature shocks led to a reduction in non-agricultural employment through agricultural channels. The authors estimate extreme temperatures may decrease employment by upto 1.4 p.p. and increase migration by a similar magnitude in rural Mexico. Dell et al. (2014) study the effects of temperature shocks in poor countries, and find a significant reduction in economic growth in both level and growth effects. While existing research documents the immediate impacts of temperature on agricultural productivity, we know less about how climate shocks affect the longer-term process of labor reallocation across sectors and space. These long run effects on structural transformation remain understudied with low availability of granular historical data in developing countries. The focus on urban development complements Liu et al. (2023), who find that temperature increases lead to lower shares of workers in non-agriculture at the district level in India. I decouple the rural and urban impacts by observing town level shifts in the share of workers in 4 occupations: cultivation, agricultural labor, non-agricultural work, and seasonal employment.

I examine how temperature increases influence structural transformation and urbanization patterns in India between 1981 and 2011. Using an empirical strategy that compares the reallocation of labor within districts and within towns, I dcoument how labor adapts to climate stress across space. I show that rising temperatures have heterogeneous effects by region: while urban areas show resilience and adaptive capacity through increased seasonal employment, rural areas experience significant declines in non-agricultural employment. This pattern suggests challenges faced by the rural economy in moving from climate-vulnerable agricultural livelihoods. These findings also suggest that temperature increases may reinforce spatial inequality, particularly by reducing local demand for non-agricultural goods and services in rural areas as documented under Liu et al. (2023). Rising temperatures appear to be creating "development traps" that limit the traditional pathways of structural transformation. Gollin and Rogerson (2014) present a model of productivity, transport costs and subsistence agriculture that serves as a theoretical framework to uncover the general equilibrium effects of climate induced labor reallocation. Additionally, Bustos et al. (2016) provide a theoretical framework under which structural transformation depends on the factor bias of change in technology across agriculture and industry. This divergence in comparison with urban regions has important implications for development policy, in rethinking traditional approaches to rural development and labor mobility.

2 Theoretical Framework

This section develops a theoretical framework to understand the impact of climate shocks on long-term structural transformation across rural and urban areas. The model builds on the existing framework of agricultural productivity and transport costs in Gollin and Rogerson (2014). This extension incorporates spatial heterogeneity in climate impacts and seasonal employment as an adaptation mechanism. To capture the key features from empirical findings, I focus on differential temperature sensitivity across regions and sectors, and the role of seasonal work in urban adaptation to climate shocks.

2.1 Model Setup

Consider an economy with two regions - rural (r) and urban (u) - where the urban region consists of multiple towns. Each region has three types of work: agricultural (a), non-agricultural (n), and seasonal (s). The key insights is modeling heterogeneity in the impacts of climate shocks by region and by sector. The agricultural and non-agricultural sectors serve as regular sources of employment while seasonal work is incorporated as an adaptation mechanism.

2.2 Production

Agricultural and non-agricultural output in region j follow:

$$Y_a^j = A_a^j(T)F(L_a^j) \tag{1}$$

$$Y_n^j = A_n^j(T)G(L_n^j) \tag{2}$$

where $A_k^j(T)$ is the temperature-dependent productivity in sector k and region j, while L_k^j represents sector-specific labor.

The temperature sensitivity of productivity follows two key patterns:

$$\frac{\partial A_a^j}{\partial T} < \frac{\partial A_n^j}{\partial T} < 0 \quad \text{(both sectors are negatively impacted, with agriculture more sensitive)} \tag{3}$$

$$\frac{\partial A_a^r}{\partial T} < \frac{\partial A_a^r}{\partial T} < 0 \quad \text{(agricultural productivity in rural areas more sensitive)} \tag{4}$$

$$\tag{5}$$

Seasonal work provides supplemental income through:

$$Y_s^j = A_s^j H(L_s^j) \tag{6}$$

where A_s^j captures region-specific seasonal work opportunities.

2.3 Labor Allocation

Workers choose their primary sector $k \in \{a, n\}$ and region j to maximize:

$$\max_{j,k}\{w_k^j + \max(w_s^j - c_s, 0) - m\mathbf{1}_{j \neq origin}\} \tag{7}$$

where:

- w_k^j is the wage in sector k, region j
- w_s^j is the seasonal wage
- c_s is the cost of engaging in seasonal work
- m is the migration cost incurred if the worker is not in their original region

2.4 Spatial Linkages

Transport costs τ create a wedge between regions:

$$p_a^u = (1+\tau)p_a^r \tag{8}$$

Local demand for non-agricultural goods depends on agricultural income:

$$Y_n^j = \gamma(w_a^j L_a^j + w_s^j L_s^j) \tag{9}$$

where γ represents the local multiplier effect.

