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ABSTRACT

Climate Change and Political Participation: Evidence from India

We study the effects of extreme temperature shocks on political participation using data from Indian elections between 2009 and 2017. Taking advantage of localized, high-frequency data on land surface temperatures, we find that areas with greater cumulative exposure to extreme temperatures experience an increase in voter turnout and a change in the composition of the pool of candidates who stand for election. As a consequence, electoral outcomes are affected. We provide evidence that our results are driven by the negative effect of climate change on agricultural productivity. First, we show that the results are strongest in areas with a larger rural population. Second, we show that there is a non-monotonic relationship between temperatures and turnout which closely mirrors the relationship between temperatures and agricultural productivity. We also find that, following temperature shocks, winning candidates are more likely to have an agricultural background. Finally, we show that politicians with an agricultural background invest more in irrigation, which mitigates the effects of high temperatures, on both agricultural production and on turnout. Our paper provides new evidence about the ways in which political agents in developing countries (including both voters and candidates) may respond to climate change via political channels.

JEL Classification: O13, P48, Q54

Keywords: climate change, political economy, voter turnout

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1 Introduction

The earth's climate is warming, bringing with it an increase in the frequency and severity of extreme weather events, such as droughts, floods and periods of extreme heat. These shocks have been shown to reduce productivity (Somanathan et al. (2021)) - especially in the agricultural sector (Burke et al., 2015) - and increase mortality - especially in rural areas (Burgess et al., 2017). Rural inhabitants are particularly vulnerable due to their reliance on agriculture for employment and income, and their relative lack of access to institutions and markets which might help mitigate risk and smooth consumption, such as financial and insurance markets (Langsdorf et al., 2022).

Nevertheless, even poor inhabitants of rural areas have ways of responding to climate change-induced shocks to agricultural productivity. For example, farmers have been shown to adjust their input use and crop choices, and to smooth consumption by disposing of assets (Aragón et al. (2021); Garg et al. (2018); Liu et al. (2021)). Such shocks have also been shown to stimulate migration (Jessoe et al., 2018) and reallocate labor towards non-farm employment (Colmer, 2020). Governments can also be instrumental in the response and adaptation to severe economic shocks such as droughts and floods, for example, by providing relief or investments in irrigation which mitigate the impact of certain shocks (Liu et al. (2021), Cole et al. (2012), Wang et al. (n.d.)).

In this paper we investigate whether electoral democracy may provide a means for responding to climate change. We focus on the case of India, the largest democracy in the world and a country with very high levels of political participation (Kasara and Suryanarayan, 2015, Pande, 2003). Our measure of climate shocks is based on the degree of exposure to high temperature events, which are particularly bad for agricultural outcomes. Our approach follows the climate change literature and allows for estimating non-linear effects of temperature on agricultural productivity (Burke et al., 2015, Hsiang et al., 2016, Schlenker and Roberts, 2006a, 2009), which in turn allows us to test for non-linear behavioral responses to extreme temperatures (Aragón et al., 2021, Carleton and Hsiang, 2016, Jessoe et al., 2018, Taraz, 2018).

We study three types of outcomes: i) the behaviour of voters (in particular, voter turnout), ii) the behaviour of (potential) political candidates (e.g. decisions to run and changes in the composition of the pool of political candidates), and iii) electoral outcomes (e.g. election results, including which types of candidates are more likely to win in response to such climatic shocks). A better understanding of these questions should shed light on the political implications of climate change in developing countries, and thus, the extent to which democratic politics may provide a means for responding to climate change constructively.

Our analysis takes place at a fine level of aggregation: the State Legislative Assembly (SLA) Constituency level in India[1], for which we construct measures of exposure to extreme temperatures over time. More specifically, we take advantage of localized, high-frequency (i.e. daily) data on land surface temperatures to measure "harmful degree days" (HDDs) in the previous year or agricultural season, i.e. the cumulative exposure to extreme temperatures. We regress various political outcomes (e.g. voter turnout) against our measures of HDDs, along with a variety of controls (including location and time fixed effects). We begin by confirming a sharp, non-monotonic effect of HDDs on agricultural productivity - which has been found in the literature previously. Then we turn to our analysis of political outcomes, showing that the effect of HDDs on voter turnout exactly mirrors the effect of HDDs on agricultural productivity, with harmful weather over the previous year/growing season driving voters to the polls in an identically non-monotonic fashion. We also show that HDDs affect the composition of the candidate pool by, for example, inducing marginal candidates to drop out. Finally, we document an effect on political outcomes, with, among other things, incumbents being penalized and election winners being more likely to come from agricultural backgrounds - in constituencies that experience an increase in HDDs over their average values. 90% of the elections in our sample take place in electoral constituencies where the share of rural population is larger than 50%, which means that elections are effectively decided in rural areas, by voters who suffer the effects of high temperatures in their economic activities.

Our results are consistent with a very simple conceptual framework wherein high temperatures reduce incomes, which - in a context of diminishing marginal utility of consumption and political candidates providing pecuniary benefits to citizens if elected - induces more citizens to vote. At the same time, given that contesting for elections in India involves a potential pecuniary cost - namely, candidates must stake a deposit[2] which is not returned unless they obtain at least one sixth of the vote -, the decrease in incomes due to high temperatures is expected to reduce the incentives of marginal candidates to run for election.

Turning to mechanisms, we provide evidence that the effects we observe are due to the fact that high temperatures negatively affect agricultural productivity. First, we show that the effect of HDDs on turnout is larger in areas that are more dependent on agriculture, whether measured by the share of rural population or the share of non-farm employment. Second, we

[1] India currently has about 4,000 SLA constituencies.

[2] Deposits are 10,000 Rs., approximately 125 USD.

conduct a mediation analysis to decompose the total effect of high temperatures on political outcomes into a direct effect and an indirect effect through agricultural productivity. In every case, the percentage of the total effect of HDDs on turnout that can be attributed to the effect of HDDs on agricultural productivity is in excess of 70%.

Finally, we investigate whether our findings might be influenced by the fact that politicians can help mitigate the effects of temperature shocks on agriculture. One way in which they can do this is by investing in irrigation, which has been shown to moderate the effects of high temperatures (Tack et al. (2017) and Zaveri and B. Lobell (2019)). Thus, we would expect irrigation to alter the relationship between very high temperatures and both turnout and agricultural productivity. We compute the percentage of area that is irrigated at the assembly constituency level using data from Ambika et al. (2016), and find that, as expected, irrigation does mitigate the effects of HDDs on agricultural productivity and turnout. We then take advantage of the fact that some agricultural candidates win in close elections against candidates with other backgrounds to show - with a regression discontinuity design - that agricultural candidates are more likely to invest in irrigation if elected.

With this paper we contribute to the growing literature analyzing the effects of climate change on various outcomes in developing countries (Guiteras (2009), Burgess et al. (2017), Aragón et al. (2021), Colmer (2020), Garg et al. (2018), and Somanathan et al. (2021)). Another strand of literature has studied the effects of climate change related shocks on the behaviour of politicians regarding environmental policies, but has been limited to developed countries (Gagliarducci et al. (2019), Sambrook et al. (2021), Herrnstadt and Muehlegger (2014), Peterson (2021)). As far as we are aware, our paper provides the first estimates of the political response to climate change related shocks in a developing country. This is significant because developing countries - such as India - are more reliant on agriculture and hence more exposed to temperature shocks.

There is a separate literature which has explored the effects of other economic shocks on voter turnout in elections. These studies - which mainly focus on developed countries and use unemployment to measure shocks - find that the effect is context dependent (Burden and Wichowsky, 2014, Guiso et al., n.d.)). One exception is Cole et al. (2012), which shows that in India voters punish incumbent politicians for negative economic shocks due to rainfall (Cole et al. (2012)), but do so less if the government responds vigorously to the crisis.

The rest of the paper proceeds as follows. Section 2 discusses the background and conceptual framework. Section 3 discusses the data and methodology. Section 4 presents the results, while Section 5 discusses the mechanisms. Section 6 concludes.

2 Background

2.1 Indian Elections

With a parliamentary style of administration at both the federal and state levels, India is the world's largest democracy. In single-member seats, elections are held every five years using a first-past-the-post method. Each candidate for the state elections is elected in an electoral constituency, with borders drawn by the Election Commission of India in order to ensure that all constituencies have very similar population numbers. We use data from 2008, when the last delimitation order was implemented, in order to be able to follow the same electoral constituency over time. The states in India hold elections every five years, but at different points in time, and in different months. There are many political parties in India, but there is no specific political party representing the needs of those working in agriculture.

