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Night and Day: Physiological Limits to Urban Structural Transformation in India

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Abstract

How does extreme heat affect structural transformation and urbanization in the long run? We document a physiological threshold to the agricultural labor response to heat, and show that aggregate relationships between temperature and labor reallocation hide two opposing climate regimes. While night warming (T_n) suppresses yields and pulls labor into agriculture, rising daytimes (T_d) paralyze the heat-exposed outdoor occupations of agriculture and construction. Consistent extreme days ($T_{max^{LR}} > 31°C$) sterilize crops, reducing the demand for services as workers seek final refuge in manufacturing. We further find that heat generates sprawl and stagnates the creation of new towns and generates sprawl as workers seek seasonal employment in the growing services economy. These results suggest that urban structural transformation is bounded by a thermal limit, post which the agricultural exit reflects a churn for survival rather than a pathway to sustained economic growth.

1 Introduction

Climate change is fundamentally reshaping the economic geography of the developing world. Extreme weather has been shown to have short-run and long-run adverse effects on worker productivity, agricultural yields, and economic growth (Schlenker et al. 2006, Somanathan et al. 2021, Dell et al. 2012). While conventional wisdom suggests that climate-vulnerable agricultural labor exits under heat stress for resilient non-agricultural sectors, recent evidence indicates that rising temperatures can paradoxically trap labor in the farm sector through both demand and supply channels (Liu et al. 2023, Jessoe et al. 2017).

In India, where agriculture continues to employ nearly half of the workforce (56% Census 2011), it is important to quantify the urban capacity limits of absorbing agricultural labor. While prior literature on the effects of heat stress on labor reallocation has primarily focused on average temperatures and district aggregates, we show that these results hide a heterogeneous mechanism *within* towns. Night We document the intensive margin of urbanization, that Census-designated urban areas experience "distress swelling" in cooler regions and "thermal stagnation" in the hottest zones.

In this paper, we document a non-linear relationship between temperature and urban occupations in the long run. We combine a decadal panel of Indian towns (1981–2011) with high-resolution daily climate data to show that adaptation follows a physiological hierarchy: moderate heat drives agricultural intensification, but extreme heat wipes out farm yields and drives an exit of the agricultural workforce into seasonal employment indoors. Our empirical analysis relies on a newly constructed panel dataset covering the universe of Indian towns ($N = 8,786$) over four decades. We digitize and harmonize town-level Primary Census Abstracts to track employment outcomes at a granular spatial scale unavailable in prior district-level studies. To identify the causal effect of climate, we leverage random variation in decadal average weather during growing seasons, controlling for time-invariant town characteristics and state-specific structural transformation paths (State $\times$ Year FE). By focusing on decadal averages rather than annual shocks, our estimates capture the *adaptation* response to persistent climatic shifts. We further supplement this with household-level employment data from the National Sample Survey (NSS) to decode the sectoral identity of the "seasonal" workforce, bridging the gap between the *duration* of work (Census) and the *sector* of work (NSS).

We establish three core findings. First, we identify a **thermal limit to the agricultural trap** in towns. Consistent with prior literature, we find that rising growing season degree days (DDs) generally induce urban "structural regression" – the share of non-agricultural employment falls and agricultural labor rises. However, this agricultural safety net collapses when daytime extremes breach the physiological limit of 32°C. Beyond this thermal threshold, the capacity of the agricultural sector to employ labor falls to zero, forcing a net exit of farm wage workers towards precarious, seasonal employment.

Second, we decompose the physical mechanism behind this non-linear response. By distinguishing between long-run increases in daily minimum (T_n) and maximum (T_d) temperatures, we isolate two distinct biological channels. Rising nighttime temperatures (T_n) suppress crop yields via respiration without killing the plant; households respond to this yield suppression through **agricultural intensification** ($L_a \uparrow$) to maintain subsistence. In contrast, extreme daytime temperatures (T_d) breach physiological limits for both crops (sterilization) and humans (wet-bulb thresholds). This triggers an **exit** from agriculture, forcing labor into the "backstop" of seasonal work.

Third, we characterize the destination of this displaced labor as **"Distress Urbanization."** Using log-level estimates, we show that heat shocks drive an expansion in town population and physical urban area, consistent with towns engulfing the heat-stressed rural hinterland. However, in the hottest towns ($> 75^{th}$ percentile), this demographic expansion ceases as the capacity for physical sprawl hits a limit. Crucially, the modern non-agricultural sector fails to absorb this supply shock. Instead, surplus workers are integrated into the **seasonal/marginal** workforce. Leveraging NSS data (Ruggles et al. 2024), we decode this surge, showing that rising daytime extremes correspond to a shift from outdoor labor (Agriculture and Construction) into **informal manufacturing**, which offers a physiological refuge from the heat but on precarious economic terms.

