Night and Day: Physiological Limits to Structural Transformation *

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Abstract

Do rising temperatures trap or expel agricultural labor in the long run? I show that aggregates of daily temperature mask divergent labor reallocation responses. Using a harmonized panel of Indian towns and districts (1981–2011), I incorporate wet-bulb globe temperatures (WBGT) to demonstrate that structural transformation is constrained by two distinct physiological mechanisms. Nighttime humid heat (T_{min}) acts as an agricultural income shock: reducing cereal yields and crashing farm-to-gate prices, without reducing cultivated area. The loss of farm revenue collapses local demand for stable non-agricultural services, forcing a transition to the precarious, seasonal sector. Conversely, extreme daytime heat (T_{max}) acts as a physical supply shock: it breaches human physiological limits, driving a reduction of both labor and land in agriculture, and an increase in prices. Synthesizing data from the Census and National Sample Survey (NSS), I find neither heat shock triggers modern structural transformation. Displaced workers do not transition into manufacturing or education; rather, they are absorbed by casual construction and seasonal survival work. These findings suggest the physiological exit from agriculture masks a precarious quality of urbanization in the developing world.

Keywords: Climate Change, Structural Transformation, Urbanization, India

JEL Codes: O1, Q54, J43, R11

*Work-in-progress. Empirical results recently incorporated Wet-Bulb Globe Temperature (WBGT) and harvest price mechanisms. The tables in the current draft are being updated to reflect these new specifications.

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1 Introduction

Climate change is remapping the economic geography of the developing world. How do rising temperatures impact urbanization and structural change in the long-run? Standard models of structural transformation (Herrendorf et al. 2014) predict that a heat-induced decline in agricultural productivity should push labor out of agriculture towards the climate-resilient and higher productivity non-agricultural sector. Recent empirical evidence indicates that rising temperatures can paradoxically trap labor in the farm sector, or reduce demand for agricultural labor in the short-run (Liu et al. 2023), (Jessoe et al. 2017), (Colmer 2021). 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).

In India, where agriculture continues to employ nearly half of the workforce (56% Census 2011), it is therefore important to quantify the capacity of farms to sustain agricultural labor. The barrier of social networks and caste boundaries already inhibit mobility and the transition to services, the backbone of the urban economy (Munshi and Rosenzweig 2016). Where prior literature on the effects of temperature on labor reallocation has primarily focused on average temperatures and district aggregates, we zoom into towns and show that these results hide a heterogeneous mechanism by the *time of day* when heat is experienced. Our model is underpinned by a biological asymmetry: under rising nighttime temperatures, crops are the first casualties facing respiration stress. While humans can adapt with hydration and breaks, extreme daytimes limit the capacity for manual labor.

In this paper, we document a long-run non-linearity on the effects of temperature on structural transformation. We combine data from the Indian Census and National Sample Survey (NSS) with high-resolution daily climate data to show that adaptation follows a physiological hierarchy: night warming drives an agricultural intensification response, but daytime heat displaces outdoor labor into the indoor sectors of manufacturing and services. Our empirical analysis relies on a newly constructed panel dataset of Indian towns ($N = 2,970$) over four decades (1981–2011). We digitize and harmonize town-level Primary Census Abstracts to track employment outcomes at a spatial resolution 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, these estimates capture the *adaptation* of labor in response to persistent climate change. We further supplement this with household-level employment data from the NSS to further 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, benchmarking our results against the aggregate agricultural trap (Liu et al. 2023). **First**, we show that rising minimums negatively impact yields of *rice and wheat*,

reallocating labor into farms to compensate for productivity losses. Conversely, rising maximums cause physiological distress, driving an agricultural labor exit towards urban seasonal employment in low-skill services. **Second**, we identify a thermal bound to this agricultural trap. When long-run minimum temperatures are under 20°C, the cold relief of night warming results in an agriculturally led expansion of urban areas with no shocks to non-agricultural demand. Above the threshold, households intensify labor under night heat but are forced into distress migration with daytime extremes breaching physiological limits. **Third**, we show that these thermal regimes distort urbanization. Extreme heat restricts the declassification of unviable towns, resulting in *ghost urbanization*, where administrative frictions trap unviable towns. These towns are forced to engulf heat-stressed rural hinterland. In the hottest regions, the loss of agricultural income constrains local demand, leaving displaced workers to compete in a stagnant, low-skill service sector.

These results suggest that structural transformation in developing economies is bounded by physiological limits amidst increasing heat. With rising nights, households intensify labor on wilting farms, driving low-productivity urban sprawl. Physiological limits under daytime extreme heat forces an exit from agriculture into precarious services. Together, this reveals India's service transition not as an engine of growth, but as a physiologically constrained churn for survival.

2 Theoretical Framework

We develop a general equilibrium framework, building upon prior models from Gollin and Rogerson (2014) and Liu et al. (2023). We model an agrarian economy with three sectors: Agriculture (a), Seasonal (s), and Non-Agriculture (m). The representative household is endowed with labor L and fixed land $Z = 1$ and allocates labor hours over the three sectors.

2.1 Production

The agricultural and non-agricultural sector produce local goods a, m with unit prices $p_a, p_m = 1$, while the seasonal sector (s) produces either good a or good m. Production follows constant returns to scale and is determined by productivity $\mathcal{A}$, effective labor supply $\tilde{L} = \phi L$, and land $Z = 1$, such that $Y = F(\mathcal{A}, \tilde{L}, 1)$. Aggregate output $\mathbf{Y}$ is summed across sectors $i \in \{a, m, s\}$, with climate-dependent productivity $\mathcal{A}$ and effective labor ϕL. This productivity parameter $\mathcal{A}(\mathbf{T}, \mathbf{P})$ takes input vectors $\mathbf{T}$ for temperature and $\mathbf{P}$ for precipitation.

$$\mathbf{Y} = \sum_{i \in \{a,m,s\}} \left[\mathcal{A}_i(\mathbf{T}, \mathbf{P}) \cdot (\phi_i L_i)^{\theta_i} \right] \tag{1}$$

where the efficiency of labor in sector i is given by $\phi_i \in [0, 1]$, and output elasticity of labor is $\theta_i \in [0, 1]$.

Productivity $(\mathcal{A}_a, \mathcal{A}_m)$ is a function of climate, and labor is supply elastic to output by (θ_a, θ_m). The seasonal sector (s) represents temporary employment. We assume productivity is linear and independent of climate $(\mathcal{A}_s = \bar{s})$, with constant efficiency $\phi_s = 1$. This sector represents a flexible labor market, with unit-elastic labor supply $(\theta_s = 1)$, such that $Y_s = \bar{\phi s} L_s$. This yields the marginal productivity of labor each sector, $MPL_a = (\theta_a Y_a / L_a)$, $MPL_m = (\theta_m Y_m / L_m)$, $MPL_s = \bar{\phi s}$.

2.2 Preferences

The household has non-homothetic Stone-Geary preferences over consumption of a and m, defined by a subsistence requirement $\bar{a}$:

$$U(c_a, c_m) = \alpha \ln(c_a - \bar{a}) + (1 - \alpha) \ln(c_m) \tag{2}$$

Households optimize utility subject to their allocation of effective labor L across three sectors $i \in \{a, m, s\}$. Returns to labor (wages w_i) are equal to marginal productivity, i.e. $w_i = MPL_i$.

$$L = L_a + L_m + L_s$$

We assume the household operates near subsistence. The marginal utility of agricultural consumption $U'(c_a) \to \infty$ as $c_a \to \bar{a}$, which implies households prioritizes food security (a) over other consumption (m).

2.3 Mechanism

We model a heterogenous mechanism to the timing of rising temperatures: the night (T_{min}) and day (T_{max}). Initial nighttime warming makes agriculture viable in colder regions, but negatively impacts crop yields in hotter regions. Day heat damages crops and extreme temperatures impact labor effectiveness ϕ_i.

