Climate Change and Urban Transformation: Long-term impacts on occupation and demography in Indian towns

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Abstract

This study investigates the long-term impacts of climate change on urban occupational and demographic structure in India. I construct a panel of 7,715 Indian towns between 1961-2011 and employ fixed-effects regression approach. I find that temperature increases significantly affect occupations with heterogeneous impacts by gender and across sectors. A 1°C rise in mean decadal temperature is associated with a 2.3 p.p. (percentage points) decrease in non-working population and 1.6 p.p. increase in total workforce. This increase is driven by reallocation of cultivation to non-agricultural work, and inward migration of agricultural labourers. The reallocation channel are more pronounced for male workers and during the Kharif (monsoon) season. These findings contribute to our understanding of climate-induced structural transformation in developing economies and have important implications for policy responses to climate change.

1 Overview and Contribution

Climate change brings significant challenges to developing economies, particularly for agriculture reliant populations. In India, where agricultural work is the dominant share of the workforce (54.6%) according to the 2011 Census, understanding the impact of temperature changes on occupational structure is crucial to effective policy making. I contribute to the literature by:

1. Constructing a novel panel of towns over six decades (1961-2011) from the Census of India tables.
2. Analyzing the long-term effects of temperature changes on occupational structure.
3. Examining nonlinearities and heterogeneous impacts by seasons, demography, and geography.
4. Providing evidence of climate-induced migration and urban structural transformation, which has implications for economic policy.

This research builds upon and extends prior work by Liu et al. (2021), Jessoe et al. (2018), Dell et al. (2012), and Somanathan et al. (2021) - studying historical patterns in urban occupational structure. The long run effects of climate shocks on structural transformation remain understudied with low availability of granular historical data in developing countries. The focus on urban development complements Liu et al. (2021), 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 main occupations. (Jessoe et. al, 2018) find that temperature shocks in rural Mexico led to a reduction in non-agricultural employment, operating through an agricultural channel. The authors estimate extreme climatic events may decrease employment by upto 1.4 p.p. and increase migration by the same magnitude. Dell et al. (2012) study the effects of temperature shocks in poor countries, and find a significant level and growth reduction on economic growth. I find evidence in support of rural-urban migration as a result of temperature increases, with an increase in the urban shares of agricultural labor and a decrease in land-holding cultivators. These findings highlight the interconnected nature of temperature shocks, urban development, and rural migration in India.

2 Data and Methodology

This study utilizes a panel dataset of 7,715 Indian towns, combined with gridded temperature and rainfall data from the Indian Meteorological Department (IMD). The analysis employs a fixed-effects regression approach, controlling for town, decade, and state-year effects, to examine the impact of temperature changes on occupational structure and demographics in urban India.

1. Census of India - Urban Primary Census Abstract [1961-2011]: Decadal town demography and employment statistics. The indicators are disaggregated by gender and caste groups (SC/ST)
2. IMD Gridded Climate Data [1951-2023]: Daily minimum and maximum temperatures, and mean rainfall at 1-degree grid level.

Table 1 demonstrates the demographic and occupational statistics per Census decade. The number of towns in the analysis data are reported at the bottom of the table. As the average town grow larger, total population and workforce grow at a greater pace, with the increase being primarily in non agricultural work. Statistics from the 2011 census on town area were not available in the Primary Census Abstract.

Table 1: Town level descriptive statistics

	(1) 1961	(2) 1971	(3) 1981	(4) 1991	(5) 2001	(6) 2011
Area in sq. km	13.85	13.90	13.28	14.33	16.78	.
Population density per sq. km	3,828.95	5,457.94	5,150.52	8,524.65	4,391.10	.
Total population	25,450.94	36,097.58	42,255.69	65,124.69	74,382.39	70,985.29
Total SC	2,364.02	3,013.11	4,398.17	7,833.49	8,526.04	8,737.91
Total ST	261.32	385.93	783.77	1,146.20	1,394.02	1,500.14
Total workers	8,636.54	10,309.49	12,597.65	19,244.56	23,829.44	25,105.16
Total cultivators	706.56	576.03	649.05	746.52	474.84	450.80
Total agricultural labour	405.24	680.86	772.53	1,020.27	613.73	767.67
Total household industry workers	799.40	517.70	620.13	518.09	938.67	893.85
Total other or service workers	6,725.34	8,534.89	10,555.94	16,959.68	19,778.05	20,142.80
Observations	2496	2907	3722	4409	4863	7599