2.5 Equilibrium

The equilibrium consists of prices $\{w_k^j, p_k^j\}$ and allocations $\{L_k^j\}$ satisfying:

1. Labor market clearing:
$$L = \sum_j (L_a^j + L_n^j + L_s^j) \tag{10}$$

2. Wage equalization net of costs:
$$w_k^j - m = w_k^{j'} \text{ for all } j, j' \tag{11}$$

3. Market clearing for each good

2.6 Key Predictions

The model generates several testable predictions that map directly to our empirical analysis:

1. Temperature reduces non-agricultural shares more in rural areas:

$$|\frac{\partial L_n^r / L^r}{\partial T}| > |\frac{\partial L_n^u / L^u}{\partial T}| \tag{12}$$

   This occurs through two channels:

   - Direct productivity effects: Rural areas are more sensitive to temperature
   - Local demand effects: Lower agricultural income reduces demand for non-agricultural goods

2. Seasonal work increases more in urban areas:

$$\frac{\partial L_s^u}{\partial T} > \frac{\partial L_s^r}{\partial T} > 0 \tag{13}$$

   This differential response arises from:

   - Greater diversity of opportunities in urban areas
   - Rural workers constrained by agricultural calendar

These predictions map directly to the empirical specification:

$$Y_{irt} = \beta_1 T_{irt} + \beta_2 P_{irt} + \alpha_i + \lambda_t + \delta_{rt} + \epsilon_{irt} \tag{14}$$

where Y_{irt} captures various measures of structural transformation, including sectoral employment shares and seasonal work participation.

3 Data

This study combines rich data on demography and occupation from the Census of India with high-resolution weather data from the Indian Meteorological Department to examine climate impacts on structural transformation between 1961-2011.

3.1 Census of India

The main source of data is the Primary Census Abstract (PCA) from the Census of India published under 'District Census Handbooks', with population, literacy and occupation totals at the town and district level. The dataset constructs a panel of 640 districts and 7,715 towns spanning six decades from 1961 to 2011, with separate aggregation for rural and urban areas within districts.

Worker classifications in the census distinguish between main workers, who are employed for more than 183 days annually, and marginal or seasonal workers employed for less than 183 days. Workers are further categorized into agricultural laborers, cultivators, and non-agricultural workers. While these definitions have remained consistent from 1981 onwards, there were slight variations in the 1961 and 1971 rounds, as detailed in the Appendix.

The town panel reflects the evolution of India's urban landscape through multiple entry and exit of Census towns. A Census town is defined as an area meeting 3 criteria– A minimum population of 4,000, at least 75% of male working population in non agricultural activity, and a population density of over 400 persons per sq. km. Larger sets of Census towns consitute urban agglomerations. Of the total 8,794 unique towns that appear in the data the final analysis focuses on a sample of 2,655 towns with consistent data between 1981-2011, ensuring comparability in worker definitions and measurement.

3.2 Climate Data

Weather data comes from the Indian Meteorological Department's (IMD) gridded dataset, which provides daily temperature and precipitation measures from 1951-2023. The temperature data is available at 1-degree spatial resolution, recording daily minimum and maximum temperatures in degrees Celsius. Rainfall data offers a higher resolution picture at 0.25 degrees, with precipitation measured in 10 mm.

Seasonal degree days Heat exposure is measured through Seasonal Degree Days (DDS), which has been used in prior empirical studies on the weather and agriculture relationship, by Blakeslee and Fishman (2015) in India and Schlenker et al. (2006) in the U.S. I construct the DDS measure by summing the daily degree day measure over the months occurring in each season to calculate seasonal measure of weather. DDS is calculated at the grid-point level for all days d in a calendar year. As per the Indian Meteorological Department, the months of June to September are classified as the monsoon season, October to December as the post-monsoon season and March to May as the pre-monsoon season. Daily observations on minimum (T_{min}) and maximum (T_{max}) temperature are averaged to calculate the mean temperature (T), using the function described in equation (16). Finally, I aggregate the mean DDS for the past 10 years.

$$DDS = \sum_{d} D(T_d) \text{ ; where } T_d = \frac{T_{min,d} + T_{max,d}}{2} \tag{15}$$

$$D(T) = \begin{cases} 0, & \text{if } T \leq 8°C \\ T - 8, & \text{if } 8°C < T \leq 32°C \\ 24, & \text{if } T > 32°C \end{cases} \tag{16}$$