Our framework isolates these physiological mechanisms based on rising night and day temperatures, split by a temperature threshold T^* :

1. **Night Warming: Ag. Productivity Rises and Falls**

   $\uparrow T_{min} \implies (A_a \uparrow \text{ or } A_a \downarrow)$

   Below the threshold, increasing nighttimes provide 'cold relief', improving agricultural feasibility. This boosts farm productivity $(\mathcal{A}_a \uparrow)$, making agricultural labor lucrative $(L_a \uparrow)$. Above the threshold, farm productivity declines with increased crop respiration, suppressing farm yields. Due to subsistence constraints, labor reallocates to agriculture, compensating for yield losses.

   $$\left(\frac{\partial \mathcal{A}_a}{\partial T_{min}} \middle| [T_{min} \leq T^*] \right) > 0 \implies \mathcal{A}_a > 0 \implies L_a \uparrow (\text{since } A_a > 0) \tag{3}$$

$$\left(\frac{\partial \mathcal{A}_a}{\partial T_{min}} \middle| [T_{min} > T^*] \right) < 0 \implies \mathcal{A}_a < 0 \implies L_a \uparrow (\text{if } A_a > 0) \tag{4}$$

2. **Day Heat: Damaged Crops and Labor Exit**

   $\uparrow T_{max} \implies A_a \to 0$ and $(\phi_a \downarrow$ or $< \phi_a \to 0)$

   Below the threshold T^*, daytime heat damages crops. Although farm productivity declines, labor is retained on the farm if $MPL_a > MPL_s$. When daytime heat breaches T^*, human labor capacity collapses ($\phi_a \to 0$) (Dunne et al. 2013) (Somanathan et al. 2021). Unlike the crop shock, this shock reduces the *effectiveness* of labor itself. As $\phi_a \to 0$, the effective marginal product of labor on the farm crashes below the seasonal wage floor ($MPL_a < \bar{\phi s}$). Households are forced to exit agriculture ($L_a \downarrow$) and purchase food using wages from the seasonal sector.

$$\left(\frac{\partial \phi_a}{\partial T_{max}} \middle| [T_{max} \leq T^*] \right) < 0 \implies A_a \to 0, \phi_a > 0 \implies L_a \uparrow \tag{5}$$

$$\left(\frac{\partial \phi_a}{\partial T_{max}} \middle| [T_{max} > T^*] \right) < 0 \implies A_a \to 0, \phi_a \to 0 \implies L_a \downarrow \tag{6}$$

Consistent with agronomic literature on maintenance respiration rates in C3 crops (Peng et al. 2004) (Welch et al. 2010), we identify this threshold empirically for yields of rice and wheat, the primary cereals in India. Yields increase in regions below, and decline in regions above $T^* = 20^\circ$ C.

3 Data

We combine four datasets to link climatic conditions, agricultural yields, demographic change, and labor reallocation: (1) daily gridded weather data from the IMD, (2) district level crop yields (ICRISAT), (3) district and town level tables from the Indian Census, and (4) urban household-level employment data from the NSS. These datasets span across 1981-2011 (Census, IMD, ICRISAT), with a shorter window from the NSS (1987-2004).

3.1 Climate (Indian Meteorological Department)

We rely on the Indian Meteorological Department (IMD) gridded dataset for daily temperature (1° resolution) and precipitation (0.25° 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 growing season 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 are 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_d), using the function described in equation (8).

$$DDs = \sum_d D(T_d) \text{ ; where } T_d = \frac{T_{min,d} + T_{max,d}}{2} \tag{7}$$

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

3.2 Demographics and Employment (Census of India)

Our core dataset is sourced from the District Census Handbooks (DCHBs) of India. Specifically, we digitize data tables from 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: (1) a minimum population of 4,000, (2) at least 75% of male working population in non agricultural activity, and (3) 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. We additionally calibrate our results with a district level panel, which allows for a comparison of population statistics between the rural and urban components.

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 preceding enumeration. A 'main' worker is thus under regular employment and a 'marginal' worker is seasonally employed. While a marginal/seasonal worker may be present in either agriculture or non-agriculture, this definition allows us to measure the *duration* of work and distinguish between seasonal and regular employment.

3.3 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 (Ruggles et al. 2024). We categorize occupations into "Outdoor" (Cultivation, Agricultural Labor, Construction, Mining) and "Indoor" (Manufacturing, Services) work. We further restrict our sample to urban households, serving as a benchmark to the Census town-level data. This linkage allows us to observe the destination for heat-displaced labor, sorting into seasonal gigs rather than stable employment in manufacturing or services.

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 outcomes of structural transformation and urbanization. We employ a panel estimation and a long-difference approach (Burke and Emerick 2016).

$$Y_{irt} = \beta \mathbf{T}_{irt} + \phi \mathbf{P}_{irt} + \mu_i + \gamma_{jt} + \varepsilon_{irt} \tag{9}$$

$$\Delta Y_{ir} = \beta \Delta \mathbf{T}_{ir} + \phi \Delta \mathbf{P}_{ir} + \mu_i + \gamma_r + \varepsilon_{ir} \tag{10}$$

where Y_{it} is the outcome of interest (e.g., share of agricultural laborers) for district/town i, within region/state j at time t of observation. $\mathbf{T}_{it}$ is a vector of average heat measures: degree days (DDs), nighttime (T_{min}), or daytime (T_{max}) temperatures, each during the growing seasons of the kharif/monsoon (Jun–Oct) and rabi/winter (Nov-Feb). Heat measures average the daily temperature, weighted by inverse squared distance to observation gridpoints within 250 km of town or 500 km of district i's center. $\mathbf{P}_{it}$ additionally controls for daily precipitation (mm.) averaged over the same duration of growing seasons, to decouple the temperature channel from rainfall.

Our identification strategy relies on the assumption that accounting for the geographic unit, year and state $\times$ year fixed effects, all remaining variation in temperature and rainfall is random to the outcome in district/town i (Dell et al. 2012; Liu et al. 2023). By using a 10-year average rather than annual weather, our coefficient vector β captures *adaptation* to persistent climatic shifts rather than transient responses to weather shocks. We include town/district fixed effects (μ) to control for time-invariant unobservables specific to the geographic unit, such as elevation, soil quality, or baseline industrialization. We include additional controls for Region $\times$ Year and State $\times$ Year fixed effects (γ_{jt}), to absorb time-varying regional shocks, such as trade liberalization (1991) and labor policies (NREGA). In a final set of controls, we fit a linear trend on time-varying shocks to each Region $\times$ Year and State $\times$ Year clustered above.

Our preferred specification chooses the vector $\mathbf{T} = \{T_{min}, T_{max}\}$, i.e. we specify nighttime and daytime temperatures simultaneously. As an alternate specification, we regress the night and day

temperatures independently. The estimates remain identical in magnitude and error bounds under both specifications. We further allow for spatial autocorrelation up to a radius of 250 km from a town's centroid or 500 km from a district's centroid, alongside serial correlation up to 4 decades (Conley 1999). To test the theoretical prediction of non-linear adaptation regimes, we estimate the following threshold model:

$$Y_{it} = \sum_{Zones(k)} [\beta \mathbf{T}_{it} + \mathbf{P}_{it} + \varepsilon_{it}\ ] \times \mathbb{1}[\text{Zone}_i \in k] \tag{11}$$

For example, in Figure 1, the rolling thresholds model selects $\mathbb{1}[T^*_{min} \geq \{17, 17.5, 18...\}]$, subsetting only district/towns above the specified threshold long-run night temperature (T^*_{min}) over 1981-2011.

5 Results

Table 1 presents the estimates of long-run heat exposure on growth of workers and sectoral shares, using data at the district level from the Census. We model estimates of an exogenous unit increase in each measure **T**, during growing seasons months of June-February over decade preceding Census enumeration. In Panel A, we use Degree Days (DDs) over the past decade's growing seasons as the measure of heat **T**. In Panel B, we decompose the aggregate effects of (DDs) by night (T_{min}) vs day (T_{max}) components to daily temperatures over the same period. Our outcomes are further split for both rural and urban aggregates within districts.