State governments are in charge of various development policy areas in India's federal system, including law and order, health and education, agricultural development, and village council financing. Party leaders choose their candidates in each constituency under India's political system. There are no primaries, like there are in the United States. The candidate selection process is not transparent, but parties tend to value the probability of winning, considering characteristics such as recognition within the constituency, service to the party, financial resources, caste identity and internal party support.

2.2 Conceptual Framework

In this section of the paper, we provide a brief sketch of the conceptual framework which undergirds our empirical analysis.[3] Our framework aims to aid in understanding how a climate shock such as an increase in harmful degree days (HDDs) might affect 1) a citizen's decision regarding whether or not to turn out to vote, and 2) a politician's decision regarding whether or not to run for office. We consider each aspect of the problem separately and in partial equilibrium. In both cases, the mechanism we focus on is driven by diminishing marginal utility of consumption: a reduction in income (as a result of more HDDs) will increase the marginal benefit of pecuniary payoffs, leading to greater turnout among voters and fewer candidates running for office (under the assumptions sketched out below).

First let us consider the decision of citizens regarding whether or not to participate in the political process through voting. We assume that voting is costly (and that the cost is

[3] Further details of the framework, in the form of two very simple models, are provided in Appendix C.

non-pecuniary), but that it can entail certain (perceived) economic (i.e. pecuniary) benefits.[4] We imagine that there might be a perceived benefit of voting if a) voters believe that their vote has some positive probability of being influential, and b) their preferred candidate will implement financially beneficial policies (e.g. an investment in irrigation that will improve agricultural outcomes).

In other words, we imagine that the (perceived) marginal benefit of voting is fundamentally pecuniary, while the marginal cost of voting is non-pecuniary. Assuming voters' preferences are characterized by diminishing marginal utility of consumption/expenditure, the marginal (net) benefit of voting will be declining in income, since the (pecuniary) marginal benefit is declining while the marginal cost is constant in income (as the cost is non-pecuniary). Thus, if an increase in HDDs has the effect of reducing incomes for a given voter (due to a loss in agricultural output or a reduction in agricultural productivity), the marginal benefit of voting (and thus the likelihood of casting a vote) for such a voter would go up. Also implied is that an increase in HDDs may increase the vote share for candidates who are perceived as being able to improve financial outcomes for those adversely affected (potentially, this could include candidates with agricultural backgrounds).

Next, we consider the decision of a politician regarding whether or not to run for office. We imagine that gaining office may entail certain benefits (potentially pecuniary and non-pecuniary in nature), and that running carries an explicit pecuniary cost. In particular, political candidates in our empirical context must provide a 10,000 Rs. deposit, which is forfeited if they lose with less than one sixth of the vote.

Again assuming standard curvature of the pecuniary component of a politician's utility function, a reduction in income will increase the marginal benefit from pecuniary payoffs and increase the marginal cost of a pecuniary loss (such as the expected cost of losing one's deposit). This means that, for marginal candidates (who are more likely to lose their deposit), the net marginal cost of running increases when facing a shock - such as an increase in HDDs - that reduces their incomes (which may occur if their incomes are based on agriculture or are otherwise tied to the conditions of the local economy). If the effect is large enough, it may lead to a reduction in the number of marginal candidates running for office. On the other hand, an increase in HDDs may increase the net marginal benefit of running for candidates who are more likely to win, if the expected pecuniary benefit of winning is high enough.[5]

[4] The cost of voting includes not only the cost of physically going to vote, but also the intellectual effort involved in learning about who is running and about how the candidates' platforms differ from one another.

[5] However, in this case the effect is unlikely to increase the number of such candidates running (since they are not likely to be marginal).

Thus, the main takeaways from the frameworks sketched above are the following: an increase in HDDs which reduces incomes may be expected 1) to increase voter turnout by increasing the marginal benefit of voting (i.e. the expected pecuniary payoff is more valuable), and 2) to decrease entry of marginal political candidates by increasing the marginal cost of losing one's deposit.

3 Data and Methodology

3.1 Data

In order to conduct this study we combine data on political outcomes in Indian State Legislative Assemblies at the constituency level between 2008 and 2017, with satellite imagery data (containing information on agricultural and weather-related variables) and information on socioeconomic and population characteristics at the constituency level. The data on the State Legislative Assemblies of India at the electoral constituency level come from Lok Dhaba (Ananay Agarwal et al. (2021)). These data provide information on electoral outcomes and turnout, but also include some candidate characteristics such as political party, incumbency and gender. We combine these data with affidavit information from SHRUG (Asher et al. (2020) and Prakash et al. (2019)) and ADR (Association for Democratic Reforms). The latter provides information on other candidate characteristics such as criminal convictions, education, age and occupation.

We combine the political data with high resolution satellite imagery data. The advantage of these data, compared to monitoring station data is the wider geographical availability, which allows us to exploit variation at a very micro level. First, the main variable we are interested in is Land Surface Temperature (LST), obtained from the MODIS tool aboard the Terra satellite.[6] The readings are processed to obtain daily measures of daytime temperature on a grid of 0.05 x 0.05 degrees, which is around 5.6 km squared (at the Equator). These are available from 2008 to 2017. Second, we use data on agricultural yields (Annual Net Primary Production, NPP), also from the MODIS tool. This is provided at 30 arcseconds (approximately 1 km) and we use information on this outcome from 2008 to 2015.

We also use local monthly precipitation data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) (Funk et al. (2015)), which provides data on a grid of 0.05 x 0.05 degrees (5.6km squared approximately). These data are available between

[6]Moderate Resolution Imaging Spectroradiometer on NASA's Terra satellite.

2008 and 2017. Some descriptive statistics are provided in Table 1.

3.2 Non-linear effects of temperature

There is a large literature in economics that documents non-linear effects of temperatures on a variety of economic and social outcomes. Economic growth, labor supply, factor and total productivity, agricultural output, migration, and mortality have all shown to have steeper responses in the presence of high temperatures (See Burke et al. (2015), Carleton and Hsiang (2016) for a review).

In the case of rural India, several papers document non-linear effects of hot temperatures on agricultural productivity (Burgess et al., 2017, Costa et al., 2020, Taraz, 2017). To explore how this shock to rural incomes affects electoral outcomes we use daily Land Surface Temperature (LST) from MODIS in order to construct two measures of *cumulative exposure to heat*, as in Aragón et al. (2021), Deschênes and Greenstone (n.d.), Schlenker and Roberts (2006a,b). The first measure captures the harmful effect of extreme temperatures by aggregating the cumulative exposure to daily temperatures above a threshold ($> \tau$) over a certain period of time (Harmful Degree Days, HDD). The second measure captures the cumulative exposure to "good" temperatures (> 8°C and $\leq \tau$) over some period (regular degree days, DD).

These two measures require very high frequency (i.e. daily) data, and are defined by equations (1) and (2), where h_x is the average daytime temperature on day x , and n is the total number of days over some period (for example, a growing season, or the year before an election).

$$HDD = \frac{1}{n}\sum_{x=1}^{n}(h_x - \tau)1(h_x > \tau) \tag{1}$$

$$DD = \frac{1}{n}\sum_{x=1}^{n}(min(h_x, \tau) - 8)1(h_x > 8) \tag{2}$$

In order to analyze the effect of very high temperatures on agricultural productivity, turnout, political participation and electoral outcomes, we first estimate these relationships non-parametrically, in order to determine the value of τ. For this we compute the proportion of days that the average daily temperature in an electoral constituency falls in a particular temperature bin, b. For example, bin_b in equation (1) captures the proportion of days that