4 Empirical Specification

The empirical strategy employs the following fixed-effects regression approach:

$$Y_{irt} = \beta_{irt}\mathrm{T}_{irt} + \beta_2\mathrm{P}_{irt} + \alpha_i + \lambda_t + \delta_{rt} + \epsilon_{irt} \tag{17}$$

The main specification examines the effects of climate shocks on seasonal & main worker share of population, and non-agricultural & agricultural labor share of workers. Y_{irt} is the outcome variable for town or district i located in region r in year t. T_{irt} is the temperature measured in Celsius as the degree days over the growing season (June-February) for the past 10 years. Temperature is measured around the centroid of town or district i using daily weather grid observations within (25 km if town, or within 100 km if district, weighted by inverse squared distance. Both temperature measures are averaged over 10 years prior to t. P_{irt} is the daily precipitation (10 mm.) averaged over 10 years preceding t. α_i is a vector of town/district fixed effects, controlling for any time invariant factors in i that may be correlated with climate or economic outcomes. λ_t controls for year fixed effects, i.e. changes over time. δ_{irt} accounts for region-year fixed effects to control for region-specific confounders over time. ϵ_{irt} is an idiosyncratic shock to i observed in each t. Standard errors are clustered at the town/district level to account for autocorrelation within i. This approach controls for time-invariant town/district characteristics, common time trends and region-specific heterogeneity varying over time.

The identification relies on the assumption that any variation in climate is plausibly exogenous to the outcome variable, conditional on town/district, year and region-year fixed effects. The key independent variables capture past decadal exposure to climate variation. Temperature exposure, measured through seasonal degree days (DDS), focuses on the growing season to capture agricultural relevance. The 10-year averaging period serves two purposes: first, it reduces measurement noise in annual weather fluctuations, and second, it allows examination of adaptation responses to persistent changes in climate. Similarly, precipitation is averaged over the same period to maintain consistency in measuring climate exposure. Primary outcomes include the logarithm of population shares in different employment categories: (1) seasonal workers as a share of total population; (2) agricultural laborers and cultivators as shares of total workers; and (3) non-agricultural workers as a share of total workers. These log transformations allow interpretation of the coefficients as percentage changes in response to climate shocks.

5 Results

5.1 Long-run spatial reallocation of labor

Table 1: District aggregate estimates of an increase in rainfall and growing season temperature

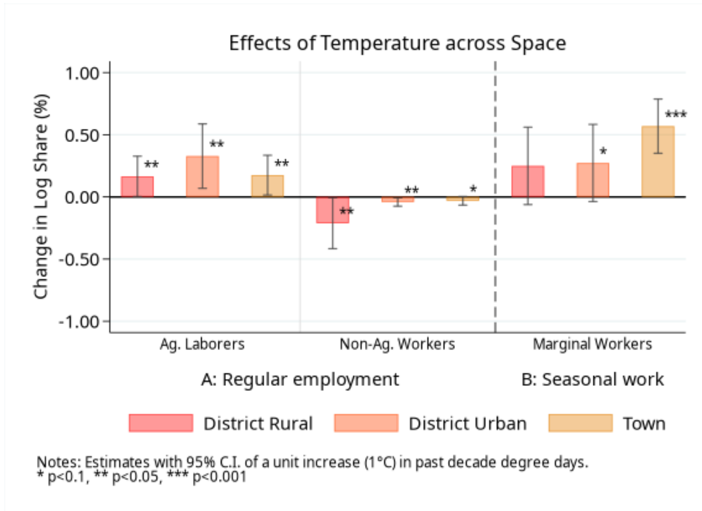
	Log	Log share of population		Log share of workers		
	Population	Regular Work	Seasonal Work	Ag. Labor	Cultivation	Non-Ag.
Seasonal degree days (DDS)	0.348***	0.145***	0.281*	0.168**	0.121	-0.286***
	(0.113)	(0.031)	(0.151)	(0.084)	(0.084)	(0.083)
Precipitation (10 mm)	-0.010	0.003	-0.094*	-0.050	-0.009	-0.061***
	(0.023)	(0.006)	(0.048)	(0.031)	(0.020)	(0.021)
# Districts	283	283	283	282	282	283
# Years	4	4	4	4	4	4
N	1132	1132	1132	1128	1128	1132

Standard errors in parentheses
Panel at district year level between 1981-2011.
Additional controls for district, year and region-year fixed effects included.
* p¡0.10, ** p¡0.05, *** p¡0.01

In Table 1, rising temperatures generate significant labor market reallocation at the district level. A unit increase in seasonal degree days leads to a 34.8% increase in district population, which could potentially be explained by climate-induced migration. This demographic change is accompanied by a shift in occupational structure, with a 16.8% increase in agricultural labor share and a 28.6% decrease in the share of non-agricultural workers. The positive but non-significant effect on cultivator share (12.1%) suggests that temperature shocks primarily affect agricultural wage labor rather than land-holding farmers. These estimates are in line with the literature, documenting an increase in agricultural labor from Liu et al. (2023) (18.1%) alongside supporting evidence from Burgess et al. (2017) of the larger impacts that temperature has than rainfall on agricultural productivity.