Table 1: Estimates of Rising Temperatures on Structural Transformation

	Districts		Towns (Share of Workers)					
	Log (Yields)		Agriculture		Seasonal		Non-Agriculture	
	Panel	L. Diff	Panel	L. Diff	Panel	L. Diff	Panel	L. Diff
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
T_{min}	0.346***	0.331***	0.028**	0.068***	-0.004	-0.001	-0.023*	-0.068***
	[0.063]	[0.061]	[0.012]	[0.024]	[0.008]	[0.011]	[0.012]	[0.026]
T_{max}	-0.257***	-0.529**	0.008	0.059**	0.018*	0.041**	-0.036***	-0.110***
	[0.099]	[0.240]	[0.011]	[0.029]	[0.010]	[0.020]	[0.012]	[0.033]
Mean	6.26	0.38	0.18	-0.11	0.08	0.10	0.74	0.01
Observations	940	235	8,771	2,339	8,771	2,339	8,771	2,339

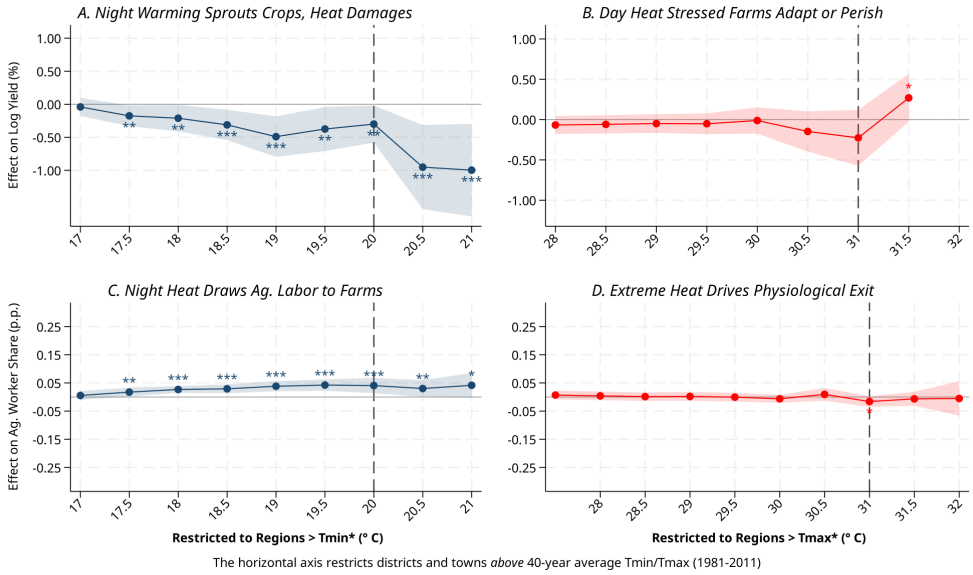
Notes: Standard errors are **spatially corrected (Conley, 500km from district center)** and allow for serial correlation (4 decades). Columns 1-2 measure the log total workers, interpreted as a percentage change. Columns 3-8 denote the share of the total workforce (0-1), interpreted as a percentage point change. Seasonal workers may be employed in either agriculture or non-agriculture, defined as those employed for <183 days in the preceding calendar year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Panel A benchmarks our aggregate result of heat "inhibiting" structural transformation to estimates from Liu et al. 2023. We additionally find that a unit increase in DDs causes a significant growth in the rural and urban workforce. This growth is led by a significant increase in the share

of agricultural labor in both regions with a decrease in the rural non-agricultural share. We further document heterogeneous effects of heat shocks to the night (T_{min}) and day (T_{max}) temperatures. The average result of daily heat on the agricultural trap is driven by T_{min}, while we observe an exit of agricultural labor in rural areas with T_{max}. Additionally, we find a significant growth in total workers with nighttime heat, but no detectable change in the growth with daytime heat.

In Figure 1, we visualize a thermal limit to the agricultural intensification response by restricting our subsamples over 'rolling thresholds' of 0.5° C on the long-run temperatures T^*_{min}, T^*_{max}. By doing so, we isolate the effects of night and day heat in *progressively hotter* regions, represented on the horizontal axis. We focus on the 10-year **log yield** of rice and wheat in districts and **share of workers** in agriculture (both labor and cultivation) in towns. The vertical axis plots coefficients of a 1° C increase in night vs day temperatures, interpreted as a p.p. change worker shares and percentage change in yields. The climate thresholds of $T^*_{min} \geq \{17, ..., 22\}$ and $T^*_{max} \geq \{28, ..., 32\}$ degrees Celsius range over the bottom and top deciles of long-run temperatures.

Figure 1: Minimum vs Maximum Thresholds to Yields and Agricultural Worker Share



Notes: The horizontal axis plots coefficients by subsampling regions **above each threshold** T^*, ranging from $T_{min} = 17 \rightarrow 22°C$. The vertical lines distinguish these samples into a cool and hot zone, i.e. nights below and above $T_{*=20°C}$ respectively. The coefficients plot effects of a $1°C$ increase in the nighttime (T_{min}) and daytime (T_{max}) temperatures during growing seasons of the past decade. The dependent variable in panels A and B is the *district log yield of rice and wheat* and *town share of agricultural labor* in panels C and D. Conley standard errors reported with 90% confidence intervals, adjusting spatial correlation upto 250 km from town center (workers) & 500 km from district center (yields), with a temporal lag of 4 decades.

The agricultural response to nights is heterogeneous across a cool zone and hot zone crossing the night threshold of $T^*_{min} = 20$. In Panels A and C, we show the night heat (T_{min}) leads to a significant decline in rice and wheat yields owing to respiration stress, compensated by a significant increase of workers in agriculture. Farm productivity crashes in zones crossing $T^*_{min} \geq 21$: the sterility threshold for rice. Panels B and D demonstrate that daytime heat (T_{max}) continues to wipe out yields, until

farms either adapt or perish. At the physiological limit $T^*_{max} \geq 31$, there is an exodus of workers from the urban agricultural sector. We report the kernel densities of these temperature measures in Figure 3, and visualize the spatial distribution of towns with $T^*_{min} \geq 20$ in Figure 5.

Table 2: Theoretical Framework Predictions

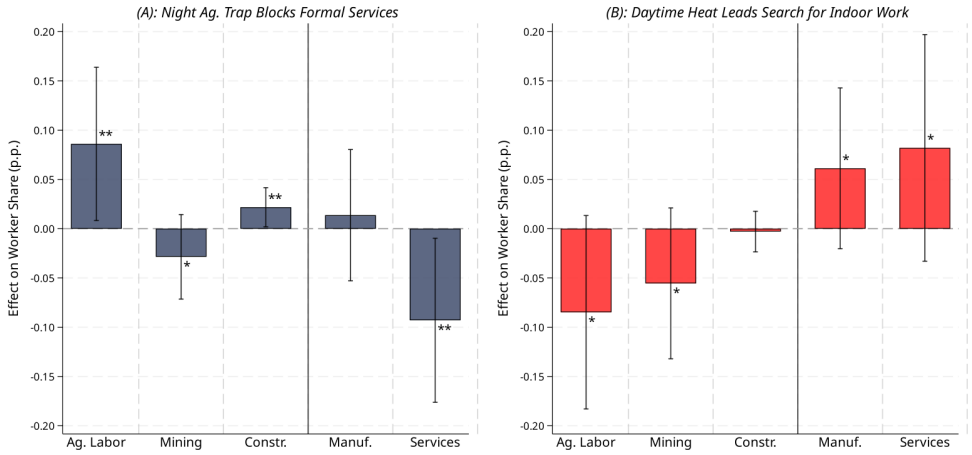
	Town		Town Share of Workers					
	Share(Cultivators)		Ag. Labor		Non-Agriculture		Seasonal	
	(1) Below T*	(2) Above T*	(3) Below T*	(4) Above T*	(5) Below T*	(6) Above T*	(6) Below T*	(8) Above T*
Below/Above Max. Threshold ($T^* = 31°C$)								
T_{min}	0.012	0.038	0.065***	0.062***	-0.079***	-0.056	0.000	0.019
	[0.015]	[0.024]	[0.012]	[0.016]	[0.024]	[0.045]	[0.011]	[0.029]
T_{max}	0.029**	-0.014	0.060**	-0.048**	-0.137***	0.060***	0.041	-0.009
	[0.015]	[0.013]	[0.023]	[0.024]	[0.037]	[0.022]	[0.027]	[0.020]
Mean	-0.06	-0.04	-0.05	-0.05	0.01	0.02	0.11	0.07
Observations	1,951	388	1,951	388	1,951	388	1,951	388
Rainfall Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region or State × Year FE	Region	State	State	State	State	State	State	State