Table 1: Descriptive Statistics

	Mean/SD
Degree Days	19.37
	(3.80)
Harmful Degree Days	0.40
	(0.65)
Log median yields	8.51
	(1.14)
Turnout	71.25
	(12.21)
Number of candidates	10.94
	(5.32)
Number of candidates with lost deposits	6.56
	(5.16)
Proportion candidates Independent	0.28
	(0.21)
Proportion candidates Congress	0.11
	(0.12)
Proportion candidates BJP	0.11
	(0.12)
Proportion candidates Other parties	0.50
	(0.20)
Number new candidates	1.91
	(1.77)
Number female candidates	0.29
	(0.69)
Number of agricultural candidates	0.87
	(1.30)
Number of candidates with experience	1.01
	(0.83)
The incumbent contests	0.53
	(0.50)
Average age of candidates	49.04
	(6.65)
Average education of candidates	11.79
	(1.85)
Average number of crimes of candidates	0.86
	(1.93)
Average number of serious crimes candidates	1.52
	(4.50)
Log asseets	16.50
	(1.59)
Log liabilities	11.08
	(6.85)
Age winner	50.93
	(10.49)
Education winner	11.96
	(2.28)
Log assets winner	16.36
	(2.03)
Major crime winner	0.07
	(0.26)
Years punishment winner	2.08
	(8.60)
Winner agricultural candidate	0.24
	(0.43)
Log liabilities winner	7.84
	(9.00)
Female winner	0.08
	(0.28)
Number crimes winner	1.03
	(2.84)
Winner Congress	0.25
	(0.44)
Winner BJP	0.25
	(0.43)
Winner other parties	0.46
	(0.50)
Incumbent won	0.26
	(0.44)
Winner was new candidate	0.49
	(0.50)
Vote share incumbent	44.87
	(10.10)
Vote share new candidate	42.23
	(11.66)
Vote share candidate who contested before	43.65
	(10.60)
Percentage area irrigated	0.26
	(0.19)
Observations	8173

fell in the bin between 9°C and 10°C over some period:

$$bin_b = \frac{1}{n}\sum_{x=1}^{n} 1(10 \geq h_x \geq 9) \tag{3}$$

Of course, we examine the robustness of our results to different numbers of bins and bin sizes - as well as different thresholds for the value of τ.

We begin by estimating non-parametric regressions of agricultural productivity at the assembly constituency (AC) level against average daily temperature by bin - using the full set of temperature bin dummies - along with a set of controls including precipitation, location and time fixed effects:

$$y_{idt} = \sum_{b=B_{min}}^{B_{max}} \gamma_b bin_{bidt} + \beta_3 PP_{idt} + \beta_4 PP_{idt}^2 + \delta_d + \sum_{m=1}^{12} \mu_m * \lambda_t + \varepsilon_{idt} \tag{4}$$

In the above regression, y_{idt} denotes outcome y in AC i, district d, in election year t, b indexes the temperature bins, running from B_{min} ($\leq$ 8°C) to B_{max} ($\geq$ 47°C) in increments of 2, bin_{bidt} denotes the proportion of days in that temperature bin in the past year/growing season (in that AC), PP_{idt} denotes precipitation over the previous year/growing season, δ_d denotes district fixed effects, state or state-year fixed effects (depending on the specification), λ_t denotes year fixed effects and μ_m denotes month of year fixed effects.

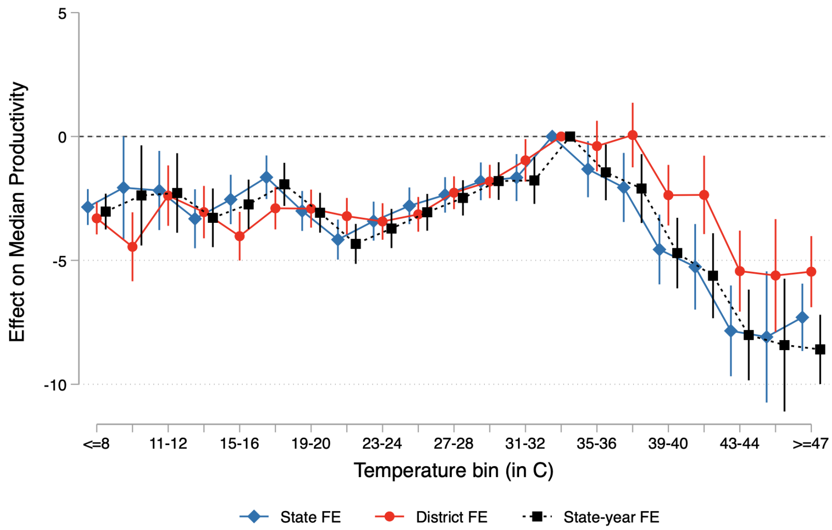
Figures 1 and 2 plot the coefficients for the temperature bins (γ_b) from the bin regressions when using alternative regional fixed effects and different definitions of the growing season. From visual inspection it becomes clear that the incidence of temperatures beyond 36°C lead to a reduction in our measure of agricultural productivity. While the specific threshold is sensitive to the measurements of temperature (e.g. land surface temperature from remote sensing instruments, reanalysis or ground-level monitoring stations) and agricultural productivity, this non-linear effect of hot temperatures has been documented in a variety of contexts across the developing world, including in India (Burgess et al., 2017, Costa et al., 2020, Taraz, 2017).

We subsequently use our threshold to compute measures of HDD and DD in the previous growing season as defined in (eqn 1) and (eqn 2) to run the following regressions:

$$y_{idt} = \beta_1 DD_{idt} + \beta_2 HDD_{idt} + \beta_3 PP_{idt} + \beta_4 PP_{idt}^2 + \delta_d + \sum_{m=1}^{12} \mu_m * \lambda_t + \varepsilon_{idt} \tag{5}$$

Here, y_{idt} denotes outcome y in AC i, district d, and election year t, DD_{idt} denotes the proportion of "good" degree days in the past year, and HDD_{idt} denotes the proportion of

Figure 1: Temperature in the Previous Growing Season VS Agricultural Productivity



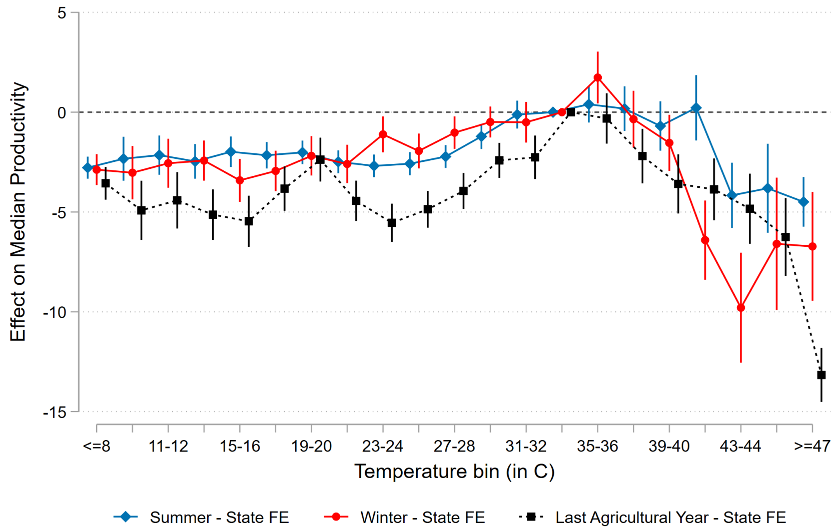
Notes: Figure displays the estimates of the effect of an increase of 1 percentage point in the proportion of growing-season days in a given temperature bin on a State Assembly's median ln(output per ha). Shapes represent points estimates, while lines indicates 90% confidence intervals using robust standard errors. All specifications include month-year fixed effects and either state, district or state-year fixed effects.

"harmful" degree days in the past year. The coefficient β_2 provides the estimated effect of a larger proportion of harmful degree days during the time period under consideration on the outcome of interests. As before the specification also includes precipitation over the previous period, PP_{idt} and its square, in addition to location fixed effects (δ_d, denoting either district, state or state-year fixed effects), and time fixed effects (λ_t denotes year fixed effects, and μ_m denotes month of of the year fixed effects). Standard errors clustered at the constituency level.

Importantly, there is a considerable amount of within-constituency variation in HDDs over time. Figure 3 shows the minimum and maximum average HDDs in a growing season in each Assembly Constituency between 2008 and 2017. In many ACs in most parts of the country, there are years when the average HDD in a growing season is quite low (top panel), as well as years in which the average HDD is very high (bottom panel).