2.1 Identification

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

$$Y_{it} = \beta_{it} Temperature_{it} + \beta_2 Rainfall_{it} + \alpha_i + \gamma_t + \delta_{st} + \epsilon_{it} \tag{1}$$

Where:

1. Y_{it} is the outcome variable (e.g., share of agricultural labor) for town i in decade t
2. Temperature$_{it}$ and Rainfall$_{it}$ are past-decadal averages of daily measurements, i.e. the mean temperature and rainfall on an *typical* day for 10 years preceding t.
3. α_i, γ_t, and $\delta_s t$ are town, decade, and state-year fixed effects, respectively.

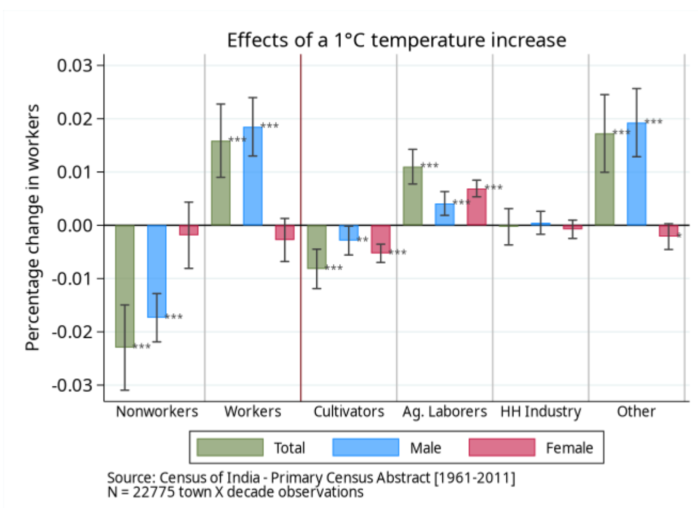
This approach controls for time-invariant town characteristics, common time trends, and state-specific time-varying factors. The identification relies on the assumption that, controlling for these innate town traits, any variation in climate is plausibly exogenous to employment shares.

3 Results

3.1 Occupation

3.1.1 Sectoral Shifts in Employment

Figure 1: Estimates on occupational structure by gender

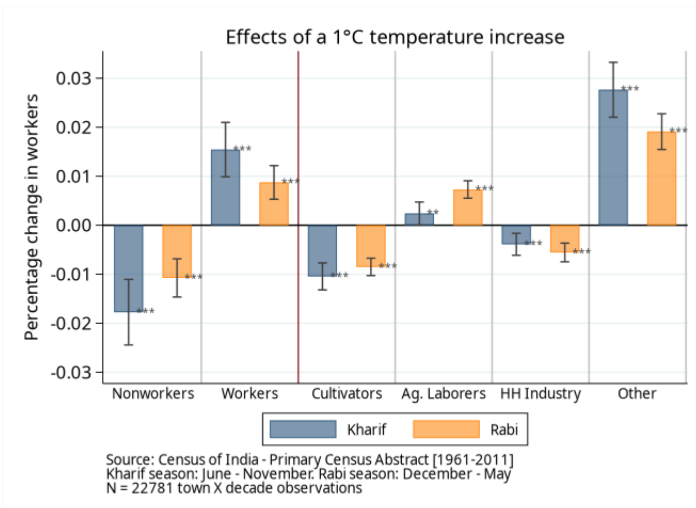


Coefficients on shares of overall, male, and female population. Bars show point estimates with 95% C.I.
Fixed effects included at the town, year, and state-year level.
Stars indicate significance levels: * p<0.1, ** p<0.05, *** p<0.01