Notes: Standard errors are **spatially corrected (Conley, 500km from district and 250km from town center)** and allow for serial correlation (4 decades). Estimates represent separate subsample regressions for regions below and above threshold T^*. Columns 1-2 measures the log mean yield of rice and wheat. In Columns 2-6, we estimate effects on the share of the town workers (0-1). Seasonal workers may be employed in either agriculture or non-agriculture, defined as those employed for <183 days in the preceding calendar year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Paired with Figure 1, Table 2 empirically validates the heterogenous physiological mechanism under our theoretical framework. We estimate the effects of temperature on **district** agricultural productivity and the **town** share of workers across the two zones split by long-run night temperature: $T^*_{min} = 20$ and $T^*_{max} = 31$. In Panels A and B, we report the effects of minimum and maximum temperatures crossing these thresholds respectively. In the "benign" zone below T^*, rising minimums trigger an influx of farm labor and increasing yields. In the "stressed' zone above T^*, the agricultural trap is triggered, reallocating labor towards agricultural labor and cultivation. Towns in the benign zone employ additional farm labor as well and regress to cultivation on inert yields. The resulting loss in income contracts demand for the non-farm sector, declining the non-agricultural share of workers. In contrast, we observe daytime heat collapsing farm yields, resulting in a contraction for non-agricultural labor demand. When daytime temperatures cross the physiological limit of $31°C$, we see a significant decline in land-owning cultivators, while the null effect on yields suggests surviving farms' adaptation to heat.

In Figure 2, we turn to the National Sample Survey (NSS) to characterize the destination of seasonal labor, as they offer a finer disaggregation of occupations. We presents the effects of rising day and night heat on the *urban* share of workers in six sectors: agricultural labor, cultivation, mining, construction, manufacturing and services. Consistent with estimates from the Census, night warming increases the share of workers in agriculture. We observe an exit from mining, which is often

Figure 2: Physiological Sorting under Daytime Heat Stress



Notes: The figure reports estimates at the district level of rising minimum (T_{min}) and maximum (T_{max}) temperatures. The dependent variable is the share of urban employment per sector. Data: NSS 1987-2004. All specifications control for decadal mean rainfall. Estimates reported with Conley standard errors adjusted for spatial dependence up to 500 km from district center and serial correlation up to 4 decades.

underground and highly sensitive to heat, and a marginal reallocation of labor into construction. We further observe a null effect on manufacturing, and a contraction in the share of service workers. In contrast, daytime heat shocks lead to a sharp exit from the three outdoor sectors: agriculture, construction and mining. These displaced workers appear to move overwhelmingly into the services sector, which corresponds to the jump in seasonal labor in the Census. We interpret this surge as precarious employment in low-skill services. Finally, we observe a stagnation of growth in both total town workers and area, consistent with our district level estimates from Table 7.

Table 3 examines the effects of rising temperatures on urbanization patterns and labor markets. In Panel A, we report estimates from the Census on urban aggregates at the district level. We observe a growth in the population simultaneously with workers, and aggregate urban area. Further, night heat blocks the formation of new towns due to the higher magnitude of rural regression into agriculture, as documented in Table 7. With rising maximums, urbanization patterns stagnate. We find no detectable change in town workers, population or area. Concurrently, there is a significant increase in the total number of towns present with a district. This increase is caused by impeded natural declassification of Census urban areas, as workers exit from agriculture and the region is administratively retained as a town.

Panel B reports estimates from the NSS employment schedules in *urban* households, aggregated to the district level. We benchmark our results on growth of total workers, which grow under rising nights but show null results with days. Our finding shows that rising nights significantly decrease the share of total migrant workers, while the rural household is forced to maintain agricultural land. However, daytime extremes result in a marginally significant increase in total share of migrant

workers and a significant increase in the share of out-of-state migrants. In a final estimation, we examine the effects of night and day heat on growth of nominal wages. We find temperature raises manufacturing wages, with no detectable change in wages for work in either agricultural labor or services. These results suggest a stagnation in wage growth and urbanization, despite a significant reallocation from agriculture towards services caused by daytime distress.

Table 3: Effects of Night vs Day Heat on Urban Expansion and Labor Markets

	Census (1981-2011)			NSS (1987-2004)		
	(Log) Town Area (1)	(Count) Towns (2)	(Count) Declassified (3)	(Share) Ag. Labor (4)	(Share) Manufacturing (5)	(Share) Services (6)
A. Warming Threshold ($T^*_{min} = 20°C$)						
$T_{min} \times T_{min}$ Below 20	0.212	-1.318**	-0.018	0.049**	0.019	-0.090**
	[0.155]	[0.642]	[0.393]	[0.024]	[0.028]	[0.039]
$T_{min} \times T_{min}$ Above 20	0.530*	-1.402	1.106	0.032	-0.032	0.008
	[0.289]	[1.548]	[1.006]	[0.052]	[0.056]	[0.083]
Mean (Below T*)	2.44	11.06	0.65	0.08	0.15	0.58
Mean (Above T*)	2.68	12.89	1.20	0.10	0.20	0.53
Observations (Below T*)	4,583	804	804	1,076	1,076	1,076
Observations (Above T*)	1,505	320	320	352	352	352
B. Thermal Limit ($T^*_{max} = 31°C$)						
$T_{max} \times T_{max}$ Below 31	0.281*	2.741**	-1.262**	-0.053***	-0.011	0.173***
	[0.154]	[1.155]	[0.559]	[0.018]	[0.019]	[0.037]
$T_{max} \times T_{max}$ Above 31	-0.033	1.356	-0.211	0.031	0.129*	-0.220***
	[0.201]	[2.154]	[1.438]	[0.055]	[0.069]	[0.085]
Mean (Below T*)	2.44	11.06	0.65	0.08	0.15	0.58
Mean (Above T*)	2.68	12.89	1.20	0.10	0.20	0.53
Observations (Below T*)	4,583	804	804	1,076	1,076	1,076
Observations (Above T*)	1,505	320	320	352	352	352

Notes: Standard errors are **spatially corrected (Conley, 500km from district center)** and allow for serial correlation (4 decades). 'Formed' towns denote new Census classification; 'Declassified' denotes loss of urban status. Day heat generates *ghost urbanization*, increasing the number of towns by blocking declassification of unviable towns. All specifications control for decadal mean rainfall. We additionally control for State × Year fixed effects in panels A and B. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

6 Conclusion

To our knowledge, this paper provides the first evidence that the long-run adaptation to climate change in India is bounded by physiological limits. Decomposing temperature into its nighttime and daytime components, we document two distinct regimes of structural transformation that are obscured by aggregate average temperatures.