These results suggest that urban climate adaptation in developing world is bounded by physiological limits. Below the limit, towns experience structural regression into farm labor to meet subsistence; while above the limit, this safety net collapses into precarious industrialization.

2 Theoretical Framework

We develop a general equilibrium framework to interpret the non-linear adaptation response. Building upon Gollin and Rogerson (2014) and Liu et al. (2023), we model a town economy inhabited by a representative household endowed with labor L and fixed land $Z = 1$. The household allocates labor across three sectors: Agriculture (a), Non-Agriculture (m), and a Seasonal backstop sector (s).

2.1 Preferences and Technology

Preferences The household has non-homothetic Stone-Geary preferences, defined by a subsistence food consumption requirement $\bar{a}$:

$$U(c_a, c_m) = \alpha \ln(c_a - \bar{a}) + (1 - \alpha) \ln(c_m) \tag{1}$$

We assume the household operates near subsistence. The marginal utility of agricultural consumption approaches infinity as $c_a \to \bar{a}$, creating a "safety first" dynamic where labor allocation prioritizes food security.

Production and Climate Limits Agricultural output Y_a is subject to diminishing returns and a climate-dependent productivity parameter $\mathcal{A}(T_n, T_d)$:

$$Y_a = \mathcal{A}(T_n, T_d) \cdot L_a^{\theta} \tag{2}$$

where $\theta \in (0, 1)$ represents the labor elasticity. The productivity function $\mathcal{A}(\cdot)$ captures two distinct biological mechanisms:

1. **Yield Suppression (T_n):** Rising minimum temperatures increase plant respiration, continuously reducing biomass accumulation ($\frac{\partial \mathcal{A}}{\partial T_n} < 0$).
2. **Physiological Limit (T_d):** Extreme daytime heat exhibits a threshold response. If $T_d > T_{crit}$, crop sterility occurs, and productivity collapses ($\mathcal{A} \to 0$). Consistent with agronomic literature on rice, we identify this threshold empirically at $\approx 30°$C.

The non-agricultural sector (m) produces a local good with constant returns ($Y_m = A_m L_m$). The **seasonal backstop sector** (s) offers a fixed subsistence wage $w_s < \text{MPL}_a^{baseline}$, representing precarious casual labor (e.g., informal manufacturing workshops) that serves as a refuge when farming fails.

2.2 Equilibrium Regimes

The household's optimization problem yields two distinct regimes based on the severity of the thermal shock.

Regime I: The Agricultural Trap (Intensification)

Condition: Yield suppression ($T_n \uparrow$) without failure ($T_d < T_{crit}$).

Since the subsistence constraint binds, the household must produce $c_a = \bar{a}$. Labor demand in agriculture is determined by the technological requirement:

$$\mathcal{A}(T_n) L_a^{\theta} = \bar{a} \implies L_a^* = \left(\frac{\bar{a}}{\mathcal{A}(T_n)} \right)^{\frac{1}{\theta}} \tag{3}$$

As T_n rises and $\mathcal{A}$ falls, L_a^* must **increase** to maintain subsistence.

$$\frac{\partial L_a^*}{\partial T_n} > 0 \quad \text{(Intensification)} \tag{4}$$

Prediction: Moderate heat shocks crowd out non-agricultural employment as labor is reallocated to the farm. This matches the "Trap" results in **Figure 1 (Blue Bars)**.

Regime II: The Thermal Limit (Distress Exit)

Condition: Physiological Failure ($T_d > T_{crit}$).

When heat breaches the physiological limit, the land cannot produce $\bar{a}$ regardless of labor input. The marginal product of agricultural labor collapses below the backstop wage ($MPL_a < w_s$).

- **Exit:** The household ceases intensification. Labor exits agriculture ($L_a \to 0$ or stagnates).
- **Distress:** Displaced labor floods into the backstop sector (s) to secure food via market purchase ($\frac{\partial L_s}{\partial T} > 0$).

Prediction: Extreme daytime heat triggers a structural break. Agricultural labor shares collapse, while the share of seasonal/marginal workers surges. This matches the "Exit" results in **Figure 1 (Red Bars)** and **Figure 2**.

2.3 Demand Linkages

Finally, the contraction of the non-agricultural sector is driven by a local demand shock. The demand for the non-agricultural good c_m is a function of residual income:

$$c_m = \frac{Y_{total} - p_a\bar{a}}{p_m} \tag{5}$$

Since heat shocks reduce aggregate income (Y_{total}), the demand for locally consumed services contracts ($\partial L_m/\partial T < 0$). This explains why the Service sector (NSS) stagnates despite the labor supply shock, forcing migrants into the export-oriented or informal manufacturing sector.