Table 2, using our main specification (eqn 5), shows the negative effects of HDDs on agricultural productivity. Moreover, we see from columns 1 to 6, that the effects are robust to different specifications. In particular, results are the same whether we focus on the

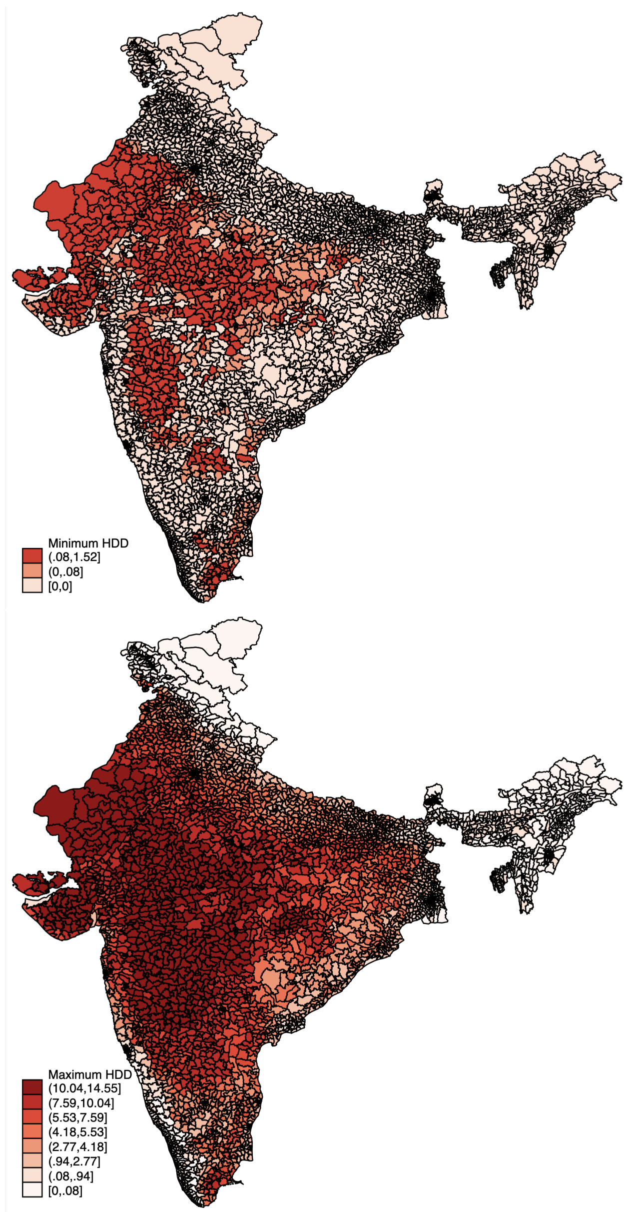
Figure 2: Previous Temperatures on Agricultural Productivity by Growing Season



Notes: Figure displays the estimates of the effect of an increase of 1 percentage point in the proportion of days in a given temperature bin over a specified period on a State Assembly's median ln(output per ha). Shapes represent points estimates, while lines indicates 90% confidence intervals using robust standard errors. All specifications include month-year and district fixed effects.

summer or winter seasons, although the effect of extreme temperatures is more harmful for productivity during the winter season. Given that rainfall is always lower during the winter season, high temperatures are going to be more harmful during that season, and this is what we find. Even after adding rainfall as a control, the negative effect of HDDs on agricultural productivity is almost four times higher in the winter season. We can also see this in Figure 2, where a much larger decrease in median productivity is observed after the proportion of days with higher temperatures increase. As shown in column 6, results also hold if we use the whole agricultural year before the election, instead of just the previous growing season.

Figure 3: Minimum and Maximum HDD in sample years by Assembly Constituency



Notes: Top (bottom) shows the the minimum (maximum) average harmful degree days (HDD) in a growing season for each Assembly Constituency between 2008 and 2017

Table 2: Extreme Temperatures and Agricultural Productivity

	Log Agricultural Productivity (Median)					
	(1)	(2)	(3)	(4)	(5)	(6)
Growing Season:	Previous	Previous	Previous	Summer	Winter	Previous Agricultural Year
DD	0.074***	0.129***	0.030***	0.103***	0.132***	0.137***
	(0.010)	(0.011)	(0.008)	(0.008)	(0.012)	(0.012)
HDD	-0.497***	-0.311***	-0.120***	-0.188***	-0.650***	-0.546***
	(0.051)	(0.049)	(0.021)	(0.046)	(0.049)	(0.055)
Regional FE	State	District	AC	District	District	District
N	6,120	5,901	3,985	5,901	5,274	5,901
R2	0.464	0.632	0.987	0.630	0.615	0.637

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include month-year fixed effects and control for rainfall and rainfall squared.

4 Results

In this section we analyze the effect of exposure to extreme temperatures on political participation by looking separately at voters' behaviour, candidates' participation (and composition of the candidate pool), and equilibrium outcomes.

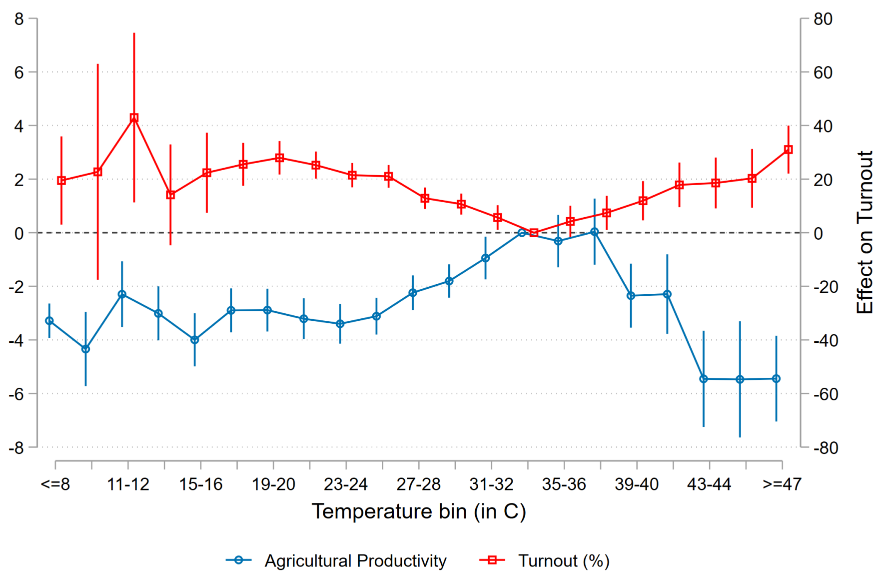
4.1 Voter Turnout

We begin by investigating the response of voters in Assembly Constituency elections to extreme temperature realisations in the previous growing season. Figure 4 summarizes the key result: the effect of temperature on turnout mirrors the effect of temperature on agricultural productivity. Within the range of "good" degree days (i.e., those that positively affect agricultural production), warmer temperatures decrease voter turnout. For temperatures above the threshold (i.e., when temperatures start to reduce agricultural productivity), higher temperatures increase turnout.

In Table 3 we show regression results of turnout on temperatures for different specifications. Column 1 confirms the negative effect on turnout of good degree days (DD) and the positive effect on turnout of harmful degree days (HDD) - i.e., days with extremely high average temperatures. An additional average hot/harmful degree day (i.e. the equivalent of a daily increase of one degree every day throughout the previous growing season) increases turnout by 1.44 percentage points. The result is statistically significant at the 1% level, and represents almost 12% of a standard deviation. Column 2 restricts the sample to those assembly constituencies that also have information on agricultural productivity, and we see that the effect is undiminished. Column 3 regresses voter turnout on agricultural productivity alone, demonstrating that there is a strong and direct negative relationship between agricultural productivity and voter turnout. Columns 4, 5 and 6 show that the results hold whether we focus on the summer growing season, the winter growing season, or the whole agricultural year prior to the election. Just as we saw with agricultural productivity in Table 2, the effect of extreme temperatures on turnout during the winter season is much larger than during the summer season. Given that rainfall is much lower during the winter season, and the damaging effect of high temperatures on agricultural productivity is more important then, we find a correspondingly larger increase if high temperatures occur during the winter season.

If agricultural productivity is the mechanism through which temperature affects political outcomes, we would expect the effects of temperature on political participation to be stronger

Figure 4: Temperatures, Agricultural Productivity and Turnout



Notes: Figure displays the estimates of the effect of an increase of 1 percentage point in the proportion of growing-season days in a given temperature bin on a State AC's mean ln(output per ha) and share of electors that voted. Shapes represent point estimates. Both specifications include month-year and district fixed effects and use temperatures for the previous growing season.