First, we identify an Agricultural Trap driven by night warming. As minimum temperatures rise above $20°C$, crop yields decline due to respiration stress. Far from exiting the sector, households respond through intensification and increase labor supply to the farm to maintain subsistence. Second, we identify a *physiological exit* driven by daytime extreme heat. When maximum temperatures

breach the thermal limit, the capacity for outdoor manual labor collapses. This forces a distress exit from agriculture and construction, not into productive manufacturing, but into a refuge of precarious, seasonal employment in services.

These mechanisms manifest in a stark divergence between administrative urbanization and economic reality. In cooler regions, climate-induced migration fuels genuine urban expansion and growth. However, in the hottest districts, we document the phenomenon of *ghost urbanization* with rising days. The workforce ceases to grow under extreme heat, yet the number of census towns increases. We show this accumulation is driven by a failure of the natural exit from urban status due to reallocation of labor into services. Distressed settlements are unable to sustain growth, yet administratively prevented from declassifying as agriculture remains unviable.

Our findings have urgent implications for development policy in a warming world.

Realigning Agricultural Subsidies Current agricultural policies target night heat-induced fall in agricultural yields. In states like Andhra Pradesh and Telangana, nights remain hot yet heavy subsidies for heat-sensitive C_3 crops (rice and wheat) encourage workers to remain in agriculture. This persistence of subsidies deepens the trap, forcing households to expend more effort for diminishing returns. Policy must pivot toward incentivizing heat-tolerant C_4 crops (e.g., millets, maize, sorghum) particularly in the hot night zones. Shifting the safety net from crop-specific procurement to income support may allow households to adapt crop choices in response to local thermal realities, without losing their lifeline.

Industrial Location and Climate Adaptation Our results show that the refuge under daytime heat is currently dominated by low-skill services, with null effects on reallocation towards manufacturing. This represents a missed opportunity, specifically above the threshold. Towns experiencing daytime warming are generating a large supply of labor exiting agriculture. Industrial policy should explicitly target these transition zones for labor. By locating climate-controlled manufacturing plants in regions where the "push" from agriculture is strongest, policy can convert a distress exit towards productive structural change.

Managing Administrative Lock-in Finally, managing the ghost towns in the hottest zones is paramount. The finding that extreme heat blocks Census town declassification suggests that administrative rigidity may incentivize unviable urban settlements. Indian social safety nets often depend upon rigid classification rules, where the inability to exit a dying town amplifies vulnerability. In the hottest districts, policy should shift from "holding the line" to a managed urban retreat. This requires scaling portable social benefits (e.g., One Nation One Ration Card) that allow households to migrate without losing food security. It also calls for flexibility in defining urban areas, that allows unviable towns to regress and free up resources for growing urban centers.

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7 Appendix

Table 4: Towns Summary

	1981	1991	2001	2011
Panel A: Municipal Towns				
Town Characteristics				
Population	55,251.21	106098.98	150550.17	202954.42
Total Workers	16,203.97	31,778.95	47,476.02	71,007.33
Area (sq. km)	16.58	21.66	29.56	31.82
New Towns (0/1)	0.12	0.08	0.04	0.14
Decommissioned Towns (0/1)	0.00	0.00	0.00	0.00
Share of Workers by Category				
Non-Agricultural	0.75	0.75	0.80	0.79
Agricultural Labor	0.11	0.11	0.05	0.06
Cultivation	0.10	0.10	0.04	0.04
Seasonal	0.04	0.03	0.11	0.12
Climatic Indicators (Growing Seasons)				
Degree Days (DDs)	15.75	15.83	15.96	16.55
Daily Temp (° C)	23.81	23.91	24.04	24.61
Nighttime Temp: Tmin (° C)	17.91	17.90	18.18	18.75
Daytime Temp: *T_max* (° C)	29.71	29.92	29.90	30.47
Daily Precipitation (mm.)	3.12	3.11	3.05	3.00
Observations	1,838	2,044	1,798	1,817

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

Table 5: District Summary

	1981	1991	2001	2011
Panel A: Rural				
Characteristics				
Population (in Thousands)	1,476.74	1,765.70	1,574.63	1,683.07
Total Workers (in Thousands)	580.97	721.67	843.99	920.10
Share of Workers by Category				
Non-Agricultural	0.18	0.19	0.39	0.39
Agricultural Labor	0.23	0.25	0.14	0.17
Cultivation	0.47	0.44	0.27	0.22
Seasonal	0.11	0.12	0.20	0.21
Climatic Indicators (Growing Seasons)				
Degree Days (DDs)	15.64	15.76	15.78	16.05
Daily Temp (° C)	23.70	23.83	23.85	24.12
Nighttime Temp: Tmin (° C)	17.80	17.89	18.00	18.24
Daytime Temp: *T_max* (° C)	29.60	29.76	29.70	29.99
Daily Precipitation (mm.)	3.18	3.18	3.18	3.06
Observations	286	286	286	286
Panel B: Urban				
Characteristics				
Population (in Thousands)	465.02	628.86	628.64	817.22
Total Workers (in Thousands)	138.70	189.45	220.20	323.46
Town Changes				
Total Towns	11.44	11.94	10.86	12.06
New Towns	3.30	0.96	0.84	1.58
Decommissioned Towns	0.44	0.46	1.93	0.38
Share of Workers by Category				
Non-Agricultural	0.81	0.81	0.83	0.80
Agricultural Labor	0.07	0.09	0.03	0.04
Cultivation	0.08	0.08	0.04	0.03
Seasonal	0.03	0.03	0.10	0.12
Climatic Indicators (Growing Seasons)				
Degree Days (DDs)	15.64	15.76	15.78	16.05
Daily Temp (° C)	23.70	23.83	23.85	24.12
Nighttime Temp: Tmin (° C)	17.80	17.89	18.00	18.24
Daytime Temp: *T_max* (° C)	29.60	29.76	29.70	29.99
Daily Precipitation (mm.)	3.18	3.18	3.18	3.06
Observations	286	286	286	286