3 Data

We combine three primary datasets to link climatic conditions, demographic shifts, and sectoral sorting: (1) town-level demographics from the Indian Census, (2) daily gridded weather data from the IMD, and (3) urban household-level employment data from the NSS. These datasets span across 1981-2011 (Census, IMD) and 1987-2004 (NSS).

3.1 The Town Panel (Census of India)

Our core dataset is the Primary Census Abstract (PCA), covering the universe of Indian towns from 1981 to 2011. A Census town or urban area is defined as meeting 3 criteria in 1981 – 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. We construct a balanced panel of 2,655 towns that appear consistently across four decades, ensuring that our analysis considers intensive margin adjustments rather than the reclassification of urban areas.

For consistency in definition, occupations are aggregated to 3 mutually exclusive categories: Cultivators (landowners), Agricultural Laborers (wage workers), and Non-Agricultural Workers. Crucially, the Census additionally distinguishes between "Main" and "Marginal" workers, based on whether an individual was employed under or over 183 calendar days in the year preciding enumeration. A 'main' worker is thus under regular employment and a 'marginal' worker is seasonally employed, while either type of worker may be present in any of the 3 occupations above. This distinction in the nature of employment allows us to isolate the surge in precarious, short-term labor associated with distress migration and urbanization.

3.2 Sectoral Sorting (National Sample Surveys)

While the Census provides the volume of labor reallocation, it lacks granularity on the destination sectors within non-agriculture in 1981 definitions. To identify where displaced labor ends up, we study a panel of five rounds of the National Sample Survey (NSS) Employment and Unemployment Schedules (1987-2004), as harmonized by IPUMS. We restrict our sample to urban households and classify employment into "Outdoor" sectors (Agriculture, Construction, Mining) and "Indoor" sectors (Manufacturing, Services). We further disaggregate Manufacturing into "Formal" (organized) and "Casual/Informal" (household enterprises). This linkage allows us to test the "Refuge" hypothesis: that heat-displaced labor sorts into indoor, low-productivity manufacturing rather than outdoor construction or high-productivity services.

3.3 High-Resolution Climate Exposure

We rely on the Indian Meteorological Department (IMD) gridded dataset for daily temperature ($1\circ$ resolution) and precipitation ($0.25\circ$ resolution), restricted to the Census and NSS years. Observations on daily min and max temperature are aggregated to a moving average over the past decade's growing seasons. The growing season occurs between the months of June-February, with March-May being the agricultural lean season.

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. We 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. 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 (7).

$$DDS = \sum_{d} D(T_d) \text{ ; where } T_d = \frac{T_{min,d} + T_{max,d}}{2} \tag{6}$$

$$D(\mathrm{T}) = \begin{cases} 0, & \text{if } \mathrm{T} \leq 8^{\circ}\mathrm{C} \\ \mathrm{T} - 8, & \text{if } 8^{\circ}\mathrm{C} < \mathrm{T} \leq 32^{\circ}\mathrm{C} \\ 24, & \text{if } \mathrm{T} > 32^{\circ}\mathrm{C} \end{cases} \tag{7}$$

4 Empirical Strategy

To identify the impact of long-term climate trends on urban labor markets, we employ a fixed-effects panel specification. Our baseline model estimates the effect of decadal average climate exposure on sectoral employment shares:

$$Y_{it} = \beta_1 \text{Heat}_{it} + \beta_2 \text{Precip}_{it} + \mu_i + \phi_{st} + \varepsilon_{it} \tag{8}$$

where Y_{it} is the outcome of interest (e.g., share of agricultural laborers) for town i in state s during Census year t. The variable Heat_{it} represents the temperature exposure (Degree Days, T_n, or T_d), constructed as a 10-year moving average over the growing season (June–February) preceding the Census year. Heat measures are constructed using inverse squared distance weighted observations of gridded daily temperature within 100 km of the town or 250 km of the district i's centroid. Precip_{it} controls for decadal mean rainfall to isolate the temperature channel, and is measured in milimeters.

We include town fixed effects (μ_i) to control for time-invariant unobservables such as elevation, soil quality, or baseline industrial composition. We include State $\times$ Year fixed effects (ϕ_{st}) to absorb time-varying regional shocks, such as state-level labor policies (e.g., NREGA implementation), agricultural subsidies, or infrastructure development.

4.1 Identification and Inference

The identification strategy relies on random fluctuations in decadal climate trends after accounting for location-specific means and regional time trends (Dell et al. 2012; Liu et al. 2023). By using a 10-year average rather than annual weather, our coefficient β_1 captures *adaptation* to persistent climatic shifts rather than transient responses to weather shocks.

To account for spatial dependence in climate variables that extends beyond administrative boundaries, we report **spatially corrected (Conley) standard errors**. We allow for spatial autocorrelation up to a radius of 500 km from the town or district centroid, alongside serial correlation up to 4 decades (**Conley1999**).