Table 3: Extreme Temperatures and Turnout

	Turnout (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
Growing Season:	Previous	Previous	Previous	Summer	Winter	Previous Agricultural Year
DD	-1.003***	-1.033***		-0.645***	-0.940***	-1.010***
	(0.124)	(0.136)		(0.095)	(0.154)	(0.158)
HDD	1.439***	1.791***		0.432**	1.841***	1.361***
	(0.278)	(0.304)		(0.220)	(0.424)	(0.355)
log Median Yields			-2.582***			
			(0.144)			
Regional FE	District	District	District	District	District	District
N	7,532	5,806	5,804	7,532	6,902	7,532
R2	0.778	0.767	0.778	0.775	0.784	0.776

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared. Column (2) restricts the sample to Assembly Constituencies that also have information on agricultural productivity.

in areas where a shock to agriculture is more damaging. In Table 4 we look at heterogeneous effects along dimensions correlated with agricultural activities. Column 1 shows that HDDs are associated with larger increases in turnout, the larger the share of rural population in the assembly constituency. Columns 2 and 5 show that the effects are stronger in areas with lower levels of literacy and non-farm employment, respectively. While the point estimates have the expected signs in Columns 3 and 4, we do not find significantly different effects for constituencies with larger shares of scheduled caste or scheduled tribe populations, or for constituencies with more area classified as rural in population censuses, even if the latter coefficient is large.

4.2 Candidates' behavior and characteristics

Next we explore the effect of exposure to harmful temperatures on politicians' decisions to run for election in the State Legislative Assembly (SLA). In Table 5 we find that the realisation of extreme temperatures over the year preceding an election reduces the number of candidates running to be Members of the SLA. An additional average harmful degree day (HDD) decreases the number of candidates running by 0.44, which is 8% of a standard

Table 4: Extreme Temperatures and Turnout - Heterogeneous Effects

	Turnout (%): Heterogeneous Effects				
	(1)	(2)	(3)	(4)	(5)
HDD	-0.450	4.208***	0.588	-1.479	1.704***
	(0.625)	(0.867)	(0.484)	(1.528)	(0.379)
indicator	7.198***	-14.585***	1.507	12.648***	-13.162***
	(0.682)	(1.906)	(1.522)	(1.485)	(4.131)
HDD x Indicator	1.254*	-7.060***	0.188	2.028	-16.238***
	(0.641)	(1.566)	(1.830)	(1.523)	(4.309)
Population Indicator	Rural	Literate	SC/ST	Rural Area	Non farm emp
N	5,291	5,284	5,284	3,546	4,660
R2	0.817	0.811	0.803	0.835	0.846

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

deviation. The effects are larger in elections with more than 10 or 15 candidates (columns 3 and 5), suggesting that marginal candidates choose not to run after a bad agricultural year. This is confirmed in column 6, which shows that an increase in HDDs reduces the number of candidates that have lost their deposits due to insufficient support from voters; in India, candidates that obtain less than one-sixth of the total vote share forfeit the deposit (10,000 Rs, which is approximately 125$) they must pay in order to contest in the election.

This reduction in the number of candidates seems to affect the party composition of candidates. Table 6 shows a slight reduction in independent and traditional parties at the expense of regional parties. The reduction in the proportion of independent candidates is consistent with our finding that marginal candidates choose not to contest, given that independent candidates tend to have a lower probability of winning elections.

One logical follow-up question is the following: do characteristics of the candidate pool change substantially after this reduction in the number of candidates? Specifically, we look at whether extreme temperatures affect the number of candidates that are new (versus having contested before), female, work in agriculture, and have won before. We also look at whether the incumbent re-contests, as well as average age, education, assets, liabilities, number of crimes they have been charged with, and the likelihood of being charged with a serious crime. The results, which can be found in Tables 7 and 8, suggest that the pool of candi-

Table 5: HDDs and Number of Candidates

Dependent variable:	(1)	(2)	(3) Number of candidates	(4)	(5)	(6) Candidates w/ lost deposits
DD	0.329***	0.039*	0.481***	0.125***	0.327**	0.256***
	(0.044)	(0.023)	(0.081)	(0.031)	(0.143)	(0.048)
HDD	-0.439**	0.137	-0.671***	0.039	-0.640*	-0.519***
	(0.183)	(0.119)	(0.227)	(0.128)	(0.382)	(0.172)
Number of candidates	all	less 10	more 10	less 15	more 15	
N	7,533	3,156	4,230	5,804	1,654	7,599
R2	0.601	0.586	0.345	0.627	0.350	0.519

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

Table 6: HDDs and Political Parties

	Proportion of candidates			
Dependent variable:	(1) Independent	(2) INC	(3) BJP	(4) other
DD	0.005***	-0.001	-0.000	-0.004*
	(0.002)	(0.001)	(0.001)	(0.002)
HDD	-0.016**	-0.003	-0.007*	0.026***
	(0.007)	(0.004)	(0.004)	(0.007)
Regional FE	District	District	District	District
N	7,599	7,599	7,599	7,599
R2	0.466	0.473	0.350	0.369

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

dates remains broadly similar in elections following extreme temperatures, both in terms of socio-demographic characteristics, criminal activities from affidavits, and incumbency status. There does seem to be an increase in the probability that the candidate is experienced (the share of candidates that have been successful in the past increases by 6% per extra HDD) and poorer (an extra HDD lowers the average value of assets by 23%).

Table 7: HDDs and Characteristics of the Candidate Pool (1)

	number of				
	(1)	(2)	(3)	(4)	(5)
Dep var:	new cand	female cand	agr cand	cand won before	incumbent contests
DD	-0.032***	-0.018**	-0.068***	-0.021***	0.005
	(0.012)	(0.009)	(0.012)	(0.005)	(0.007)
HDD	-0.049	0.003	-0.024	0.058**	0.008
	(0.061)	(0.026)	(0.045)	(0.028)	(0.022)
Regional FE	District	District	District	District	District
N	7,668	7,668	7,668	7,668	5,457
R2	0.552	0.125	0.482	0.565	0.294

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

Table 8: HDDs and Characteristics of the Candidate Pool (2)

	average			average prob	ln average	
	(1)	(2)	(3)	(4)	(5)	(6)
Dep var:	age	education	num crimes	serious crimes	assets	liabilities
DD	0.178**	0.078***	0.042**	0.006	0.072***	-0.080
	(0.090)	(0.024)	(0.017)	(0.036)	(0.022)	(0.082)
HDD	-0.228	-0.049	-0.072	-0.103	-0.228***	-0.020
	(0.269)	(0.096)	(0.086)	(0.172)	(0.073)	(0.273)
Regional FE	District	District	District	District	District	District
N	7,634	7,527	7,573	7,409	7,573	7,573
R2	0.197	0.183	0.206	0.265	0.402	0.259

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

4.3 Political Outcomes

The fact that temperature shocks affect political participation among voters and candidates could translate into different voting behaviour and political outcomes. We know that political participation has increased for voters and decreased for candidates, and that the composition of the candidate pool is only slightly different. This suggests that any change in the characteristics of winners will mostly be driven by changes in the political preferences of voters.

In Tables 9 and 10, we document the effect of extreme temperature realisations on various political equilibrium outcomes (i.e. the characteristics of election winners), using the same specification as above. The results show that election winners tend to be poorer, less likely to have a criminal record, and more likely to work in agriculture. While the vote share of incumbents does drop after extreme temperature realisations, we do not find that the swing in votes is large enough to negatively affect the likelihood that an incumbent wins.