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

Figure 3: Thermal Zones and Physiological Limits

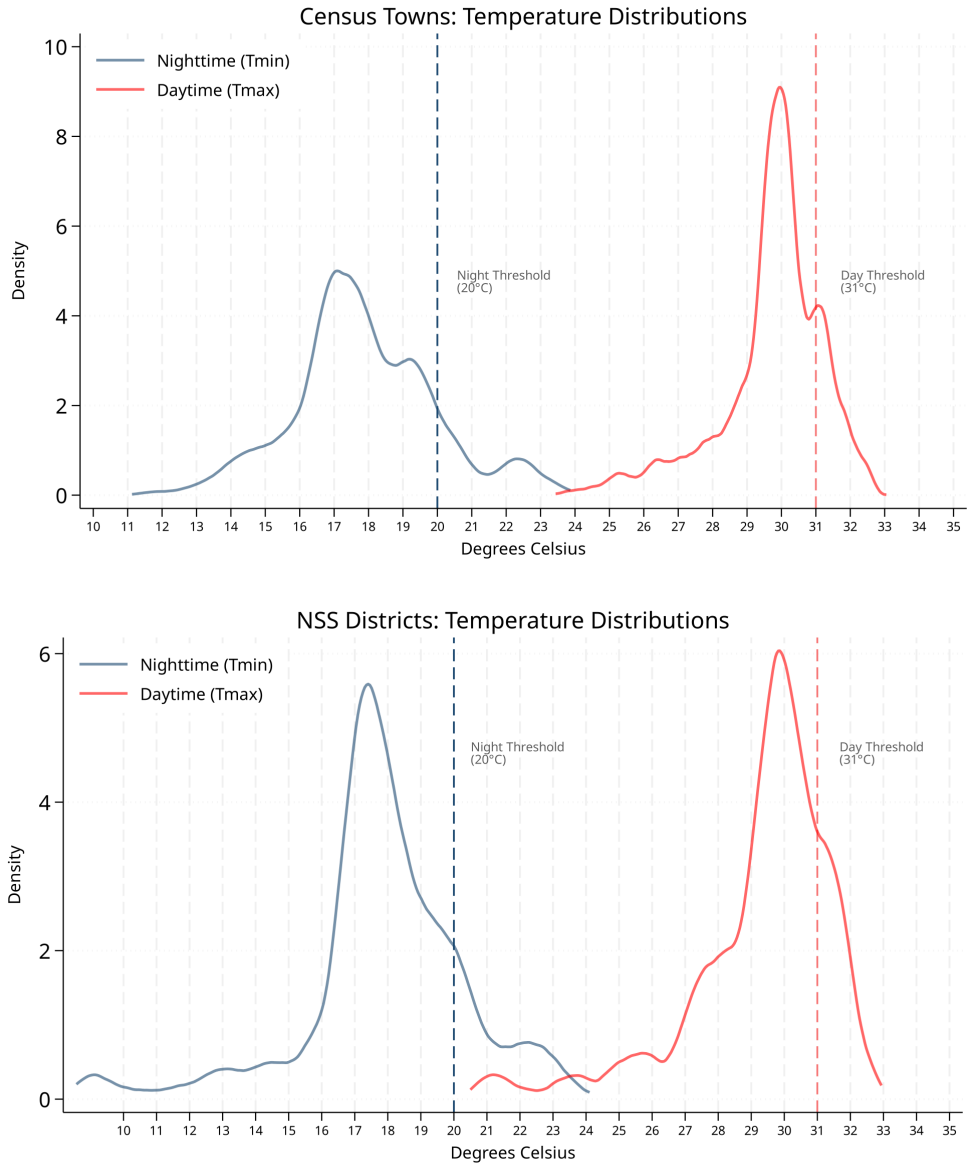
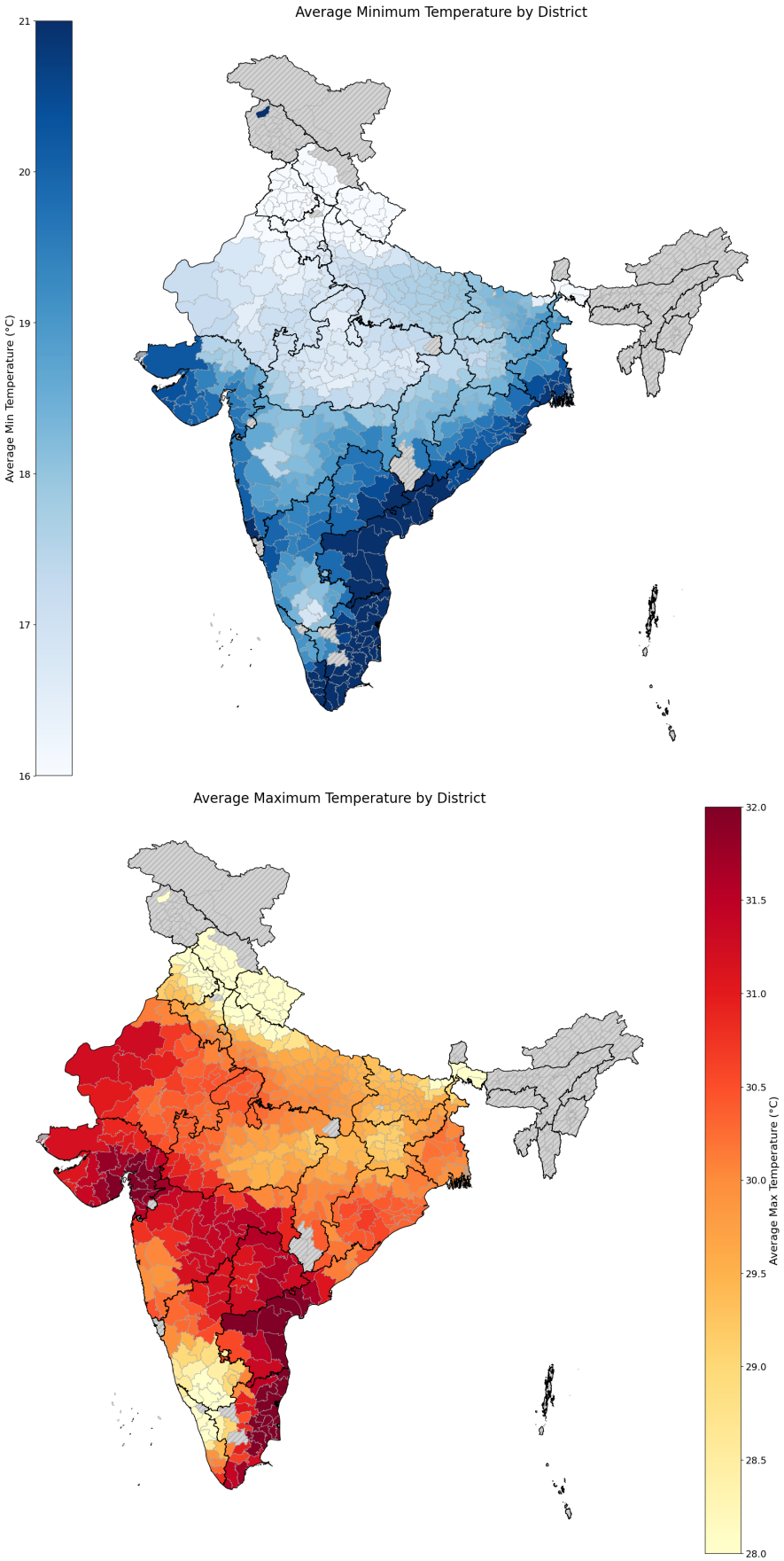


Table 6: Town Estimates by Specifications: Independent vs Simultaneous

	Share of Workers			Log	Urban Status	
	Ag. Labor	Non-Ag.	Seasonal	Town Area	Prob(Entry)	Prob(Exit)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Independent Specification						
Night Temperature (T_{min})						
Day Temperature (T_{max})						
Panel B: Simultaneous Specification						
Night Temperature (T_{min})	0.025***	-0.008	-0.010	0.274**	-0.113**	-0.016
	[0.006]	[0.010]	[0.007]	[0.130]	[0.059]	[0.021]
Day Temperature (T_{max})	0.006	-0.034***	0.016**	0.191**	-0.128**	-0.008
	[0.008]	[0.011]	[0.009]	[0.112]	[0.076]	[0.029]
Mean	0.09	0.75	0.09	2.18	0.17	0.04
Observations	11880	11880	11880	11853	35144	35144

