Preliminary Draft: Please Do Not Quote or Cite

Does Polling Day Temperature affect Elections? *

Priyadarshi Amar† Shweta Bhogale Ting Liu

July 2024

Abstract

We examine how extreme temperatures affect voter turnout and electoral outcomes in state assembly elections across India. Our findings reveal that both, low and high temperatures on polling days, lead to a decrease in voter turnout. We show that low temperatures exacerbate the gender gap in turnout, while high temperatures affect male and female turnout equally. The decline in turnout due to higher temperatures is especially pronounced when the morning and evening temperatures are high. Moreover, extreme temperatures increase the winner's vote share, indicating reduced electoral competition. We plan to expand our analysis to investigate the effects on winner characteristics and policy performance as a consequence of decreased electoral competition.

1 Introduction

Severe weather events are becoming increasingly common, bearing long-standing effects on a variety of economic outcomes, and disproportionately affecting vulnerable populations (IPCC, 2022). The literature on the impacts of extreme heat has examined agricultural incomes (Blakeslee and Fishman, 2018; Burgess and Donaldson, 2010), human capital accumulation (Shah and Steinberg, 2017; Garg et al., 2020b; Srivastava et al., 2024), conflict and crime (Burke et al., 2015; Butler and Gates, 2012; Klomp and Bulte, 2013; Colmer and Doleac, 2023), time-use of men and women (Garg et al., 2020a), work-place safety (Park et al., 2021), and structural transformation (Liu et al., 2023; Mejia et al., 2018; Stiglitz, 2017). Research in the US has shown how temperature and rainfall can affect turnout and election outcomes (Gomez et al., 2007; Washington and Keefe, 2022; Van Assche et al., 2017). However, these studies examine whether aggregate political outcomes are affected but do not indicate who is more likely to be impacted.

*We are grateful to Laura Schechter and Teevrat Garg for their helpful comments on our early analysis. We would like to thank Franziska Roscher for sharing the turnout data by gender.

†Amar: University of Wisconsin Madison, pamar@wisc.edu; Bhogale: Jameel Poverty Action Lab and UCSD GPS, sbhogale@povertyactionlab.org; Liu: University of Wisconsin Madison.

This paper establishes the relationship between severe temperature and political outcomes in India by exploiting variation in polling day temperatures. Extreme temperatures may alter voter turnout systematically for vulnerable social groups which further influences election results. This is crucial for comprehending changes in democratic participation and decision-making processes in an increasingly climate-volatile world. Consistent with the literature, we find that temperature extremes, both cold and hot, reduce voter turnout. These effects persist for both men and women. Interestingly, we find that increasing temperatures may decrease the gender gap in turnout.

Next, we explore whether temperature at different times of the day has varying impacts on voters. We find that morning and evening temperatures are more likely to affect turnout with increasing temperatures. Additionally, higher temperatures in the morning and evening also widen the gender gap in turnout. On the other hand, increased afternoon temperatures increase turnout and reduce the gender gap in turnout. This is surprising, as the afternoon is typically the hottest time of the day. We propose that these effects might be explained by differences in the types of voters who choose to vote at various times of the day and who react differently to heat. Currently, we are unable to parse the mechanisms for these effects.

Along with turnout, we find that temperature extremes, both cold and hot, increase the winner's vote share, suggesting that a decrease in turnout may reduce political competition.

2 Empirics

2.1 Data

We combine state election data and polling day temperature data for state elections between 1977 and 2020.

2.1.1 Election and Polling data

The Election Statistics are compiled and made available by the Election Commission of India, a statutory body responsible for conducting state elections. This dataset includes candidate-wise election results, turnout, electors by gender, and polling dates for each constituency. We use election results data from the Socioeconomic High-resolution Rural-Urban Geographic Platform for India (SHRUG) platform, polling date data from Factly, and turnout data from Roscher (2023). Overall, there are 4,123 constituencies, with the number of constituencies ranging from 30 to 403. Our current sample includes approximately 3,000 constituencies across 25 states of India. Due to discrepancies in polling dates, we restrict our sample to elections where the election month in SHRUG and Factly match. We plan to verify the polling dates and expand the sample to include all assembly elections. Using the election statistics, we construct the following measures for our analysis: (1) turnout (overall, male, female), (2) gender gap in turnout, and (3) winner's vote share.