Table 9: HDDs and Winner Characteristics (1)

	Winner characteristics					
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Age	Edu	Assets(log)	Major crime	Punishment	Agri
DD	0.349**	0.048	0.076**	0.002	0.022	-0.022***
	(0.136)	(0.033)	(0.033)	(0.002)	(0.062)	(0.004)
HDD	-0.576	-0.080	-0.259***	-0.023**	-1.327***	0.036**
	(0.447)	(0.118)	(0.097)	(0.011)	(0.336)	(0.016)
Regional FE	District	District	District	District	District	District
N	7,517	7,055	7,242	6,980	6,980	7,594
R2	0.156	0.155	0.325	0.235	0.191	0.367

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

Table 10: HDDs and Winner Characteristics (2)

	Winner characteristics			Vote Share		
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var.:	Incumbent Won	Incumbent Won (if contest)	New Cand Won	Incumbent	New candidate	Contested Before
DD	0.006	0.008	-0.011	0.590	-0.198	-0.025
	(0.007)	(0.013)	(0.007)	(0.375)	(0.297)	(0.132)
HDD	0.013	0.015	-0.004	-2.201**	0.996	0.258
	(0.022)	(0.034)	(0.023)	(1.030)	(0.799)	(0.434)
Regional FE	District	District	District	District	District	District
N	5,456	2,867	5,456	1,320	2,574	7,530
R2	0.180	0.201	0.227	0.503	0.434	0.345

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

5 Mechanisms

5.1 Mediation Analysis

We have shown above that an increase in HDDs affects political participation on a variety of outcomes, including voter turnout, candidate participation, and election outcomes. We have also seen that an increase in HDDs leads to a sharp reduction in agricultural productivity - a result that is widely corroborated in the literature (Aragón et al. (2021), for example). Moreover, Figure 4 shows that these two effects closely mirror one another, suggesting that HDDs reduce agricultural productivity and it is this reduction in agricultural productivity that leads to greater turnout and changes in other political outcomes. This hypothesis is corroborated by some of our heterogeneity analysis - in particular those results which show that the effect of HDDs on turnout is concentrated in areas with a larger rural population or a smaller share of non-farm employment (Table 4). Assuming this mechanism is at work, how much of the total effect of HDDs on political outcomes can be explained by agricultural productivity? In this subsection, we perform a mediation analysis to decompose the total effect of HDDs on political outcomes (e.g. turnout) into a direct effect and an indirect effect (i.e. the part of the total effect that is mediated through agricultural productivity), which allows us to quantify the relevance of this mechanism.

The indirect effect or ACME (for Average Causal Mediation Effect) can be identified under two main assumptions (Imai et al. (2010)): 1) sequential ignorability and 2) no-interaction. In our case, the sequential ignorability assumption requires the following two conditions to hold: i) that HDDs are independent of potential outcomes and potential agricultural productivity, conditional on the controls, and ii) that agricultural productivity is independent of potential outcomes conditional on the controls and the realization of HDDs. Condition i) is already required for all of our main results to be unbiased. Condition ii) implies, *inter alia*, that there are no omitted variables that influence both agricultural productivity and political outcomes (such as turnout), conditional on HDDs and other controls (including precipitation and geographic fixed effects). The no-interaction assumption requires that the effect of agricultural productivity on political outcomes be independent of the realization of HDDs (i.e. poor agricultural productivity should have the same effect on political outcomes whether HDDs are high or low).

Given these assumptions, we run the following regressions for each of our main political outcome variables: i) voter turnout, ii) the number of candidates running, and iii) whether an agricultural candidate is elected.

$$y_{idt} = \gamma_1 HDD_{idt} + \gamma_2 \boldsymbol{X}_{idt} + u_{idt} \tag{6}$$

$$NPP_{idt} = \beta_1 HDD_{idt} + \beta_2 \boldsymbol{X}_{idt} + \epsilon_{idt} \tag{7}$$

$$y_{idt} = \alpha_1 HDD_{idt} + \alpha_2 \boldsymbol{X}_{idt} + \alpha_3 NPP + \varepsilon_{idt} \tag{8}$$

where y_{idt} denotes a political outcome variable, NPP_{idt} denotes agricultural productivity, $\boldsymbol{X}_{idt}$ denotes all controls (including fixed effects), and all other variables are defined as above. The coefficient γ_1 in Equation 6 - which takes the same form as our main results - provides an estimate of the (total) effect of HDDs on political outcomes, while β_1 from equation 7 provides an estimate of the effect of HDDs on agricultural productivity, and equation 8 regresses political outcomes on HDDs while controlling for agricultural productivity (and our other controls).

The average causal mediation effect (ACME) - which is the part of the effect of HDDs on political outcomes that is mediated via agricultural productivity - is then the product of β_1 and α_3 (Imai et al. (2010); Reuben M. Baron and David A. Kenny (1986)), while the ACME as a fraction of the total effect (of HDDs on political outcomes) is $\frac{\beta_1 \alpha_3}{\gamma_1}$.

Both of these quantities are reported in the bottom panel of Table 11 for each of our three primary outcomes of interest (voter turnout, the number of candidates, and whether an agricultural candidate is elected). In every case, the fraction of the total effect of HDDs which can be attributed to the indirect effect of agricultural productivity is in excess of .7 (and is sometimes as large as .88). In other words, the primary way in which HDDs seem to effect political outcomes is via their negative effect on agricultural productivity.

Table 11: Average Causal Mediation Effects

	NPP	Turnout (%)		Number of Candidates		Agricultural Winner	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DD	0.137***	-1.145***	-0.816***	0.359***	0.258***	-0.023***	-0.018***
	(0.012)	(0.185)	(0.185)	(0.051)	(0.049)	(0.004)	(0.004)
HDD	-0.546***	1.836***	0.505	-0.463**	-0.058	0.025	0.003
	(0.055)	(0.398)	(0.399)	(0.202)	(0.198)	(0.016)	(0.016)
Ln Median Yields			-2.425***		0.739***		-0.040***
			(0.145)		(0.090)		(0.006)
Indirect Effect (ACME)			1.324		-.403		.022
Indirect Effect (fraction)			.721		.87		.884
N	5,901	5,796	5,796	5,797	5,797	5,863	5,863
R2	0.637	0.766	0.782	0.614	0.622	0.411	0.414

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: *p <0.10, ** p <0.05, *** p <0.01. DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36℃. All regressions include only those observations for which agricultural productivity data are available. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

5.2 Irrigation

In this subsection we dig deeper into the mechanism highlighted above (i.e. agricultural productivity) and explore some of the further implications. Irrigation has been shown to mitigate the effects of high temperatures on agricultural productivity; see, for example, Tack et al. (2017) and Zaveri and B. Lobell (2019). If our results for political outcomes are indeed driven by agricultural productivity, we would then expect irrigation to also affect the relationship between very high temperatures and political outcomes such as turnout. In Table 12 we test whether this is the case by interacting HDDs with the percentage of irrigated area at the assembly constituency level (from Ambika et al. (2016)). Column 1 shows results for agricultural productivity as the dependent variable. As expected, and consistent with the previous literature, the coefficient on the interaction term is positive, implying that the greater the penetration of irrigation, the smaller will be the negative effect of high temperatures on agricultural productivity. Column 2 shows results for voter turnout and, as before, the results for turnout mirror those for agricultural productivity: in assembly constituencies with more irrigation, the effect of high temperatures on turnout is smaller - which is again in line with our mechanism since the negative effect of HDDs on agricultural productivity is also attenuated.

Table 12: The Effect of Irrigation

	NPP and turnout: Mechanisms	
	(1) Log NPP	(2) Turnout
DD	0.032***	-0.413
	(0.008)	(0.332)
HDD	-0.203***	2.725***
	(0.029)	(0.319)
Irrigation	0.007	5.342***
	(0.045)	(0.797)
HDD × Irrigation	0.241***	-4.382***
	(0.047)	(0.504)
Indicator		
N	3,985	3,899
R2	0.988	0.904

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* All specifications include AC fixed effects, month-year fixed effects and control for rainfall and rainfall squared.Irrigation data from Ambika et al. (2016).

Next we aim to use the information from above regarding irrigation to rationalize and better understand some of our other results - in particular our results for election outcomes and the characteristics of election winners. In the previous section we found that, following extreme temperatures, election winners tended to be poorer, with fewer alleged crimes, and were more likely to come from agricultural occupations. In what follows we focus on the last of these outcomes, as candidates' occupations are likely to be known by voters, and it is reasonable to think that voters may prefer candidates with agricultural backgrounds, if they believe such candidates will better understand the consequences of temperature shocks for agricultural outcomes and are willing to implement policies to address such shocks.