Figure 1 reveals how these effects vary spatially by examining districts across their rural and urban aggregates, followed by higher granularity using individual town estimates. Two distinct patterns emerge– first, within regular employment, temperature increases generate stastically significant effects on agricultural labor shares in urban areas (32.8%) compared to rural (16.5%) or individual towns (17.5%). In contrast, the negative effect on non-agricultural work is substantially muted in urban areas (-4.1%) and towns (-3.2%), relative to the rural aggregate (-21.2%). This asymmetric impact suggests that urban areas can absorb displaced agricultural workers and demonstrate greater resilience in maintaining non-agricultural employment. Second, the effects on seasonal employment reveal towns' unique role in climate adaptation. While districts show a similar increase in marginal worker shares in urban (27.3%) significant (24.9%), only the urban effect is significant at 10%. Towns experience more than double this effect (56.9%) with greater statistical significance. This difference suggests towns serve as focal points for seasonal work opportunities, potentially through construction work and flexible urban labor markets. The combination of moderate increases in

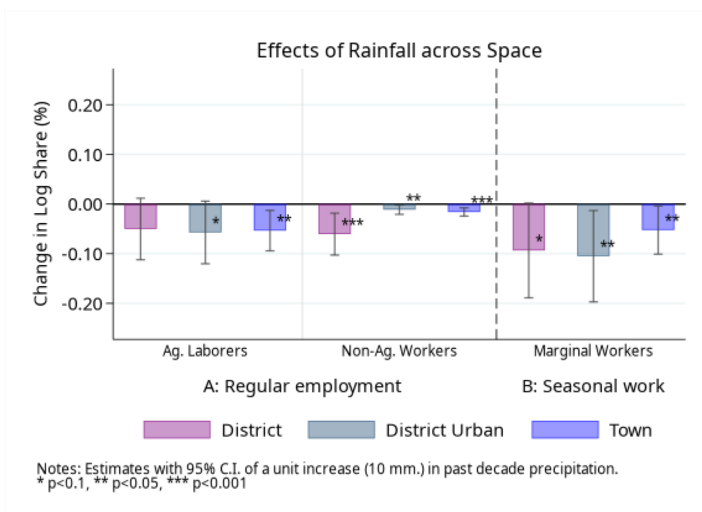
Figure 1: Temperature estimates on log shares of workers (1981-2011)



Seasonal workers measured as share of population; other shares as proportion of total workers.

agricultural labor with larger increases in seasonal work within towns points towards transitory climate-induced migration, rather than permanent sectoral shifts.

Figure 2: Rainfall estimates on log shares of workers (1981-2011)



Seasonal workers measured as share of population; other shares as proportion of total workers.

The rainfall effects in Figure 2 present a complementary story. A 10 mm. increase in precipitation generates consistent negative effects on agricultural work across all spatial levels around 5%, with stronger negative impacts on non-agricultural work in districts (-6.1%) compared to urban areas (-1.1%) and towns (-1.6%). This pattern reinforces urban areas' greater resilience to climate shocks. The negative effect on seasonal work is also more pronounced in district urban areas (-10%)

compared to towns (-5.2%), suggesting that rainfall-induced changes in labor demand are more effectively absorbed by labor markets in towns.

This spatial heterogeneity in climate effects demonstrates varying patterns of labor adaptation. While temperature shocks push workers toward agricultural and seasonal work, particularly in urban areas, urban economies demonstrate greater resilience in maintaining non-agricultural employment. Towns emerge as crucial adaptation nodes, providing flexible employment opportunities that may help workers navigate climate-induced changes in labor demand.