2.1.2 Temperature Data

Our weather data come from the fifth generation ECMWF (European Centre for Medium-Range Weather Forecasts) atmospheric reanalysis of the global climate, short as ERA5, covering the period from January 1940 to present(Buontempo et al., 2022). ERA5 provides consistent time series of multiple climate variables. Each time series is a spatial grid sequence with a resolution of 0.25° (approximately 31 kilometers at the equator) and hourly time intervals. The following ERA5 climate variables are used for our dataset: 2m temperature, and total precipitation.[1]

To generate temperature measures for every election of an assembly constituency, we map the gridded temperature data onto the assembly constituency polygons. Then, we calculate the average temperature in each constituency weighted by the share of overlap between each grid pixel and the constituency.

2.2 Methodology

We use variation in temperature over space and time during the different election days in our sample to estimate how extreme weather affects voter turnout. Our main empirical specification of interest is:

$$y_{cyt} = \alpha + \Sigma_k^K \beta^k \mathbb{I}[temp_{cyt} \in k] + \delta_y + \theta_c + X'_{cyt}\gamma + \epsilon_{cyt} \quad (1)$$

where, y_{cyt} measures outcomes in constituency c year y and date t. $\mathbb{I}[temp_{cyt} \in k]$ is a dummy variable for the average daily temperature for c on election day t in year y to belong in bin k. Our temperature bins are defined as temperature $<$ 21°C, 3°C bins between 21°C and 36°C, and temperature $>$ 36°C. The minimum and maximum temperatures in the sample are 11°C and 42°C. The excluded bin category is 27-30°C since this is the modal temperature bin. Therefore, all coefficients can be interpreted as relative to this bin. δ_y is year fixed effects, θ_c accounts for time-invariant constituency fixed effects, and X'_{cyt} controls for time-variant constituency-specific characteristics (number of registered voters, number of registered male voters) including a dummy variable for the summer season elections. We cluster standard errors at the constituency level. The identification of each β^k relies on the assumption that the polling day is quasi-random. Consequently, the average temperature on polling day within a specific temperature bin is considered exogenous to turnout on that day, after accounting for year and constituency-level characteristics. In most constituencies, consecutive elections takes place in different months, providing variation in polling day temperatures for a constituency over time (See Figure A.1).

Additionally, we also look at a specification incorporating a continuous temperature measure:

$$y_{cyt} = \alpha + \beta_1 temp_{cyt} + \beta_2 temp^2_{cyt} + \delta_y + \theta_c + X'_{cyt}\gamma + \epsilon_{cyt} \quad (2)$$

[1] We do not use the rainfall data as very few polling dates with any rain.

where, $temp_{cyt}$ is the average temperature between polling hours (7.30 am to 5.30 pm) on the election date. We use other measures like average temperature in the morning, afternoon, and evening as well.

3 Results

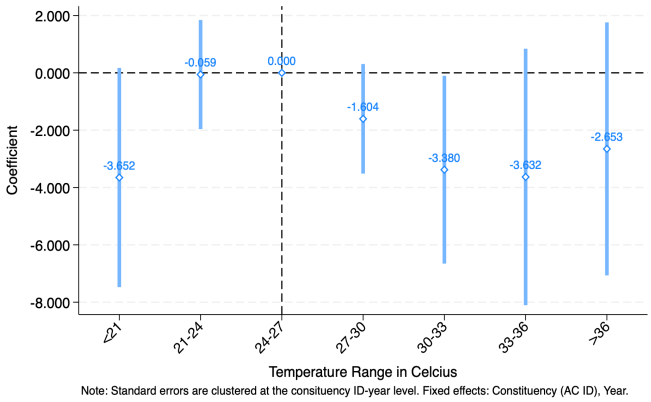
In this section, we first examine the relationship between temperature and turnout, then investigate whether temperature also affects election outcomes, and conclude with falsification tests.