The question is then: are candidates from agricultural backgrounds more likely to invest in policies (such as irrigation) that help citizens mitigate the effects of temperature shocks? The identification challenge in this case is the existence of omitted variables that may affect both who is elected and irrigation levels (e.g. perhaps agricultural candidates are more likely to be elected in ACs with more farmers, which also tend to have more irrigation). To get around this problem we take advantage of the fact that some agricultural candidates win in close elections against non-agricultural candidates, which allows us to use a sharp regression discontinuity design (RD), following the methodology in Cattaneo et al. (2019). In our data we have 1,580 AC elections with an agricultural and a non-agricultural candidate as winner and runner-up. We also have information on the margin of victory, the running variable. As expected, there is a sharp discontinuity in the probability of being elected at the zero vote margin, since winning candidates have a positive margin of victory.

Results in Table 13 show that a victory by an agricultural candidate increases the percentage of irrigated area in the following year by 7.6 percentage points, which is 35% of a standard deviation. The coefficient increases slightly when adding a second order polynomial of the vote margin as a control variable (column 2), and when adding controls for the winner's political party and the share of the population that is rural (column 3), but does not change appreciably. A graphical representation of the result can be found in Figure 13. Dividing the sample according to whether HDD was above or below the mean in columns 4 and 5 we find that the effect is only significant in areas where HDD was below the mean, but coefficients are very similar. Finally, we test whether agricultural candidates who win in close elections generate higher agricultural productivity in general, but we fail to find such an effect (last column of Table 13).

In order to be able to use RD as an identification strategy, several conditions must be met. First, there should be no manipulation of the running variable at the discontinuity. This is shown in Figure B2 of the appendix, where the estimated discontinuity is both small and not significantly different from zero. Second, covariates and pre-determined variables should also be balanced around the discontinuity. Results in Table A3 show that this is indeed the case, using variables such as past irrigation, past vote margins, and whether the profession of the previous winner was agricultural.

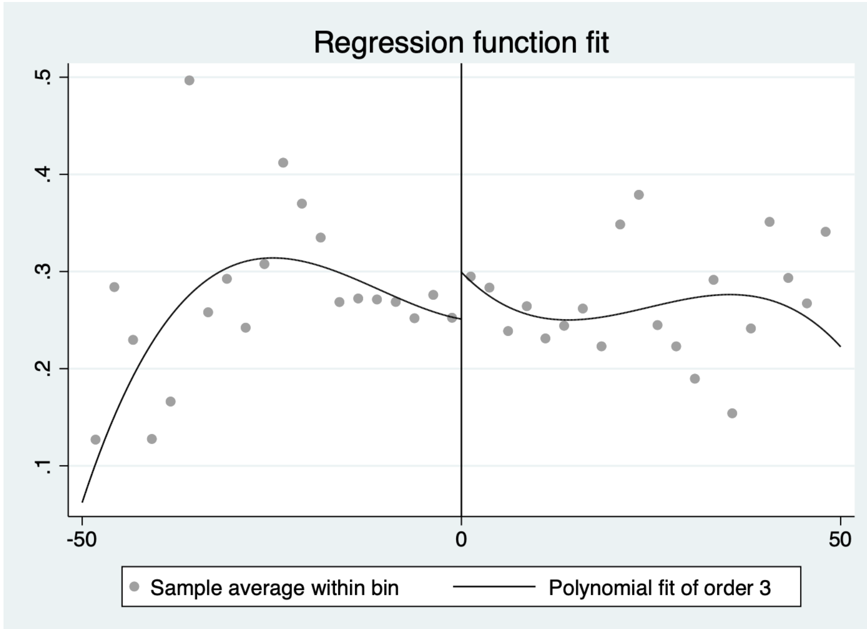
The upshot of this analysis is the following: agricultural candidates who win in close elections seem to be more likely to invest in irrigation in their constituencies. If voters know this, along with the fact that irrigation tends to mitigate the effect of high temperatures on agricultural productivity, they may be more likely to vote for agricultural candidates in response to extreme temperature realisations (especially if they believe that recent extreme temperature realisations are indicative of more frequent or more extreme temperature realisations in the future).

Table 13: Agricultural candidates in Close Elections

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Irrigation	Irrigation	Irrigation	Irrigation	Irrigation	Log NPP
Won in close elections	0.0762***	0.0942***	0.0895***	0.0644	0.0689*	-0.0153
	(0.0294)	(0.0344)	(0.0302)	(0.0410)	(0.0384)	(0.0944)
		2nd order	Controls	HDD high	HDD low	
Obs	996	996	736	537	459	725
Bandwidth	8.309	12.01	8.013	8.290	9.810	13.09
Robust p val	0.00941	0.00614	0.005	0.116	0.0729	0.871

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* Estimates produced using "rdrobust". Irrigation data from Ambika et al. (2016).

Figure 5: RD estimates: The Effect of Agricultural Candidates on Irrigation



Notes: Whole sample and a 4th order polynomial.Produced using "rdplot".

6 Conclusion

We find that extreme temperatures reduce agricultural yields and increase voter turnout, with almost identical (but opposite) effects. These effects are more pronounced in assembly constituencies that depend more on agriculture, suggesting that citizens react to a temperature shock which affects their livelihoods by increasing their political participation. Regarding politicians' behavior, we find that the temperature shock reduces the number of candidates who stand for election, in particular by dissuading marginal candidates from running (i.e. those who would ex-ante have a lower probability of winning, such as candidates who are likely to lose their deposit or independent candidates). These effects translate into changes in the political equilibrium, with an increase in the success rates of poorer candidates, candidates that committed a smaller number of crimes and candidates with an agricultural background.

Our mediation analysis suggests that the decrease in agricultural productivity caused by extreme temperatures can account for nearly all of these effects. Our investigation of the mechanism finds that agricultural candidates tend to improve irrigation, and that irrigation tends to mitigate the negative effects of high temperatures on agricultural productivity, as well as the effects on turnout.

This paper provides a first attempt to understand the political implications of climate change in democratic developing countries, as climate change is likely to bring an increase in the frequency and severity of temperature shocks - especially in warmer countries close to the equator, which also tend to be poorer. We use evidence from India, the largest democracy in the world, but future research should focus on obtaining evidence from other countries to explore how the effects may or may not differ given different political institutions and environments. Further research should also dig deeper into the mechanisms that politicians and bureaucrats have at their disposal to mitigate the effects of climate change.

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A Appendix Tables

Table A1: Extreme Temperatures and Turnout: Robustness

	Turnout (%): Robustness		
	(1)	(2)	(3)
DD	-0.998***	-0.820***	-0.760***
	(0.121)	(0.130)	(0.215)
HDD	1.438***	0.990***	0.973***
	(0.272)	(0.290)	(0.246)
Lagged DD		-0.214*	
		(0.123)	
Lagged HDD		0.760***	
		(0.267)	
Spec	No rainfall	Lags	AC FE
N	7,816	7,532	7,211
R2	0.778	0.778	0.932

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36°C. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

Table A2: HDDs and Winner Characteristics (Other results)

	Winner characteristics					
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Liab(log)	Female	Number crimes	INC	BJP	Others
DD	-0.128	-0.003	0.048*	-0.003	0.006	-0.005
	(0.111)	(0.003)	(0.026)	(0.005)	(0.004)	(0.004)
HDD	0.281	-0.017	-0.187	-0.003	0.014	-0.009
	(0.388)	(0.013)	(0.141)	(0.019)	(0.018)	(0.016)
Regional FE	District	District	District	District	District	District
N	7,242	7,468	7,242	7,594	7,594	7,594
R2	0.216	0.103	0.162	0.271	0.386	0.474

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.* DD and HDD are the average good and harmful degree days, respectively, using a threshold of 36℃. All specifications include district fixed effects, month-year fixed effects and control for rainfall and rainfall squared.