4.2 Testing Mechanisms and Thresholds

To test the theoretical prediction of non-linear adaptation regimes ("Trap" vs. "Exit"), we estimate a threshold model interacting climate exposure with baseline thermal conditions:

$$Y_{it} = \sum_{k \in \{Low, High\}} \beta_k \left(\text{Heat}_{it} \times \mathbb{1}[\text{BaseT}_i \in k] \right) + \mathbf{X}_{it} + \varepsilon_{it} \tag{9}$$

where $\mathbb{1}[\text{BaseT}_i \in High]$ is an indicator for towns with a long-run average temperature above the 75th percentile. We further decompose Heat_{it} into daily minimum (T_n) and maximum (T_d) averages to distinguish between agronomic yield suppression and physiological thermal limits.

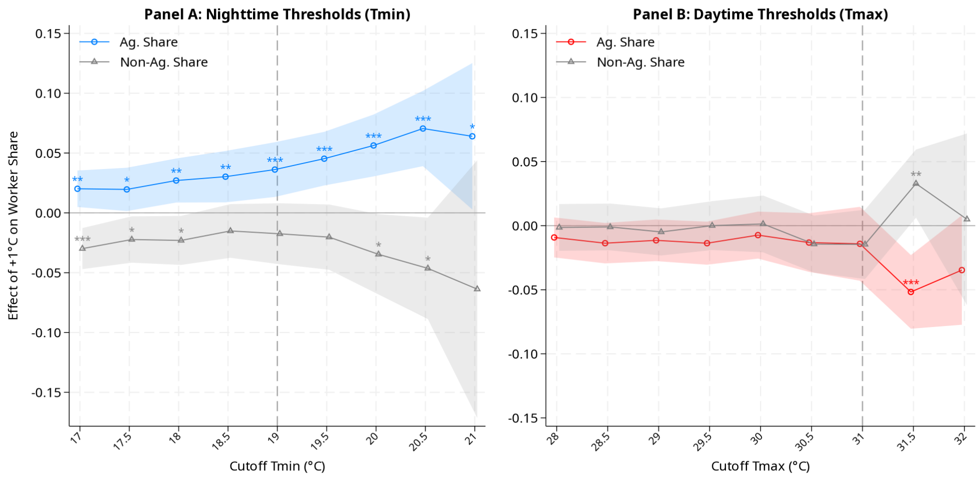
5 Results

Table 1: Effects of Rising Heat on Structural Transformation and Urbanization

	Share of Total Workers			Log Total	Town Formation	
	(1) Agriculture	(2) Non-Ag.	(3) Seasonal	(4) Area	(5) Pr(Entry)	(6) Pr(Exit)
Panel A: Decadal Growing Season Degree Days (1981-2011)						
Degree Days (DDs)	0.034***	-0.036**	0.003	0.409**	-0.223***	-0.030
	[0.009]	[0.014]	[0.011]	[0.194]	[0.085]	[0.035]
Panel B: Kharif (Monsoon) Temperatures						
Night (T_{min})	0.018***	-0.004	-0.013*	0.239**	-0.028	-0.051**
	[0.006]	[0.010]	[0.007]	[0.108]	[0.052]	[0.023]
Day (T_{max})	0.007	-0.033***	0.032***	0.275**	-0.160**	-0.081***
	[0.008]	[0.010]	[0.009]	[0.117]	[0.070]	[0.027]
Panel C: Rabi (Winter) Temperatures						
Night (T_{min})	0.019***	-0.006	-0.004	0.124	-0.084*	0.015
	[0.005]	[0.008]	[0.005]	[0.082]	[0.049]	[0.015]
Day (T_{max})	-0.001	-0.014*	0.001	0.011	-0.022	0.021
	[0.006]	[0.008]	[0.007]	[0.067]	[0.053]	[0.020]
Mean	0.09	0.75	0.09	2.18	0.17	0.04
Observations	11880	11880	11880	11853	35144	35144