3.1 Turnout

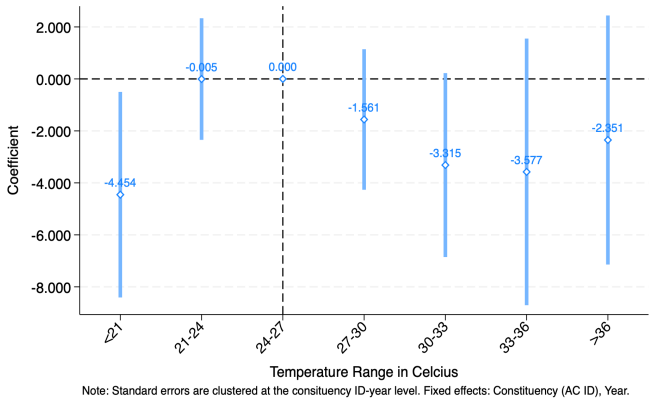
Our main findings are summarized in Figure 1 below, which illustrates the effects of temperature bins on turnout (total, female, male) and the gender gap in turnout. Turnout is defined as the total number of votes cast as a percentage of total eligible voters (ranging from 1 to 100). Female turnout is measured as the percentage of female votes cast out of the total eligible female voters, and similarly for male turnout. The gender gap in turnout is the difference in the percentage of male and female voters.

We find that relative to the reference bin (24-27°C), turnout decreases across all measures in both low and high temperature bins, while the gender gap in turnout decreases only in the low temperature bins.

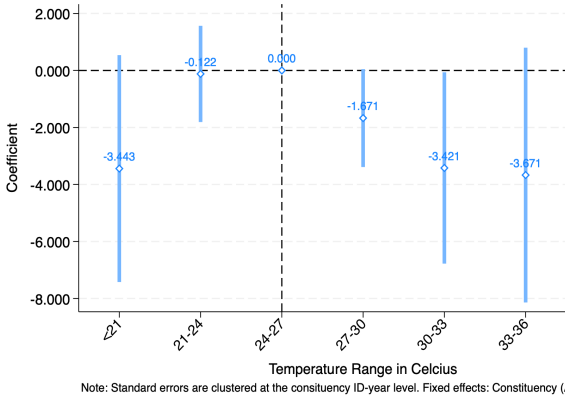
Figure 1: Temperature and Turnout (1/2)



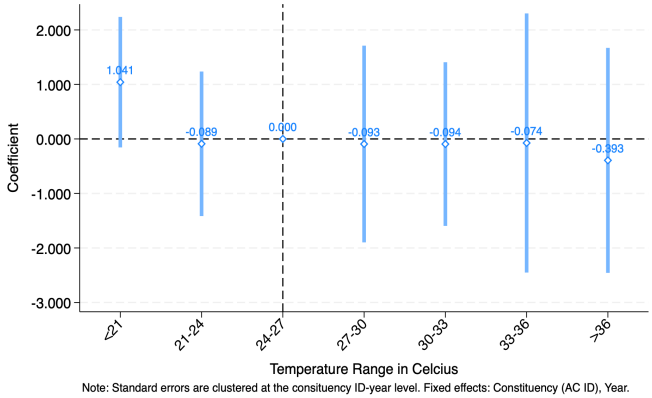
(a) Total Turnout



(b) Female Turnout



(c) Male Turnout



(d) Gender Gap in Turnout

This relationship between temperature and turnout is also reflected in the predicted marginal effects using equation (2) in Figure 2. Consistent with the results based on the non-parametric specification, these findings demonstrate a non-linear effect of temperature on turnout measures. Interestingly, the relationship between temperature and the gender gap in turnout shows a decreasing trend. In other words, increasing temperatures may reduce the gender gap in turnout.