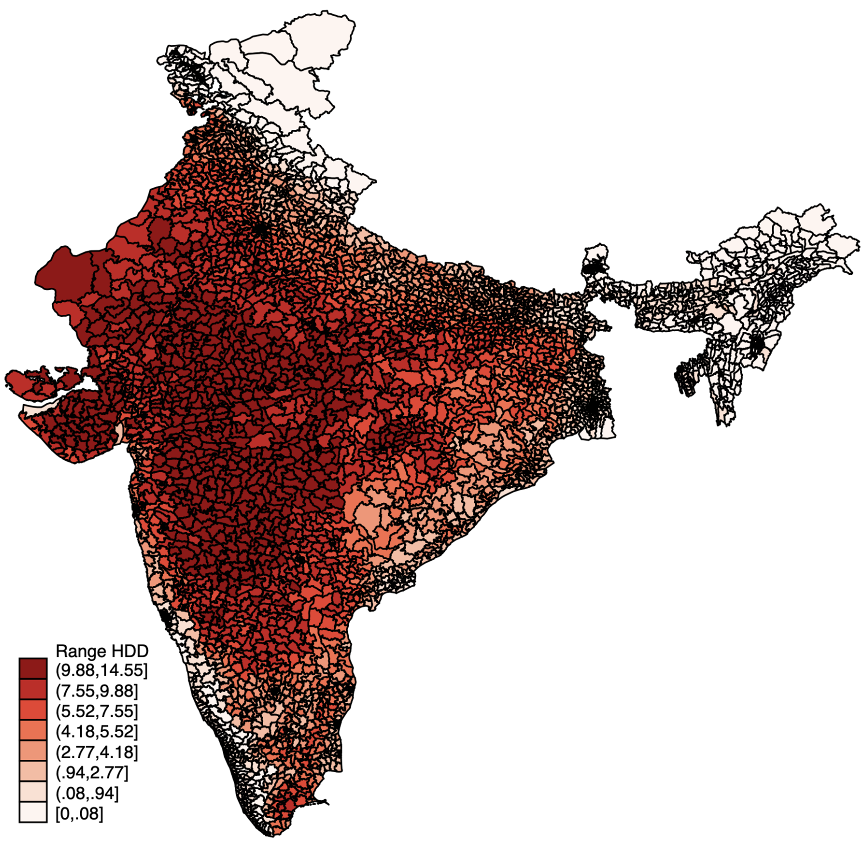
Table A3: Covariate Balance Around the Discontinuity

	(1)	(2)	(3)
VARIABLES	Past irrigation	Past margin	Previous proff agri
RD_Estimate	-0.0123	0.0581	-0.0173
	(0.0240)	(0.0556)	(0.0590)
Observations	1,099	174	1,101
Bandwidth	16.56	10.09	14.33
Robust p value	0.660	0.319	0.772

Notes: Standard errors (in parenthesis) are clustered at the constituency level. Stars indicate statistical significance: **p <0.10, ** p <0.05, *** p <0.01.*

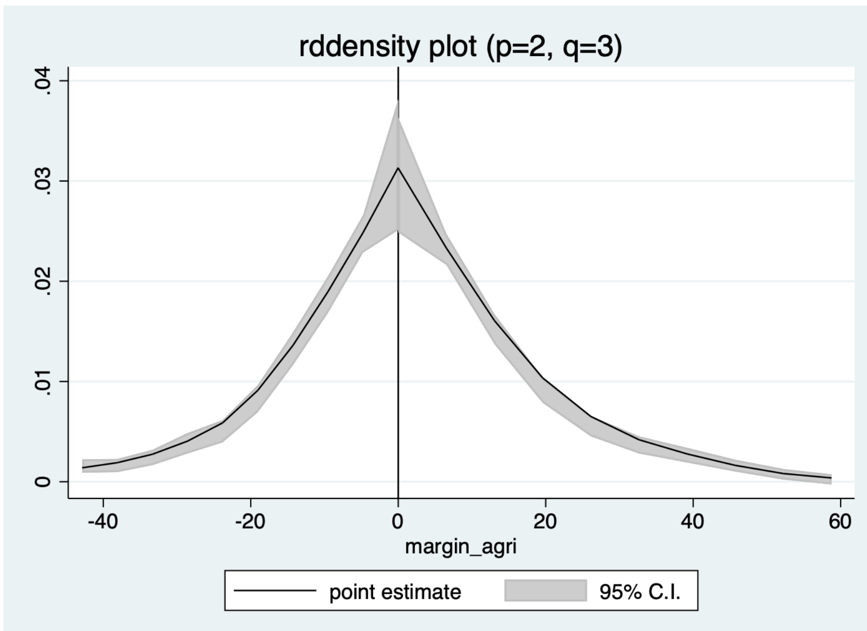
B Appendix Figures

Figure B1: Range of HDD in sample years



Notes: Difference between the maximum and the minimum average harmful degree days (HDD) in a growing season for each Assembly Constituency between 2008 and 2017

Figure B2: Test: Manipulation of the Running Variable



Notes: Discontinuity:0.245, p-value: 0.8065 , estimated using "rd-density"

C Conceptual Framework

In this section of the Appendix, we provide details for the conceptual framework sketched out in Section 2.2, in the form of two toy models. In particular, we attempt to model 1) a citizen's decision regarding whether or not to turn out to vote, and 2) a potential political candidate's decision regarding whether or not to run for office. Each optimization problem is modeled separately and in partial equilibrium. Our goal is to understand how a climate shock such as an increase in harmful degree days (HDDs) might affect each of the two outcomes.

First we discuss the decision of citizens regarding whether or not to participate in the political process through voting. We assume that voting is costly, but that it can entail certain (perceived) economic benefits. In particular, consider a citizen i with income y_i who is deciding whether to abstain or cast a vote for one of J currently running political candidates: $v_i = \{0, 1\}$. Voting entails a non-pecuniary cost, c_i, which is meant to capture not only the cost of physically going to vote, but also the intellectual effort involved in learning about who is running and about how the candidates' platforms differ.

In addition, let us assume that candidate j commits to implement a policy that will benefit voter i by amount I (relative to the next-best policy), if candidate j wins.[7] For example, this might take the form of an irrigation project, which will benefit farmers in a certain catchment area. We assume that voter i perceives a vote cast for candidate j as increasing the probability of j's victory by amount δ. That is, voter i's perceived probability that candidate j wins is given by: $p(v_i) = p' + \delta * v_i$, where p' is i's perceived probability that candidate j wins if i abstains from voting ($v_i = 0$).

Altogether, we can describe voter i's utility with the following quasi-linear utility function:

$$U(y_i, v_i) = ln(y_i + p(v_i)I) - c_i * v_i$$

Then, voter i's marginal benefit of voting is given by the following expression: $x(y_i) \equiv ln(y_i + p' * I + \delta * I) - ln(y_i + p' * I)$. This expression is decreasing in y_i (i.e. $\frac{dx}{dy_i} < 0$), implying that, given a distribution of y_i and c_i in a population of voters, an increase in income will reduce the likelihood that voting is optimal for marginal voters. Conversely, if an increase in HDDs has the effect of reducing y_i for a given voter (due to a loss in agricultural output or a reduction in agricultural productivity), the model illustrates a channel whereby the marginal benefit of voting (and thus the likelihood of casting a vote) for such a voter would go up. Also implied is that HDDs may increase the vote share for candidates who are perceived

[7] We assume that such a commitment is possible and credible.

as being able to improve financial outcomes for those adversely affected (e.g. agricultural candidates).

Next, we turn to the decision of a politician (indexed by j, with income y_j) regarding whether or not to run for office, $R_j = \{0, 1\}$. We imagine that gaining office may entail certain pecuniary and non-pecuniary benefits (α and β, respectively), but running is costly: candidates who choose to run ($R_j = 1$) must pay deposit D, which they lose with prob q_j.[8] Let us denote the probability that candidate j wins by p_j, and write the utility function of the candidate as follows, with non-pecuniary components in the linear term of the function:

$$U(y_j, R_j) = ln(y_j - R_j q_j D + R_j p_j \alpha) + R_j p_j \beta$$

Then, the marginal benefit to j of running is given by the following expression: $z(y_j) \equiv ln(y_j - q_j D + p_j \alpha) + p_j \beta - ln(y_j)$. This expression is increasing in y_j (i.e. $\frac{dz}{dy_i} > 0$) as long as $q_j D > p_j \alpha$, which is more likely to hold for marginal candidates, who face a higher risk of losing their deposits. Therefore, if weather shocks in the form of more HDDs adversely affect the incomes of politicians (which may occur if their incomes are based on agriculture or are otherwise tied to the conditions of the local economy), then an increase in HDDs will reduce the marginal benefit of running for marginal candidates, which may lead to a reduction in the number of marginal candidates running for office. Conversely, an increase in HDDs may increase the marginal benefit of running for more established candidates (i.e. those for whom $p_j \alpha > q_j D$), although in this case it is unlikely to increase the number of such candidates running (since they are not likely to be marginal).

[8] This particular feature of the model reflects the fact that political candidates in our empirical context must provide a 10,000 Rs. deposit, which is forfeited if they lose with less than one sixth of the vote.