5.2 Changes in town structure

Table 2: Town level estimates of decadal weather shocks

	Log		Log share of population		Log share of workers		
	Population	Density	Regular Work	Seasonal Work	Ag. Labor	Cultivation	Non-Ag.
Seasonal degree days (DDS)	0.120***	-0.317***	0.170***	0.569***	0.175**	-0.001	-0.032*
	(0.028)	(0.096)	(0.022)	(0.111)	(0.082)	(0.063)	(0.018)
Precipitation (10 mm.)	-0.008	-0.023	0.025***	-0.052**	-0.054**	-0.042**	-0.016***
	(0.008)	(0.015)	(0.004)	(0.025)	(0.021)	(0.017)	(0.004)
# Towns	2657	2652	2593	2655	2488	2526	2582
Mean	10.01	7.97	-1.27	-4.19	-3.01	-3.02	-0.27
N	10628	7732	10198	10231	9425	9580	10132

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01
Additional controls for town, year and region-year fixed effects included. Standard errors clustered at the town level. Estimates from a panel of towns between 1981-2011. Population density measured as total population per sq.km, not available for 2011. Seasonal workers are marginal workers employed for less than 183 calendar days in the past year.

Table 2 reveals how decadal weather shocks reshape town demographics and occupational structure. A unit increase in seasonal degree days generates a 12% increase in town population but a 31.7% decrease in population density measured as persons per square kilometre. The occupational changes in towns show significant restructuring: a 17.5% increase in agricultural labor share is accompanied significant decrease of 3.2% in non-agricultural workers. These results reveal that towns expand at a greater pace spatially than their populations in response to increasing temperatures. Additionally, they demonstrate a significant increase in both regular and seasonal employment shares. Further, there is a null and non-significant effect on the share of cultivators, but an opposing increase in agricultural labor and decrease in non-agricultural worker shares. This evidence suggests that while climate shocks may impede traditional structural transformation, adaptation in towns may operate primarily through seasonal, temporary employment as agricultural work is impacted.

5.3 Robustness checks

5.3.1 Year-wise estimates

Figure 3: Effects of temperature increase on sectoral shares in towns

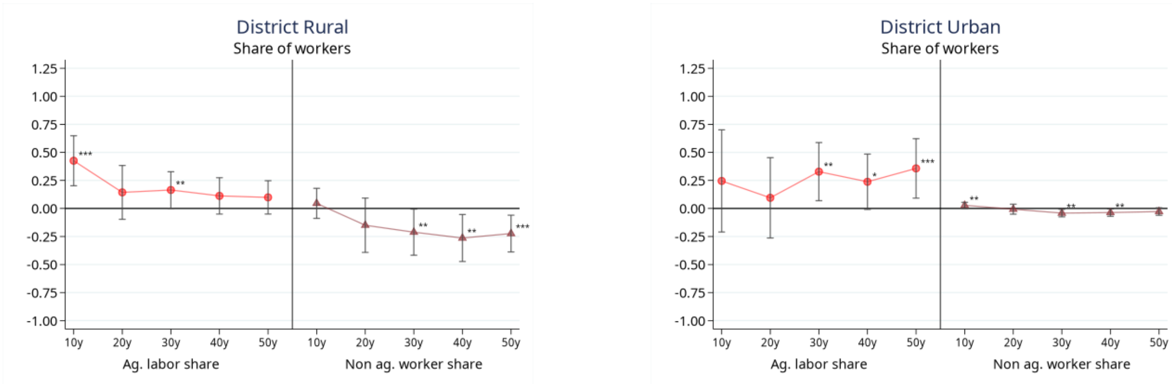
The figure plots coefficients with 95% C.I. of a unit increase in 10-year seasonal degree days on log shares of workers. Additional controls for region fixed effects included. Standard errors clustered at the town level.

The robustness checks in Figure 3 confirm the persistence of the positive estimate on agricultural labor (ranging from 12-18%) and negative estimate on non agricultural workers (-2 to -4%) over time. Additionally, the effects on agriculture intensify over time, with a gradual decadal increase in the point estimate on agricultural labor share. Further, the break points of 1991-2001 coincide with the implementation of a globalization and liberalization policy in India, which remains to be further explored.

5.3.2 Alternate panel time periods

Figure 4 shows the long-term impacts of an increase in DDS on the share of agricultural labor and non-agricultural workers within district, for rural and urban areas separately. The trend lines plot the 10, 20, 30, 40, and 50 year panel coefficients of rising temperatures on worker shares. I find the point estimates are consistent in direction but vary in magnitude, with non-linear effects across different time periods. At the district level, the effect on agricultural labor is positive and significant in rural areas over a time period of 10-30 years, and in urban areas over 30+ years. On the other hand, the effect on non-agricultural labor share is negative and significant for all time periods in rural areas. Additionally, the magnitude is closer to zero in urban areas, changing from positive between 10-20 years to negative past 20+ years.

Figure 4: Effects of rising temperatures on sectoral shares in district by panel time period



The figure plots coefficients with 95% C.I. of a unit increase in 10-year seasonal degree days on log shares of workers. Additional controls for district, year and region-year fixed effects included. Estimates plot separate panels for each base year, i.e. 2001-2011, 1991-2011, ...