Figure 2: Temperature and Turnout (2/2)

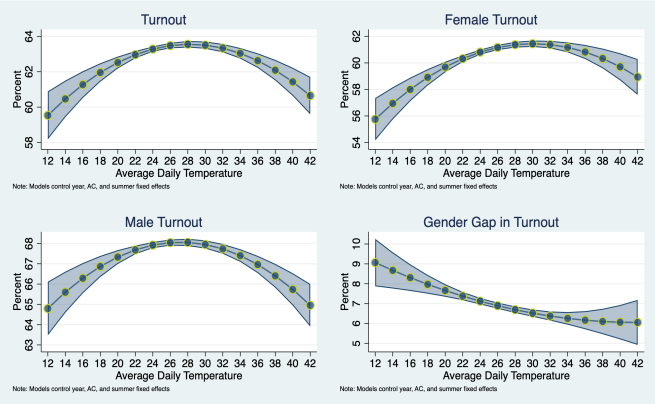


Figure 3: Total Turnout

Next, we examine the relationship between average two-hour time slot temperatures and turnout in Table 1. We find that the decline in turnout is mainly driven by morning and evening temperatures. The results also suggest that high morning and evening temperatures disproportionately affect female voters, as the gender gap in turnout increases. Conversely, high afternoon temperatures have the opposite effect. This finding underscores that high temperatures may disproportionately decrease the participation of female voters who vote in the morning or evening. Surprisingly, it also highlights an increase in the participation of those who vote in the afternoon, despite that being the hottest time of the day.

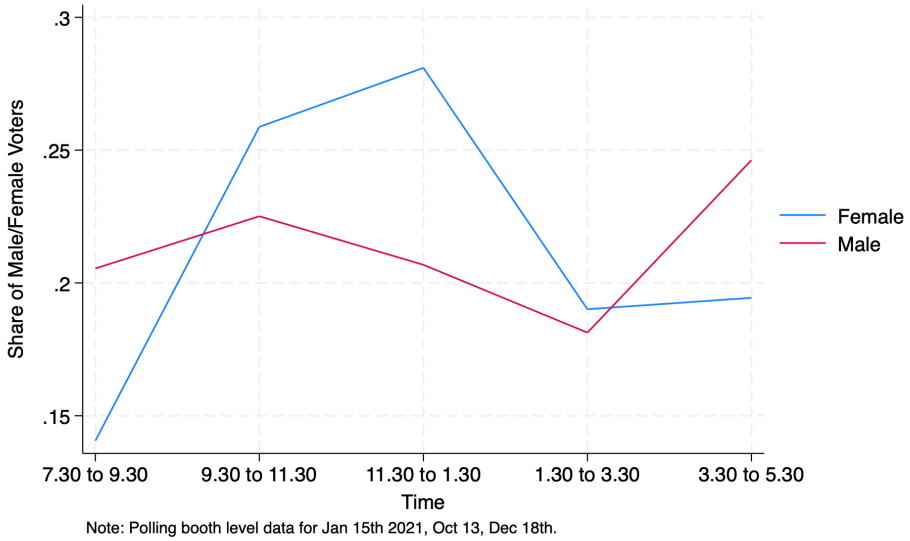
Table 1: Effects of Average Two-hourly temperature

	Turnout			Gender
	Total	Male	Female	Gap
	(1)	(2)	(3)	(4)
Avg.7:30 to 9:30 Temp	-0.21***	-0.12**	-0.28***	0.16***
	(0.06)	(0.06)	(0.07)	(0.06)
Avg. 9:30 to 11:30 Temp	-0.40***	-0.48***	-0.30**	-0.18
	(0.11)	(0.11)	(0.14)	(0.12)
Avg. 11:30 to 1:30 Temp	1.08***	0.81***	1.52***	-0.71***
	(0.14)	(0.15)	(0.18)	(0.15)
Avg. 1:30 to 3:30 Temp	-0.35***	-0.05	-0.72***	0.66***
	(0.13)	(0.14)	(0.16)	(0.13)
Avg. 3:30 to 5:30 Temp	-0.10	-0.18**	-0.14	-0.03
	(0.08)	(0.08)	(0.10)	(0.08)
Control Mean	63.04	67.62	60.72	6.91
Year FE	✓	✓	✓	✓
AC FE	✓	✓	✓	✓
Obs	12687	12670	12679	12661

Note: Controls include total number of registered voters and number of male voters. Standard errors are clustered at the AC, Year level. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

To unpack contrasting results, we explore when female and male voters vote using polling data of two-hour time slots in village-level elections from Maharashtra. Here, we find that women are more likely to vote in the afternoon, while men are more likely to vote in the morning and evening (Figure 4).