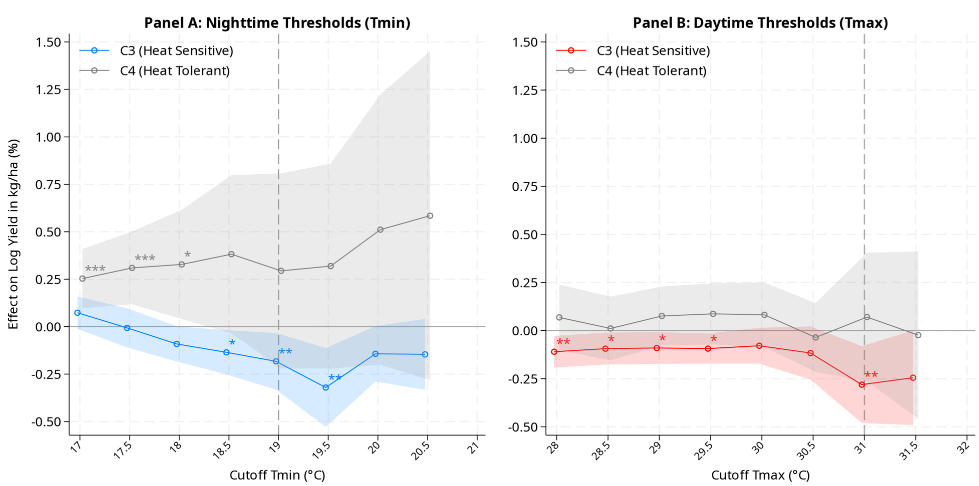
Notes: All specifications control for decadal mean rainfall. Estimates reported with Conley standard errors adjusted for spatial dependence up to 250 km from town center and serial correlation up to 4 decades. $*p < 0.1,^{**}\ p < 0.05,^{***}\ p < 0.001$. Seasonal workers may be employed in either agriculture or non-agriculture. defined as those employed for <183 days in the preceding calendar year.

Figure 1: Effects of Rising Heat on Agricultural Productivity and Labor Share



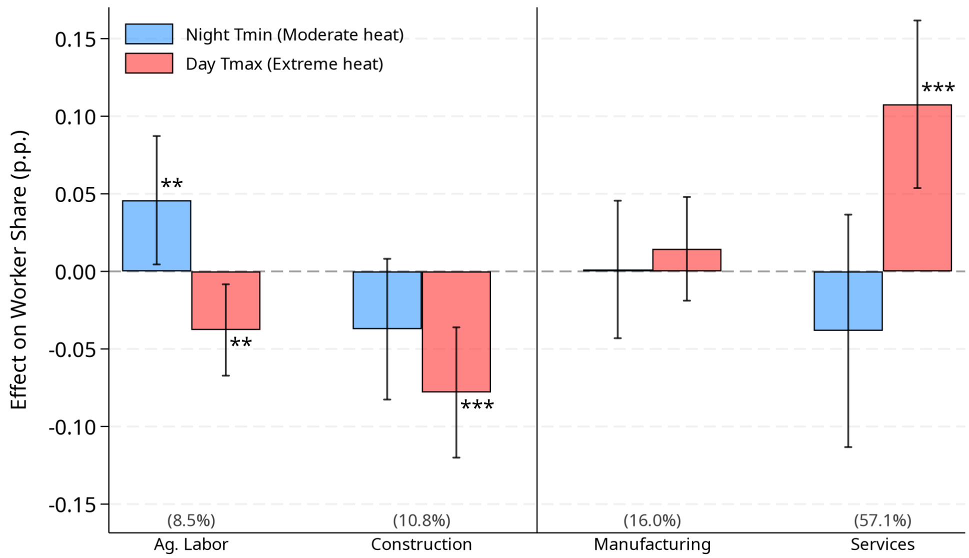
Notes: The figure plots coefficients of a 1°C *increase* in the nighttime minimum (T_n) and daytime maximum (T_d). The dependent variable is the *share of total workers* in each sector. Estimates are adjusted for temporal lag upto 4 decades and spatial correlation upto 150 km from town center. Error bars represent 90% confidence intervals with Conley adjusted standard errors. The vertical lines plot the thresholds of $T_n^* = 17.5 \rightarrow 18.5°C$ for agricultural feasibility, and $T_d^* = 30 \rightarrow 31°C$ breaching the agronomic limit.

Figure 2: Declining Crop Yields Under Extreme Heat



Estimates adjusted for temporal lag upto 4 decades and spatial correlation upto 500 km from district center. Error bars represent 90% confidence intervals with Conley adjusted standard errors. All specifications control for decadal mean rainfall. The dependent variables are *log yield (kg/ha)* of heat-sensitive C3 cereals (rice, wheat, barley) and heat-tolerant C4 crops (maize, sorghum, millets). $*p < 0.1,^{**}p < 0.05,^{***}p < 0.001$.

Figure 3: Physiological Sorting and the Exit from Outdoor Labor



Notes: The figure reports the effect of decadal average daytime maximum temperature (T_d) on the share of urban employment by sector (NSS 1987-2004). **(Left)** Sectors requiring physical labor in exposed environments (Agriculture, Construction) show contraction or stagnation. **(Right)** Sectors capable of offering indoor work environments show positive elasticity. Manufacturing acts as a significant labor absorber ($+0.09^{**}$), suggesting heat-displaced labor sorts into the sector offering the lowest barrier to entry among physiologically protected jobs.