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6 Appendix

6.1 Summary Statistics

Table 3: Share of town population in each sector by Census year

	(1) 1961	(2) 1971	(3) 1981	(4) 1991	(5) 2001	(6) 2011
Total log. population	9.409	9.532	9.607	9.807	9.909	9.741
Total % of population: main workers	0.349	0.295	0.298	0.296	0.290	0.300
Total share of workers: non-agricultural	0.778	0.822	0.750	0.744	0.837	0.842
Total share of workers: agricultural	0.207	0.272	0.251	0.245	0.148	0.151
Total share of workers: cultivators	0.139	0.131	0.124	0.110	0.069	0.057
Total share of workers: agricultural laborers	0.060	0.134	0.122	0.130	0.082	0.093
Total share of workers: marginal/seasonal workers	.	.	0.044	0.039	0.162	0.213
Observations	2393	2781	3557	4214	4646	7250

Each observation is a town in the panel. * Marginal workers not reported in 1961 and 1971. In the rounds of 1981-2011, marginal workers are defined as seasonal workers, employed for less than 183 days in the past calendar year.

Figure 5: Annual temperature and worker shares in districts (1971-2011)

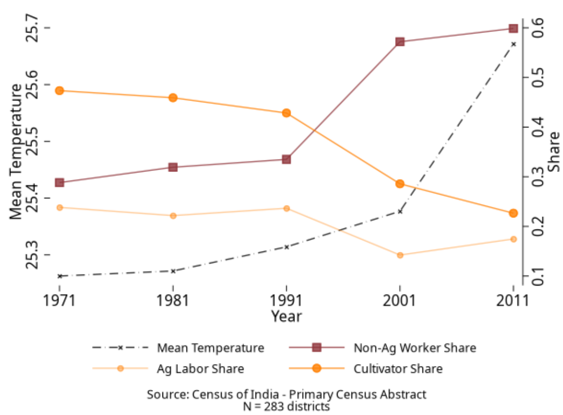
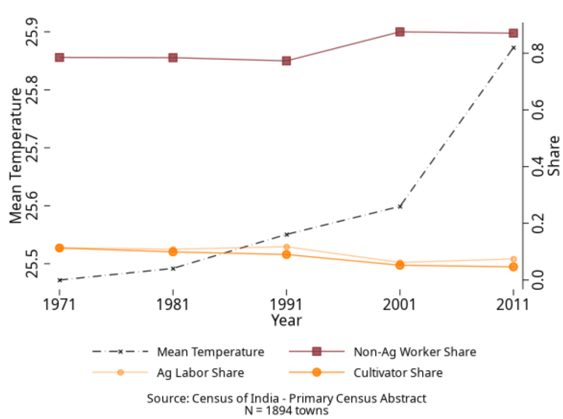


Figure 6: Annual temperature and worker shares in towns (1971-2011)



6.2 Regression estimates

Table 4: District rural estimates of climate shocks

	Log	Log share of population		Log share of workers		
	Population	Regular Work	Seasonal Work	Ag. Labor	Cultivation	Non-Ag.
Seasonal degree days (DDS)	0.326***	0.158***	0.249	0.165**	0.106	-0.212**
	(0.110)	(0.032)	(0.158)	(0.083)	(0.076)	(0.104)
Precipitation (10 mm)	-0.014	0.005	-0.102**	-0.059*	-0.013	-0.083***
	(0.024)	(0.007)	(0.050)	(0.030)	(0.016)	(0.026)
# Districts	281	281	281	280	280	281
# Years	4	4	4	4	4	4
N	1124	1124	1124	1120	1120	1124

Standard errors in parentheses
Panel at district year level between 1981-2011.
Additional controls for district, year and region-year fixed effects included.
* p¡0.10, ** p¡0.05, *** p¡0.01

Table 5: District urban estimates of climate shocks

	Log	Log share of population		Log share of workers		
	Population	Regular Work	Seasonal Work	Ag. Labor	Cultivation	Non-Ag.
Seasonal degree days (DDS)	0.324*	0.065***	0.273*	0.328**	0.166	-0.041**
	(0.191)	(0.021)	(0.158)	(0.132)	(0.146)	(0.017)
Precipitation (10 mm)	-0.007	-0.002	-0.105**	-0.057*	-0.006	-0.011**
	(0.033)	(0.004)	(0.047)	(0.032)	(0.032)	(0.005)
# Districts	281	281	281	280	280	281
# Years	4	4	4	4	4	4
N	1121	1121	1120	1117	1117	1121