Figure 4: Turnout by Gender and Time of Day



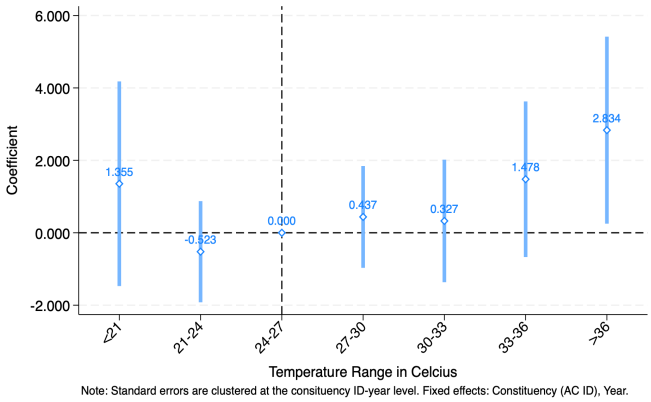
If this voting behavior extends to state elections, the decrease in the gender gap in turnout with increasing temperature, as shown in Figure 2, could be explained by two factors: firstly, most women vote in the afternoon; and secondly, the positive relationship between afternoon temperatures and turnout, especially among women voters (see Table 1). However, the causes for why increasing afternoon temperatures are associated with greater turnout remain unknown and we intend to explore regional and seasonal heterogeneities as drivers of this result.

3.2 Election Outcomes

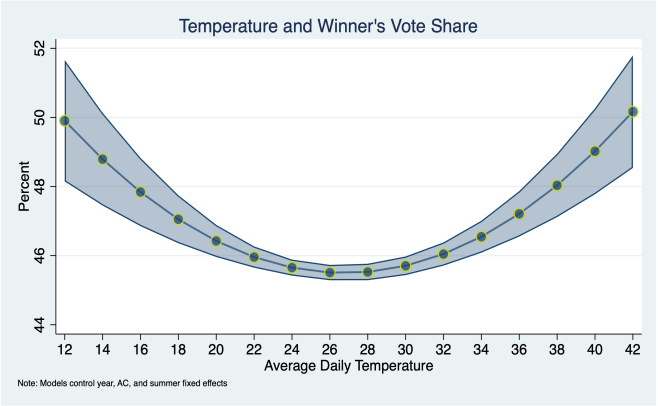
Next, we examine the relationship between temperature and election outcomes. To do so, we use the winner's voter share as a measure of electoral competition. We find that extreme temperatures increase winner's voter share in Figure 5.

Additionally, the results in Table 2 indicate that the contrasting effects on turnout and the winner's vote share continue to hold when examining the effect of average temperature in two-hour time slots.