Table 2: Physiological Sorting: Demand Constrained Services in Hot Towns

	(1) Ag. Labor	(2) Cultivators	(3) Const/Mining	(4) Manufacturing	(5) Services
Panel A: All Regions (1987-2004)					
Night (T_{min})	0.046**	0.028	-0.037	0.001	-0.038
	[0.021]	[0.019]	[0.023]	[0.023]	[0.038]
Day (T_{max})	-0.038**	-0.006	-0.078***	0.015	0.108***
	[0.015]	[0.025]	[0.021]	[0.017]	[0.028]
Mean	0.09	0.08	0.11	0.16	0.57
Observations	1460	1460	1460	1460	1460
Panel B: Day T$_{max}$ Below 31° C					
Night (T_{min})	0.015	0.032*	-0.052***	0.009	-0.003
	[0.018]	[0.018]	[0.019]	[0.019]	[0.037]
Day (T_{max})	-0.032***	-0.006	-0.069***	-0.004	0.111***
	[0.010]	[0.017]	[0.021]	[0.008]	[0.027]
Mean	0.08	0.08	0.10	0.14	0.59
Observations	1204	1204	1204	1204	1204
Panel C: Day T$_{max}$ Above 31° C					
Night (T_{min})	0.019	-0.015	-0.014	-0.024	0.034
	[0.043]	[0.030]	[0.049]	[0.047]	[0.077]
Day (T_{max})	0.036	0.056	0.013	0.120**	-0.226***
	[0.050]	[0.039]	[0.060]	[0.059]	[0.073]
Mean	0.09	0.05	0.12	0.20	0.54
Observations	368	368	368	368	368

Notes: Estimates reported with Conley standard errors in brackets allowing for spatial correlation upto 500 km from geographic unit centroid. All specifications control for decadal mean rainfall. $*p < 0.1,^{**} p < 0.05,^{***} p < 0.001$.

References

Schlenker, Wolfram, W. Michael Hanemann, and Anthony C. 2006. "The Impact of Global Warming on U.S. Agriculture: An Econometric Analysis of Optimal Growing Conditions". *Rev. Econ. Stat.* 88 (1): 113–125.

Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. 2012. "Temperature Shocks and Economic Growth: Evidence from the Last Half Century". *American Economic Journal: Macroeconomics* 4 (3): 66–95. https://doi.org/10.1257/mac.4.3.66.

Gollin, Douglas, and Richard Rogerson. 2014. "Productivity, transport costs and subsistence agriculture". *Journal of Development Economics* 107:38–48. https://doi.org/10.1016/j.jdeveco.2013.10.007.

Blakeslee, David S., and Ram Fishman. 2015. *Weather Shocks, Agriculture, and Crime: Evidence from India*. [Online; accessed 23. Nov. 2024]. https://doi.org/10.2139/ssrn.2428249.

Jessoe, Katrina, Dale T. Manning, and J. Edward Taylor. 2017. "Climate Change and Labour Allocation in Rural Mexico: Evidence from Annual Fluctuations in Weather". *The Economic Journal* 128 (608): 230–261. https://doi.org/10.1111/ecoj.12448.

Somanathan, E., et al. 2021. "The Impact of Temperature on Productivity and Labor Supply: Evidence from Indian Manufacturing". *Journal of Political Economy*, https://doi.org/10.1086/713733.

Liu, Maggie, Yogita Shamdasani, and Vis Taraz. 2023. "Climate Change and Labor Reallocation: Evidence from Six Decades of the Indian Census". *American Economic Journal: Economic Policy* 15 (2): 395–423. https://doi.org/10.1257/pol.20210129.

Ruggles, Steven, et al. 2024. *Integrated Public Use Microdata Series, International: Version 7.5 [dataset]*. Minneapolis, MN.

6 Appendix

Table 3: Log Share Effects

	Log Share of Workers			Log Levels	
	Agriculture	Non-Ag.	Seasonal	Workers	Area
Panel A: Census Urban Areas					
T_{min} (+1°C)	0.091	0.016	-0.291	-0.028	0.058
	[0.086]	[0.024]	[0.207]	[0.049]	[0.067]
T_{max} (+1°C)	-0.052	0.029	0.356	-0.058	0.040
	[0.101]	[0.035]	[0.229]	[0.044]	[0.081]
Mean	-2.32	-0.39	-2.77	8.46	1.90
Observations	3574	3574	3574	3574	3561
Panel B: Statutory/Municipal Towns					
T_{min} (+1°C)	0.098*	-0.042***	0.221	0.231**	0.270*
	[0.055]	[0.014]	[0.176]	[0.098]	[0.139]
T_{max} (+1°C)	-0.119	-0.038**	0.826***	0.260**	0.286**
	[0.076]	[0.015]	[0.252]	[0.124]	[0.144]
Mean	-2.50	-0.30	-3.42	9.35	2.31
Observations	7758	7758	7758	7758	7741

Notes: Estimates adjusted for temporal lag upto 4 decades and spatial correlation upto 150 km from town center. Error bars represent 90% confidence intervals with Conley adjusted standard errors. All specifications control for decadal mean rainfall. The dependent variables are *log share of workers* in each sector. Seasonal workers are defined as those employed for <183 days in the preceding year. $*p < 0.1,^{**} p < 0.05,^{***} p < 0.001$.