Standard errors in parentheses
Panel at district year level between 1981-2011.
Additional controls for district, year and region-year fixed effects included.
* p¡0.10, ** p¡0.05, *** p¡0.01

Table 6: Town estimates of climate shocks

	Log		Log share of population		Log share of workers		
	Population	Density	Regular Work	Seasonal Work	Ag. Labor	Cultivation	Non-Ag.
Seasonal degree days (DDS)	0.120***	-0.317***	0.170***	0.569***	0.175**	-0.001	-0.032*
	(0.028)	(0.096)	(0.022)	(0.111)	(0.082)	(0.063)	(0.018)
Precipitation (10 mm.)	-0.008	-0.023	0.025***	-0.052**	-0.054**	-0.042**	-0.016***
	(0.008)	(0.015)	(0.004)	(0.025)	(0.021)	(0.017)	(0.004)
# Towns	2657	2652	2593	2655	2488	2526	2582
Mean	10.01	7.97	-1.27	-4.19	-3.01	-3.02	-0.27
N	10628	7732	10198	10231	9425	9580	10132

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

Table 7: IPUMS/NSS estimates of climate shocks

	Log share	
	Non Agriculture	Agriculture
Seasonal degree days (DDS)	0.226**	-0.102
	(0.107)	(0.096)
Precipitation (10 mm.)	-0.035	0.018
	(0.034)	(0.028)
# Districts	261	261
Mean	-1.04	-0.59
N	1044	1043

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

	Log share	
	Non Agriculture	Agriculture
Seasonal degree days (DDS)	0.525***	-0.328***
	(0.171)	(0.105)
Precipitation (10 mm.)	0.010	-0.008
	(0.046)	(0.032)
# Districts	261	261
Mean	-1.02	-0.61
N	783	783

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

	Log share	
	Non Agriculture	Agriculture
Seasonal degree days (DDS)	0.631***	-0.359**
	(0.212)	(0.176)
Precipitation (10 mm.)	-0.003	0.036
	(0.048)	(0.053)
# Districts	261	261
Mean	-0.95	-0.65
N	522	522

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

Table 8: Town estimates: heterogeneity

	Log		Log share of population		Log share of workers		
	Population	Density	Regular	Seasonal	Ag. Labor	Cultivation	Non-Ag.
River ¡ 500 m.=0 × Seasonal degree days (DDS)	0.118***	-0.311***	0.171***	0.505***	0.141*	-0.019	-0.030*
	(0.029)	(0.095)	(0.023)	(0.110)	(0.083)	(0.063)	(0.018)
River ¡ 500 m.=1 × Seasonal degree days (DDS)	0.132**	-0.351	0.161***	1.063***	0.444***	0.147	-0.041*
	(0.056)	(0.217)	(0.031)	(0.184)	(0.130)	(0.113)	(0.025)
River ¡ 500 m.=0 × Precipitation (10 mm.)	-0.011	-0.028*	0.023***	-0.071***	-0.047**	-0.037**	-0.013***
	(0.008)	(0.016)	(0.004)	(0.026)	(0.021)	(0.018)	(0.004)
River ¡ 500 m.=1 × Precipitation (10 mm.)	0.014	0.019	0.037***	0.116	-0.084	-0.069	-0.036***
	(0.028)	(0.055)	(0.011)	(0.085)	(0.066)	(0.054)	(0.012)
# Towns	2657	2652	2593	2655	2488	2526	2582
Mean	10.01	7.97	-1.27	-4.19	-3.01	-3.02	-0.27
N	10628	7732	10198	10231	9425	9580	10132

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

	Log		Log share of population		Log share of workers		
	Population	Density	Regular	Seasonal	Ag. Labor	Cultivation	Non-Ag.
River ¡ 500 m.=0 × Seasonal degree days (DDS)	0.121***	-0.309***	0.112***	0.356***	-0.068	-0.109*	-0.060**
	(0.029)	(0.095)	(0.014)	(0.111)	(0.084)	(0.064)	(0.028)
River ¡ 500 m.=1 × Seasonal degree days (DDS)	0.153***	-0.334	0.095***	0.840***	0.202	0.019	-0.065*
	(0.055)	(0.215)	(0.028)	(0.172)	(0.129)	(0.111)	(0.033)
River ¡ 500 m.=0 × Precipitation (10 mm.)	-0.014*	-0.032**	0.020***	-0.094***	-0.049**	-0.037**	-0.016***
	(0.008)	(0.016)	(0.004)	(0.029)	(0.022)	(0.017)	(0.006)
River ¡ 500 m.=1 × Precipitation (10 mm.)	0.009	0.013	0.025***	-0.086	-0.101	-0.064	-0.046***
	(0.029)	(0.054)	(0.008)	(0.091)	(0.064)	(0.054)	(0.015)
# Towns	2657	2652	2589	2654	2484	2520	2578
Mean	9.36	7.32	-1.42	-5.13	-3.31	-3.16	-0.40
N	10621	7729	10194	10033	9421	9564	10120