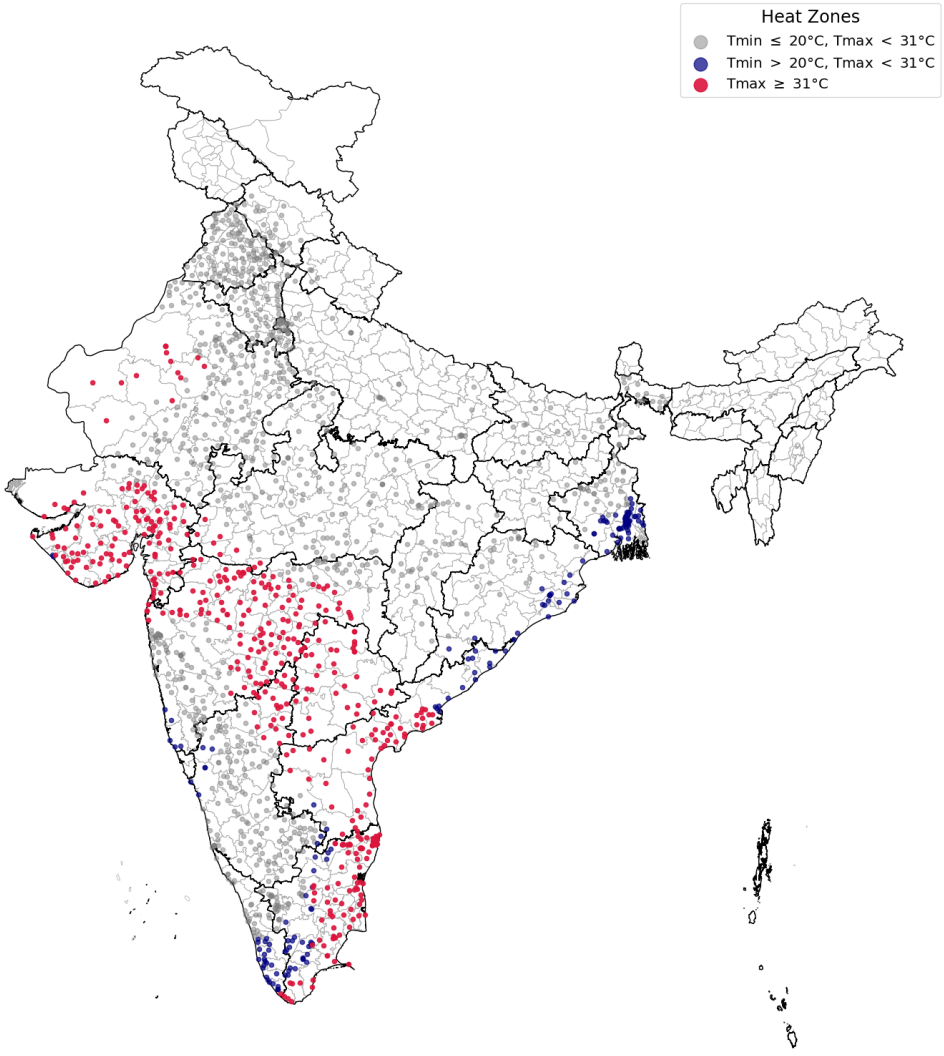
Notes: Estimates adjusted for temporal lag upto 4 decades and spatial correlation upto 250 km from town center. Error bars represent 90% confidence intervals with Conley adjusted standard errors. All specifications control for decadal mean rainfall. Seasonal workers are defined as those employed for <183 days in the preceding year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Figure 4: Long-run Temperatures in Towns (1981-2011)



Notes:

Figure 5: Distribution of Towns by Heat Zones Based on Long-run Temperature (1981-2011)



Notes: The map plots

Table 7: Effects of Rising Temperatures in Districts: Rural vs Urban Population

	Log Workers		Share (Ag. Labor)		Share (Seasonal)		Share (Non-Ag.)	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
A. Aggregate: Growing Season Degree Days (DDs)								
DDs	0.446**	0.534***	0.083***	0.024**	-0.013	-0.020	-0.076***	0.001
	[0.180]	[0.167]	[0.027]	[0.010]	[0.024]	[0.015]	[0.023]	[0.020]
B. Mechanism: Night (T_{min}) vs Day (T_{max})								
T_{min}	0.280***	0.361***	0.082***	0.017***	-0.019	-0.019**	-0.062***	0.010
	[0.108]	[0.111]	[0.016]	[0.005]	[0.013]	[0.009]	[0.011]	[0.013]
T_{max}	0.087	0.073	-0.044**	0.001	0.016	0.005	0.005	-0.018
	[0.093]	[0.121]	[0.019]	[0.009]	[0.013]	[0.009]	[0.014]	[0.014]
Mean	13.34	11.65	0.20	0.06	0.16	0.07	0.28	0.81
Observations	1,132	1,132	1,124	1,121	1,124	1,121	1,124	1,121

Notes: All specifications control for decadal mean rainfall. Standard errors are **spatially corrected (Conley, 500km from district center)** and allow for serial correlation (4 decades). Columns 1-2 measure the log total workers, interpreted as a percentage change. Columns 3-8 denote the share of the total workforce (0-1), interpreted as a percentage point change. Seasonal workers may be employed in either agriculture or non-agriculture, defined as those employed for <183 days in the preceding calendar year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Table 8: Long-Differenced Regressions

	District	Town	Town Share of Workers			
	Log. Yields (1)	Log. Workers (2)	Ag. Labor (3)	Cultivators (4)	Seasonal (5)	Non-Ag. (6)
A. Rising Nights (T_{min})						
$T_{min}\times$ 1981-1991	0.055	0.154*	-0.009	-0.001	-0.001	0.014
	[0.104]	[0.089]	[0.006]	[0.007]	[0.008]	[0.009]
$T_{min}\times$ 2001-2011	0.057	0.032	0.011	0.002	0.006	-0.018
	[0.075]	[0.035]	[0.008]	[0.004]	[0.012]	[0.012]
B. Daytime Extremes (T_{max})						
$T_{max}\times$ 1981-1991	-0.157	0.361	0.009	-0.013*	0.030***	-0.037***
	[0.131]	[0.221]	[0.008]	[0.007]	[0.006]	[0.012]
$T_{max}\times$ 2001-2011	0.004	-0.055*	-0.020**	-0.001	-0.026	0.044**
	[0.054]	[0.033]	[0.009]	[0.004]	[0.018]	[0.021]
Mean (1981-1991)	7.02	8.81	0.11	0.11	0.03	0.74
Mean (2001-2011)	7.36	9.35	0.06	0.05	0.14	0.75
Observations (1981-1991)	470	5,940	5,940	5,940	5,940	5,940
Observations (2001-2011)	470	5,940	5,940	5,940	5,940	5,940

Notes: All specifications control for decadal mean rainfall. Estimates represent separate subsample regressions for Census districts (rural aggregate) and towns. Coefficients adjusted for spatial dependence up to 500 km from district center and 250 km from town center, alongside autocorrelation upto 4 decades. Heat measures are averaged over growing seasons of the kharif (monsoon) and rabi (winter) agricultural months of June-February, during the decade preceding Census enumeration. Seasonal workers may be employed in either agriculture or non-agriculture, defined as those employed for $<$183 days in the preceding calendar year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Table 9: Log Share Effects by Status of Town

	Log Share of Workers			Log Levels	
	Agriculture	Non-Ag.	Seasonal	Workers	Area
Panel A: Census Urban Areas					
T_{min} $(+1^{\circ}C)$	0.091	0.016	-0.291	-0.028	0.058
	[0.086]	[0.024]	[0.207]	[0.049]	[0.067]
T_{max} $(+1^{\circ}C)$	-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} $(+1^{\circ}C)$	0.098*	-0.042***	0.221	0.231**	0.270*
	[0.055]	[0.014]	[0.176]	[0.098]	[0.139]
T_{max} $(+1^{\circ}C)$	-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 250 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. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Table 10: District Estimates of Day vs Night Heat

	Share of Workers			Log	Town Dynamics	
	Ag. Labor (1)	Non-Ag. (2)	Seasonal (3)	Tot. Workers (4)	New Towns (5)	Detowned (6)
Panel A: District Total (Growing Season)						
Night Temperature (T_{min})	0.049***	-0.050***	-0.008	0.218***	-0.957**	0.001
	[0.012]	[0.010]	[0.010]	[0.077]	[0.467]	[0.265]
Day Temperature (T_{max})	-0.030**	0.014	0.011	0.091	0.897	-1.160***
	[0.014]	[0.012]	[0.009]	[0.075]	[0.745]	[0.446]
Panel B: Kharif (Monsoon) Season						
Night Temperature (T_{min})	0.041***	-0.042***	-0.013	0.114*	-1.531***	-0.346
	[0.014]	[0.009]	[0.011]	[0.064]	[0.541]	[0.272]
Day Temperature (T_{max})	-0.034**	0.037**	0.033***	0.152**	0.419	-0.857*
	[0.014]	[0.015]	[0.009]	[0.075]	[0.783]	[0.485]
Panel C: Rabi (Winter) Season						
Night Temperature (T_{min})	0.044***	-0.048***	-0.007	0.214***	-0.216	0.318
	[0.008]	[0.007]	[0.009]	[0.073]	[0.354]	[0.255]
Day Temperature (T_{max})	-0.016	-0.004	-0.005	0.024	1.012*	-0.724**
	[0.011]	[0.009]	[0.009]	[0.063]	[0.538]	[0.314]
Mean	0.17	0.38	0.15	13.59	1.63	0.78
Observations	1108	1108	1108	1108	1108	1108