Figure 4: Thermal Regimes and Physiological Limits

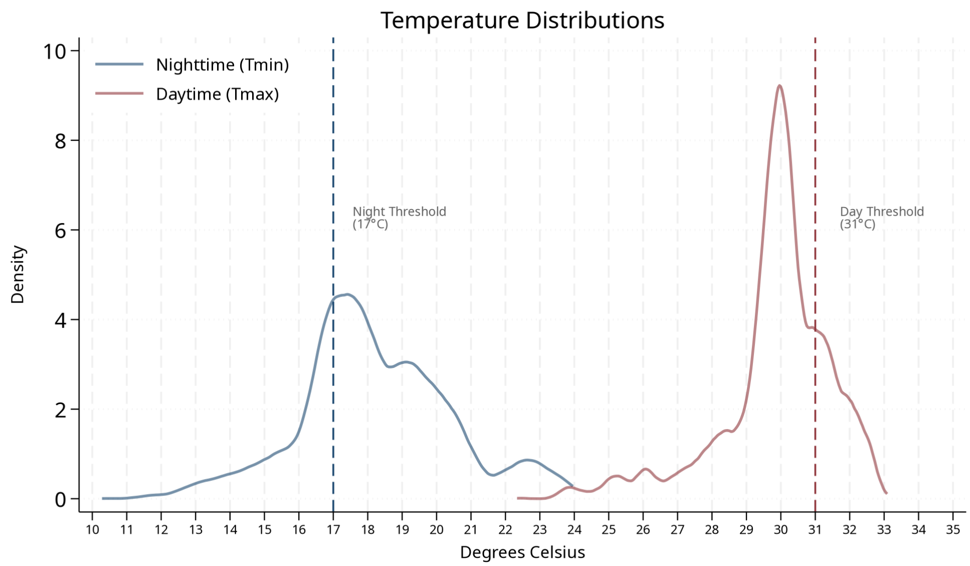
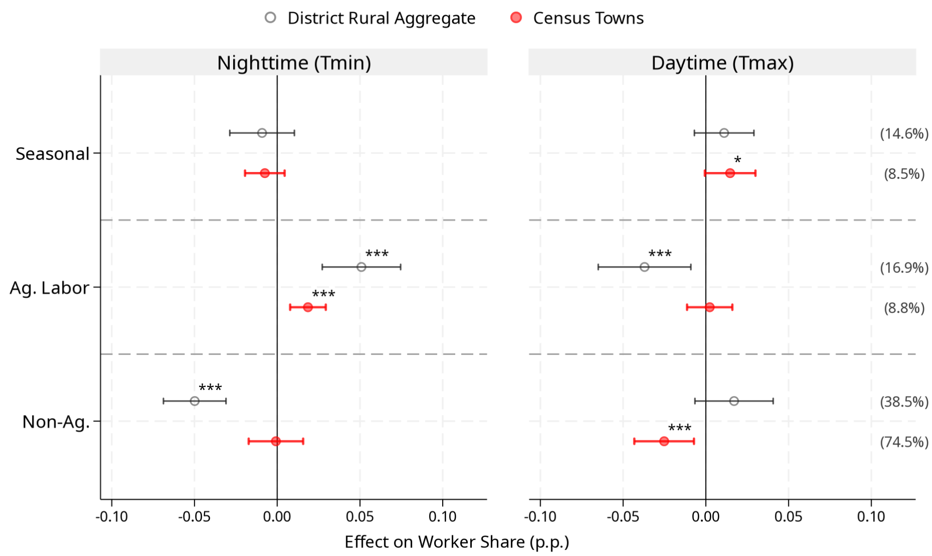


Figure 5: The Rural-Urban Adaptation Wedge



Notes:

Table 4: Effect of Rising Temperatures on Cultivated Area and Yields in Districts