Figure 1 plots the coefficients from panel regressions on shares of labor in each occupation category. All estimates account for fixed effects at the town, census decade, and state-decade level. A 1°C increase in daily temperatures is associated with a 1.6 percentage increase in the total worker participation rate, and a 2.3 percentage reduction in nonworking share of population. This effect is more pronounced for male workers (1.8 p.p.), while the magnitude slightly negative but not statistically significant for female workers.
There exist significant shifts in occupational structure. Land cultivators decrease by 0.8 percentage but agricultural laborers increase by 1.1 percentage. Simultaneously, other workers (services) increase by 1.7 percentage, with no effects on household industry. These estimates suggest a reallocation of existing cultivators towards non-agricultural work, with inward migration from rural areas taking up agricultural employment. Male workers show larger increases in non-agricultural (service) work, and the change in share of female agricultural labor is higher compared to male labor.

3.1.2 Seasonal Effects

Figure 2: Estimates on occupations by season



Coefficients on shares of overall, male, and female population. Bars show point estimates with 95% C.I.
Fixed effects included at the town, year, and state-year level.
Stars indicate significance levels: * p<0.1, ** p<0.05, *** p<0.01

Figure 2 plots the coefficients from panel regressions on shares of labor in each occupation category. The change in share of labor is compared for each category by agricultural season. The results demonstrate that a 1°C increase in daily temperatures lead to a substantial increase in other/service workers contributing to an overall in total workforce. Effects on total workers are more pronounced in the Kharif or monsoon harvest season (1.5 p.p.), which is sensitive in greater proportions to climatic shocks compared to the relatively dry Rabi/winter season (0.9 p.p.). During these sensitive months, town populations are likely to find work in service occupations, reflecting in a larger Kharif magnitude (2.8 p.p.) compared to Rabi (1.9 p.p.) in the same category. There is a significant reduction in cultivators and household industry workers, suggesting a reallocation of labor. The increase in agricultural labor is still significant, but muted in the monsoon Kharif months.

3.2 Demographics

Table 2: Estimates on town geography and demographics

	(1) Pop. density	(2) Log pop.	(3) Log SC pop.	(4) Log ST pop.	(5) Log literate pop.
Decadal mean temp. (C)	66.112	0.048	0.152***	0.661***	0.084*
	(2747.269)	(0.045)	(0.053)	(0.127)	(0.046)
Decadal mean rain (mm)	844.364	0.034**	0.030**	0.032	0.029**
	(644.935)	(0.014)	(0.013)	(0.030)	(0.013)
Mean	5640.852	9.846	7.641	5.235	9.284
N	16174	22776	22408	15486	22766

Standard errors in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

Table 2 above reports the point estimates for key demographic indicators. An increase of 1°C in daily temperatures is associated with significant increase of 15.2 % Scheduled Castes (SC) and 66.1% Scheduled Tribes (ST) residing in urban areas. While these estimates are high, the change in overall population growth is not statistically significant. This evidence supports the mechanism of inward migration, particularly from socially disadvantaged groups as they migrate to urban centers in search of employment to cope with heat.

4 Implications

These findings underscore the complex interplay between climate change and urban development in India. The results are robust to alternate specifications of fixed effects, subsample tests, and accounting for correlations in a spatial HAC regression. The shift in occupational structures, coupled with demographic changes, points to a climate-induced acceleration of urbanization processes. Policy makers should consider these dynamics when designing climate adaptation strategies and urban development plans to ensure inclusive and sustainable urban growth in the face of changing climatic conditions.

1. **Structural Transformation:** Temperature changes can drive significant shifts from agricultural self-employment (cultivation) towards non-agricultural work, indicating a potential urbanization effect.

2. **Seasonal Vulnerability:** The particularly stronger effects in the Kharif season suggest that temperature changes may be impacting critical agricultural periods, potentially accelerating rural-urban migration.

3. **Social Equity:** Increases in SC and ST populations in towns with higher temperatures may reflect climate-induced migration patterns, potentially exacerbating existing socio-economic vulnerabilities.

4. **Gender Disparities:** The heterogeneous impacts across genders, particularly in employment patterns, highlight the need for targeted policy interventions to address the differential impacts of climate change on urban labor markets and households.

5 References

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