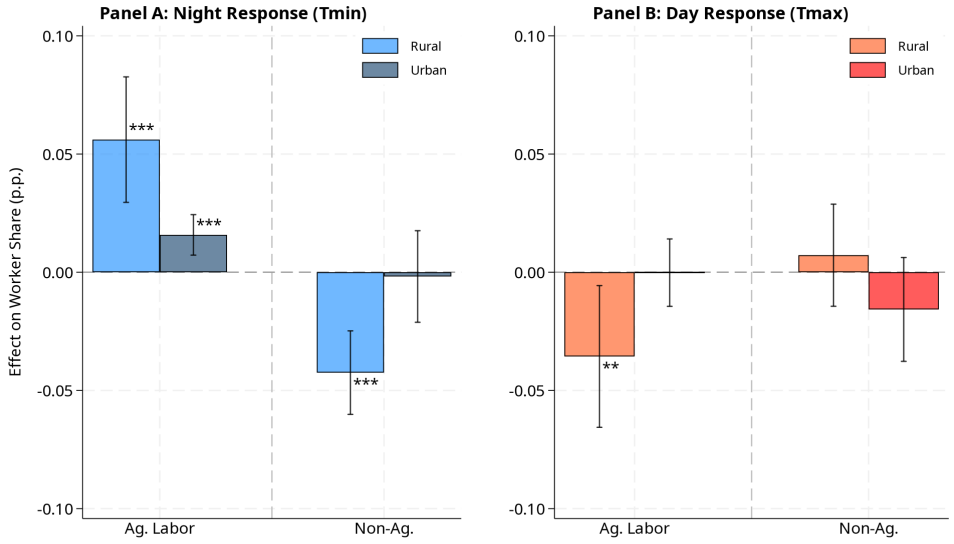
Notes: Estimates adjusted for temporal lag upto 4 decades and spatial correlation upto 500 km from district center. All specifications control for decadal mean rainfall. Seasonal workers are defined as those employed for <183 days in the preceding year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Table 11: District Rural vs Urban Estimates of Heat

	Share of Workers							
	Ag. Labor		Cultivators		Non-Ag.		Seasonal	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Degree Days (Growing Season)								
Degree Days (DDs)	0.051**	0.022***	0.001	0.002	-0.049***	-0.014	0.001	-0.008
	[0.020]	[0.008]	[0.024]	[0.007]	[0.017]	[0.015]	[0.017]	[0.011]
Panel B: Kharif (Monsoon) Season								
Night Temperature (T_{min})	0.048***	0.012**	0.011	0.003	-0.041***	-0.001	-0.011	-0.014*
	[0.015]	[0.005]	[0.011]	[0.005]	[0.009]	[0.011]	[0.011]	[0.007]
Day Temperature (T_{max})	-0.037**	-0.000	-0.035*	-0.004	0.031**	-0.020*	0.034***	0.024***
	[0.016]	[0.007]	[0.018]	[0.006]	[0.014]	[0.011]	[0.010]	[0.008]
Panel C: Rabi (Winter) Season								
Night Temperature (T_{min})	0.048***	0.015***	-0.001	-0.005	-0.036***	-0.001	-0.007	-0.009*
	[0.010]	[0.003]	[0.011]	[0.004]	[0.007]	[0.008]	[0.009]	[0.006]
Day Temperature (T_{max})	-0.020	-0.001	0.025*	0.012**	-0.007	-0.005	-0.003	-0.005
	[0.012]	[0.006]	[0.015]	[0.006]	[0.009]	[0.009]	[0.010]	[0.006]
Rural/Urban	(R)	(U)	(R)	(U)	(R)	(U)	(R)	(U)
Mean	0.20	0.06	0.35	0.06	0.28	0.81	0.16	0.07
Observations	1100	1097	1100	1097	1100	1097	1100	1097

Notes: Estimates adjusted for temporal lag upto 4 decades and spatial correlation upto 500 km from district center. All specifications control for decadal mean rainfall. Seasonal workers are defined as those employed for <183 days in the preceding year. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Figure 6: District Effects of Rising Heat: Rural vs Urban Aggregate



Notes: 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. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

Table 12: Effect of Rising Temperatures on Cultivated Area and Yields in Districts

	Heat Sensitive (C_3) Crops			Heat Tolerant (C_4) Crops		
	Rice	Wheat	Barley	Maize	Sorghum	Millet
Panel A: Crop Yield (tonnes/hectare)						
T_{min} $(+1^{\circ}C)$	0.046	0.178*	0.446***	0.228**	-0.064	0.240***
	[0.074]	[0.101]	[0.151]	[0.102]	[0.066]	[0.080]
T_{max} $(+1^{\circ}C)$	-0.279***	-0.194**	-0.383**	-0.020	0.093	0.219
	[0.101]	[0.098]	[0.148]	[0.147]	[0.083]	[0.133]
Mean	1.466	1.455	0.710	1.326	0.588	0.819
Observations	940	940	940	940	940	940
Panel B: Cultivated Area (10,000 hectares						
T_{min} $(+1^{\circ}C)$	-1.545**	-1.049	0.358	-1.103***	-0.577	0.220
	[0.695]	[0.864]	[0.289]	[0.333]	[0.700]	[0.402]
T_{max} $(+1^{\circ}C)$	-2.853***	-1.918**	-0.071	0.434	-2.369*	-1.170***
	[0.828]	[0.897]	[0.196]	[0.442]	[1.268]	[0.443]
Mean	10.765	7.058	0.373	1.741	4.479	4.239
Observations	940	940	940	940	940	940

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 13: Effects by Wet and Dry Towns

	Log Workers	Share of Workers		
	(Total) (1)	Non-Ag. (2)	Ag. Labor (3)	Seasonal (4)
Panel A: Wet towns ($> p25$ rain)				
Night Temperature (T_{min})	0.206***	-0.009	0.023***	-0.007
	[0.079]	[0.011]	[0.007]	[0.008]
Day Temperature (T_{max})	0.218*	-0.037***	0.009	0.014
	[0.111]	[0.014]	[0.009]	[0.012]
Panel B: Dry towns ($< p25$ rain)				
Night Temperature (T_{min})	0.107	0.002	0.014**	-0.016*
	[0.078]	[0.014]	[0.007]	[0.009]
Day Temperature (T_{max})	0.083	0.010	-0.013	0.015
	[0.097]	[0.014]	[0.011]	[0.012]
Mean	9.03	0.74	0.09	0.09
Observations	8920	8920	8920	8920

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 14: Effects by Municipal Status

	Log Workers	Share of Workers		
	(Total) (1)	Non-Ag. (2)	Ag. Labor (3)	Seasonal (4)
Panel A: Census Towns				
Night Temperature (T_{min})	0.061	0.008	0.023**	-0.007
	[0.039]	[0.013]	[0.009]	[0.011]
Day Temperature (T_{max})	0.030	-0.028*	0.004	0.019
	[0.045]	[0.015]	[0.011]	[0.015]
Panel B: Municipal Towns				
Night Temperature (T_{min})	0.246**	-0.023**	0.019***	-0.003
	[0.118]	[0.010]	[0.006]	[0.005]
Day Temperature (T_{max})	0.275*	-0.025***	0.006	0.013*
	[0.157]	[0.009]	[0.007]	[0.007]
Mean	8.46	0.70	0.10	0.10
Observations	5192	5192	5192	5192

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. $*p < 0.1$,** $p < 0.05$,*** $p < 0.001$.

7.1 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 engagement 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.