	Heat Sensitive (C3) Crops			Heat Tolerant (C4) Crops		
	Rice	Wheat	Barley	Maize	Sorghum	Millet
Panel A: Crop Yield (tonnes/hectare)						
T_{min} (+1°C)	0.029	0.181*	0.443***	0.216**	-0.061	0.248***
	[0.076]	[0.102]	[0.149]	[0.102]	[0.066]	[0.081]
T_{max} (+1°C)	-0.290***	-0.199**	-0.371**	-0.058	0.088	0.225*
	[0.100]	[0.099]	[0.146]	[0.150]	[0.083]	[0.135]
Mean	1.460	1.456	0.721	1.313	0.589	0.816
Observations	924	924	924	924	924	924
Panel B: Cultivated Area (10,000 hectares ≈ 100 sq. km)						
T_{min} (+1°C)	-1.563**	-1.023	0.363	-1.154***	-0.619	0.178
	[0.714]	[0.878]	[0.292]	[0.350]	[0.707]	[0.406]
T_{max} (+1°C)	-2.909***	-1.962**	-0.074	0.434	-2.188*	-1.274***
	[0.847]	[0.907]	[0.198]	[0.452]	[1.268]	[0.444]
Mean	10.752	7.016	0.380	1.751	4.241	4.238
Observations	924	924	924	924	924	924

Notes: Estimates reported with Conley standard errors in brackets, adjusted for spatial correlation upto 500km from the district center. All specifications control for decadal mean rainfall. $*p < 0.1,^{**} p < 0.05,^{***} p < 0.001$.

Table 5: Effects by Wet and Dry Towns

	Log Workers		Share of Workers					
	(Total)		Non-Ag		Ag Labor		Seasonal	
	(FE)	(T)	(FE)	(T)	(FE)	(T)	(FE)	(T)
Panel A: Wet towns (> $p25$ rain)								
DDs (1 ° C)	0.366***	0.386***	-0.028*	-0.023*	0.027***	0.015	0.010	0.016
	[0.098]	[0.117]	[0.015]	[0.014]	[0.010]	[0.010]	[0.012]	[0.011]
Mean	9.05	9.05	0.74	0.74	0.09	0.09	0.09	0.09
Observations	10524	10524	10524	10524	10524	10524	10524	10524
Panel B: Dry towns (< $p25$ rain)								
DDs (1 ° C)	0.059	0.036	0.014	0.027	0.024	0.039**	-0.031*	-0.065***
	[0.163]	[0.134]	[0.032]	[0.026]	[0.018]	[0.017]	[0.019]	[0.017]
Mean	9.25	9.25	0.77	0.77	0.07	0.07	0.08	0.08
Observations	1356	1356	1356	1356	1356	1356	1356	1356

Notes: Estimates reported with Conley standard errors in brackets, adjusted for spatial correlation upto 500km from the district center. All specifications control for decadal mean rainfall. $*p < 0.1,^{**} p < 0.05,^{***} p < 0.001$.

6.1 Summary Statistics

6.2 Additional 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)

Table 6: Towns Summary

	1981	1991	2001	2011
Panel A: All Census Towns				
Town Characteristics				
Population	36,152.10	58,841.06	66,212.07	63,486.07
Total Workers	10,671.92	17,677.71	21,082.60	22,078.81
Area (sq. km)	14.78	15.57	17.23	14.01
Employment Shares				
Non-Ag Share	0.73	0.74	0.74	0.72
Ag Labor Share	0.12	0.12	0.07	0.08
Cultivator Share	0.11	0.10	0.06	0.05
Seasonal Share	0.04	0.04	0.13	0.16
Climatic Indicators (Growing Seasons)				
Degree Days (DDs)	16.20	16.34	16.34	16.58
Daily Temp (° C)	24.25	24.40	24.40	24.63
Nighttime Temp: Tmin (° C)	18.65	18.77	18.88	19.09
Daytime Temp: Tmax (° C)	29.84	30.02	29.92	30.17
Daily Precipitation (mm.)	3.51	3.43	3.50	3.32
Observations	8,786	8,786	8,786	8,786
Panel B: Balanced Panel (1981-2011)				
Town Characteristics				
Population	38,054.31	73,166.03	92,973.08	119471.27
Total Workers	11,153.96	21,769.38	29,198.19	41,322.11
Area (sq. km)	15.29	17.55	20.67	20.25
Employment Shares				
Non-Ag Share	0.74	0.74	0.76	0.74
Ag Labor Share	0.11	0.12	0.06	0.07
Cultivator Share	0.11	0.10	0.06	0.05
Seasonal Share	0.03	0.03	0.13	0.15
Climatic Indicators (Growing Seasons)				
Degree Days (DDs)	15.81	15.93	15.95	16.20
Daily Temp (° C)	23.87	24.00	24.02	24.27
Nighttime Temp: Tmin (° C)	18.03	18.12	18.25	18.48
Daytime Temp: Tmax (° C)	29.72	29.87	29.79	30.05
Daily Precipitation (mm.)	3.28	3.26	3.24	3.12
Observations	2,970	2,970	2,970	2,970

Notes: Summary statistics on towns in sample using data from the District Census Handbook (1981-2011).

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.