Figure 5: Temperature and Winner's Vote Share



(a) Non-parametric



(b) Parametric

Table 2: Effects of Average Two-hourly temperature

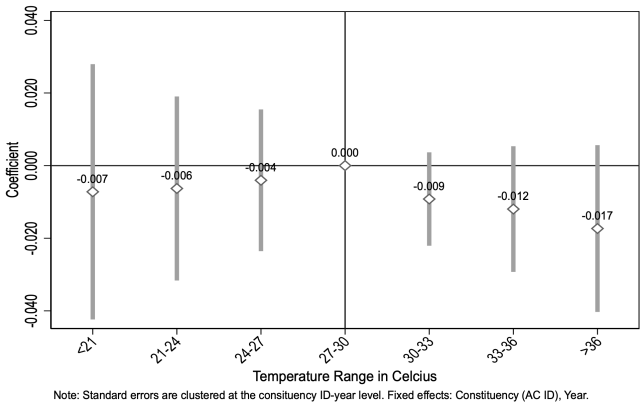
	Turnout			Gender	Winner's
	Total	Male	Female	Gap	Vote Share
	(1)	(2)	(3)	(4)	(5)
7:30 to 9:30 Avg. Temp	-0.21***	-0.12**	-0.28***	0.16***	0.20**
	(0.06)	(0.06)	(0.07)	(0.06)	(0.09)
9:30 to 11:30 Avg. Temp	-0.40***	-0.48***	-0.30**	-0.18	0.55***
	(0.11)	(0.11)	(0.14)	(0.12)	(0.17)
11:30 to 1:30 Avg. Temp	1.08***	0.81***	1.52***	-0.71***	-0.88***
	(0.14)	(0.15)	(0.18)	(0.15)	(0.20)
1:30 to 3:30 Avg. Temp	-0.35***	-0.05	-0.72***	0.66***	-0.09
	(0.13)	(0.14)	(0.16)	(0.13)	(0.18)
3:30 to 5:30 Avg. Temp	-0.10	-0.18**	-0.14	-0.03	0.26**
	(0.08)	(0.08)	(0.10)	(0.08)	(0.12)
Control Mean	63.04	67.62	60.72	6.91	46.13
Year FE	✓	✓	✓	✓	✓
AC FE	✓	✓	✓	✓	✓
Obs	12687	12670	12679	12661	12687

Note: Controls include total number of registered voters and number of male voters. Standard errors are clustered at the AC, Year level. * p<0.1, ** p<0.05, *** p<0.01.

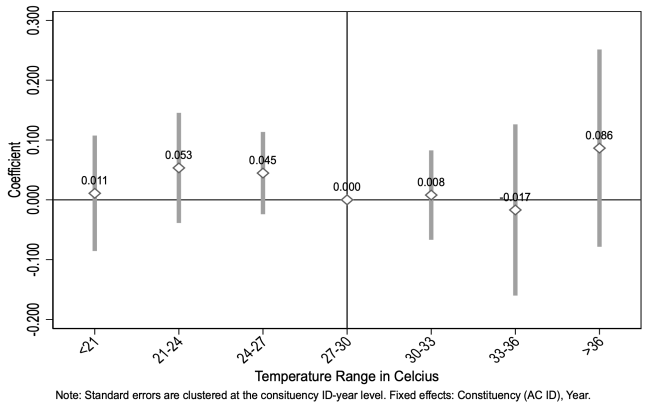
3.3 Falsification Tests

To strengthen our findings, we do falsification tests to show that these effects are driven by the effect of temperatures on the day of polling on turnout, and not any other polling political outcomes. To do so, we examine the effect on temperatures on outcomes that were determined before the polling day and should not be affected by polling day temperatures like the number of voters and number of candidates in Figure 6. We do not find evidence of a systematic relationship between these and temperature.

Figure 6: Falsification Tests



(a) Log Registered Voters by Temperature Bins



(b) Log Number of Candidates by Temperature Bins

4 Conclusion and Next Steps

In this paper, we present evidence that extreme temperatures on polling days significantly impact voter turnout and electoral competition. Additionally, this article highlights that the relationship between temperature and turnout is not straightforward. Common measures like average daily temperature may not provide a complete understanding because high temperatures at different times of the day can have varying effects on turnout. This variability may result in the exit of specific types of voters, particularly those who vote at specific times of the day.

Next, we plan to enrich our analysis by understanding the characteristics of citizens who vote in the morning, afternoon, and evening. Additionally, we aim to investigate other implications, such as whether extreme temperatures affect the characteristics of winners, and if so, how this influences the provision of public goods.

References

Assche, Jasper Van, Alain Van Hiel, Jonas Stadeus, Brad J Bushman, David De Cremer,

and Arne Roets, "When the heat is on: The effect of temperature on voter behavior in presidential elections," *Frontiers in psychology*, 2017, *8*, 929.