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

	Log		Log share of population		Log share of workers		
	Population	Density	Regular	Seasonal	Ag. Labor	Cultivation	Non-Ag.
River ¡ 500 m.=0 × Seasonal degree days (DDS)	0.122***	-0.303***	0.514***	0.552***	0.816***	0.697***	0.091**
	(0.029)	(0.095)	(0.045)	(0.115)	(0.113)	(0.108)	(0.045)
River ¡ 500 m.=1 × Seasonal degree days (DDS)	0.132**	-0.329	0.641***	0.880***	1.220***	0.982***	0.110
	(0.055)	(0.214)	(0.077)	(0.182)	(0.175)	(0.171)	(0.076)
River ¡ 500 m.=0 × Precipitation (10 mm.)	-0.015*	-0.031*	0.030***	-0.041	-0.015	-0.080**	-0.030***
	(0.008)	(0.016)	(0.009)	(0.026)	(0.026)	(0.031)	(0.010)
River ¡ 500 m.=1 × Precipitation (10 mm.)	0.014	0.016	0.089**	0.084	0.077	0.122	-0.008
	(0.028)	(0.055)	(0.035)	(0.076)	(0.095)	(0.079)	(0.033)
# Towns	2657	2651	2586	2648	2445	2497	2557
Mean	9.26	7.22	-3.45	-4.86	-4.70	-5.48	-2.56
N	10626	7729	10131	10051	8932	9028	9988

Standard errors in parentheses

* p¡0.10, ** p¡0.05, *** p¡0.01

6.2.1 Heterogeneity checks

6.3 Notes

Worker definitions In 1961, a person qualified as a worker if they had worked regularly during the last season or if they had worked at least for a day in regular (non-seasonal) work during the preceding fortnight. At the 1971 census, a person was treated as a worker only if they spent their time mainly in work or if they worked at least for a day in regular (non-seasonal) work during the preceding week. The dichotomy of worker/ non-worker of 1961 and 1971 censuses was discarded at the 1981 Census and instead a trichotomy of main workers, marginal workers and non-workers was adopted. For main worker, the time criterion of engage- ment in work for the major part of the year, i.e., at least 183 days was adopted. Those who worked for some time during the last year but not for the major part were treated as marginal workers. Those who had never worked during the last year were non-workers. This trichotomy partially permits comparabi- lity of 1981 census economic data with that of 1971 as well as 1961. The main workers of 1981 census can be expected to correspond to the workers of 1971 and the main workers and marginal workers of 1981 together to correspond to the workers of 1961.

Note: The definition of workers is consistent with the above 1991 onwards.

Definition of urban areas Urban areas or Census towns are defined as all statutory places with a municipality, corporation, cantonment board or notified town area committee, etc. These towns satisfy the following three criteria simultaneously:

1. A minimum population of 4,000 (1991) and 5,000 (in 2001)
2. At least 75 per cent of male working population engaged in non-agricultural activity
3. A population density of 400 persons per sq. km.

The proportion of male working population in (2) above is calculated in reference to regular or main workers.

Urban agglomerations An Urban Agglomeration is a continuous urban spread constituting a town and its adjoining urban outgrowths (OGs) or two or more physically contiguous towns together and any adjoining urban outgrowths of such towns. Examples of OGs are railway colonies, university campuses, port areas, etc., that may come up near a city or statutory town outside its statutory limits but within the revenue limits of a village or villages contiguous to the town or city. Each such individual area by itself may not satisfy the minimum population limit to qualify it to be treated as an independent urban unit but may deserve to be clubbed with the town as a continuous urban spread.

For the purpose of delineation of Urban Agglomerations during Census of India 2001, following criteria are taken as pre-requisites:

1. The core town or at least one of the constituent towns of an urban agglomeration should necessarily be a statutory town; and
2. The total population of all the constituents (i.e. towns and outgrowths) of an Urban Agglomeration should not be less than 20,000 (as per the 1991 Census).

With these two basic criteria having been met, the following are the possible different situations in which Urban Agglomerations would be constituted:

1. A city or town with one or more contiguous outgrowths;
2. Two or more adjoining towns with their outgrowths; and
3. A city and one or more adjoining towns with their outgrowths all of which form a continuous spread.