Blakeslee, David S and Ram Fishman, "Weather shocks, agriculture, and crime: Evidence from India," *Journal of Human Resources*, 2018, *53* (3), 750–782.

Buontempo, Carlo, Samantha N Burgess, Dick Dee, Bernard Pinty, Jean-Noël Thépaut, Michel Rixen, Samuel Almond, David Armstrong, Anca Brookshaw, Angel Lopez Alos et al., "The Copernicus climate change service: climate science in action," *Bulletin of the American Meteorological Society*, 2022, *103* (12), E2669–E2687.

Burgess, Robin and Dave Donaldson, "Can openness mitigate the effects of weather shocks? Evidence from India's famine era," *American Economic Review*, 2010, *100* (2), 449–453.

Burke, Marshall, Solomon M Hsiang, and Edward Miguel, "Climate and conflict," *Annu. Rev. Econ.*, 2015, *7* (1), 577–617.

Butler, Christopher K and Scott Gates, "African range wars: Climate, conflict, and property rights," *Journal of Peace Research*, 2012, *49* (1), 23–34.

Colmer, Jonathan and Jennifer L. Doleac, "Access to Guns in the Heat of the Moment: More Restrictive Gun Laws Mitigate the Effect of Temperature on Violence," 2023.

Garg, Teevrat, Matthew Gibson, and Fanglin Sun, "Extreme temperatures and time use in China," *Journal of Economic Behavior & Organization*, 2020, *180*, 309–324.

_ **, Maulik Jagnani, and Vis Taraz**, "Temperature and Human Capital in India," *Journal of the Association of Environmental and Resource Economists*, November 2020, *7* (6), 1113–1150. Publisher: The University of Chicago Press.

Gomez, Brad T, Thomas G Hansford, and George A Krause, "The Republicans should pray for rain: Weather, turnout, and voting in US presidential elections," *The Journal of Politics*, 2007, *69* (3), 649–663.

IPCC, "IPCC Sixth Assessment Report Impacts, Adaptation and Vulnerability," `https://www.ipcc.ch/report/ar6/wg2/` 2022.
Accessed: 2023-08-03.

Klomp, Jeroen and Erwin Bulte, "Climate change, weather shocks, and violent conflict: A critical look at the evidence," *Agricultural Economics*, 2013, *44* (s1), 63–78.

Liu, Maggie, Yogita Shamdasani, and Vis Taraz, "Climate change and labor reallocation: Evidence from six decades of the Indian Census," *American Economic Journal: Economic Policy*, 2023, *15* (2), 395–423.

Mejia, Mr Sebastian Acevedo, Mr Mico Mrkaic, Natalija Novta, Evgenia Pugacheva, and Petia Topalova, *The Effects of Weather Shocks on Economic Activity: What are the Channels of Impact?*, International Monetary Fund, 2018.

Park, Jisung, Nora M. C. Pankratz, and A. Behrer, "Temperature, Workplace Safety, and Labor Market Inequality," July 2021.

Roscher, Franziska, "Why Women Vote: When and How Clientelism Closes the Gender Turnout Gap," *Dissertation*, 2023.

Shah, Manisha and Bryce Millett Steinberg, "Drought of opportunities: Contemporaneous and long-term impacts of rainfall shocks on human capital," *Journal of Political Economy*, 2017, *125* (2), 527–561.

Srivastava, Bhavya, Kibrom Tafere Hirfrfot, and Arnold Patrick Behrer, "High Temperature and Learning Outcomes : Evidence from Ethiopia," *Policy Research Working Paper Series*, March 2024.
Number: 10714 Publisher: The World Bank.

Stiglitz, Joseph E, "Structural transformation, deep downturns, and government policy," Technical Report, National Bureau of Economic Research 2017.

Washington, Eve and John Keefe, "Will Rain Affect Turnout Tomorrow? The Answer Is Cloudy," `https://www.nytimes.com/interactive/2022/11/07/us/elections/election-weather.html` 2022.
Accessed: 2023-08-03.

A Appendix

Figure A.1: No. of unique months by constituency