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Essays on the Politics and Political Effects of Climate Change

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Essays on the Politics and Political Effects of Climate Change

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in

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by

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2016

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Co-Chair

University of California, San Diego

2016

DEDICATION

To those who made this work possible.

EPIGRAPH

"Voters are not concerned about climate change.
They're only concerned with bread and butter issues
that are affecting them on a daily basis."
– South African Member of Parliament

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Obradovich, N. and Guenther, S., "Collective responsibility amplifies mitigation behaviors", *Climatic Change*, advance online publication, May 2016.

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ABSTRACT OF THE DISSERTATION

Essays on the Politics and Political Effects of Climate Change

by

Nicholas Obradovich

Doctor of Philosophy in Political Science

University of California, San Diego, 2016

Professor James H. Fowler, Co-Chair
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This dissertation focuses on the politics and potential effects of climate change on political systems. I examine aspects of three broad questions. First, how might future climatic stressors alter the stability of political systems? Numerous studies investigate this question through the lens of conflict. Yet most political change does not arise through violent upheaval. In democratic nations at least, most political change arises through regular elections. In my first chapter, I examine the potential for climate change to disrupt the functioning of political systems through alterations in political behaviors at the ballot box. I find that – if historical relationships

persist – the climatic distributions projected for the latter part of this century may increase rates of democratic turnover, especially in poorer nations with already weaker democratic institutions. My second question relates to the political feasibility of policies designed to address climatic changes in lower income democracies. In my second chapter, I investigate the willingness of voters and politicians in Sub-Saharan Africa to lend political support to climate change policies. Evidence from these studies suggests that voters are reticent to support climate policies and that politicians are subsequently reluctant to pursue such policies. My third question focuses on the behavioral motivations for taking individual political action to address climate change. Organizations looking to motivate action on climate change often make appeals that emphasize an individual's personal responsibility for the problem, with the notion that emphasizing diffuse collective responsibility may diminish individual action. In my third chapter, I conduct a series of survey experiments with members from the National Audubon Society and from the general public and find that – contrary to expectations – emphasizing personal responsibility produces no significant increase in climate change action whereas emphasizing collective responsibility amplifies climate action. These three chapters represent a foray into vital areas of my future research program: the potential effects of climate change on political systems, the political feasibility of climate policies, and the underpinnings of political behaviors related to climate change.

Introduction

Climate change poses the largest environmental threat humanity has ever faced. Under current trends in greenhouse gas emissions, global temperature will increase by around 5°C by 2100 [1]. The myriad environmental effects of projected distributional shifts in climate are likely to substantially disrupt the functioning of ecological systems. Predicted environmental changes include amplifications of extreme temperature and precipitation events [2, 3, 4, 5], an increased incidence of drought [6, 7, 8, 9] due to lower amounts of precipitation and higher rates of evapotranspiration [10], amplified sea level rise [11, 12] that may last hundreds to thousands of years [13], acidification of the oceans [14], and more intense and frequent wildfires [15].

Humans rely heavily upon global environmental and ecological systems. Our physiological, psychological, economic, and political well-being can be disrupted by deviations from typical environmental conditions. From a physiological standpoint, extreme temperatures can produce excess human mortality [16] and hamper the attainment of sufficient sleep [17], while shifting temperature regimes may increase the range of disease vectors [18, 19, 20], potentially leading to the spread of infectious pathogens like malaria [21]. From a psychological standpoint, heat stress is associated with reduced mental well-being [22] and can amplify rates of both suicide [23] and interpersonal violence [24]. Excess rates of natural disasters may also increase the incidence of attendant psychological trauma [25]. From an economic standpoint, numerous recent studies have indicated that the temperature stressors and natural disasters associated with climate change may disrupt economic productivity [26, 27] and macroeconomic growth [28, 29], in both rich and poor nations [30]. Some of this economic disruption, especially in more agricultural nations, is due to the projected reduction of agricultural yields due to climate change [31, 32], and we are likely already experiencing climate change-induced reduction in yields globally [33, 34, 35].

From a political standpoint, social scientists have uncovered two possible significant effects of climate change on political systems: increased rates of migration and magnified occurrence of civil conflict and unrest. Findings suggest that the physiological, psychological, and economic effects of climate change – especially in areas of the world with already vulnerable citizens – may produce large-scale migration. When the crops fail [36], or when sea levels rise [37], or when economies stutter, people often may face no choice but to leave their homes and relocate to prospectively better regions [38, 39]. Further, these same social stressors may produce an increased likelihood of social unrest and conflict [40, 41], especially in countries with comparatively weak political systems [42, 43]. There are even some suggestions that the ongoing conflict and mass migration out of Syria may be due in part to climate change induced stressors [44].

Many of the likely environmental and ecological effects of climate change are projected with high degrees of certainty, while many of the potential social effects of climatic changes are more uncertain. However, what is clear from the science is that the environmental and human effects of climate change are likely to be costly on net and extremely complex.

It is with this backdrop that I approach the study of the politics and potential political effects of climate change. Unfortunately, political science as a discipline is lagging behind other social science disciplines in the attention paid to questions related to climate change [45, 46]. This disparity is made particularly acute by the recognition that the largest hurdles we face in mitigating and adapting to climate change are inherently political ones [47]. I believe there are three vital political questions that remain insufficiently addressed by our discipline. First, how might climate change interact with political behaviors and political systems in the future, and might these interactions pose threats to political stability? Second, are democratic politicians likely to be successful in implementing climate change mitigation and adaptation policies, and how might barriers to implementation vary by polity? Third, given that climate change poses a collective action problem of a magnitude never before experienced, what can motivate individual citizens to take political action aimed at addressing it?

Answers to these questions will prove integral in understanding the likely political effects of climate change, in figuring out ways to implement climate mitigation and adaptation policies in political systems hostile to such policies, and in uncovering the behavioral mechanisms that motivate individual citizens to support political action on the problem. In this dissertation, I present three studies, each of which addresses a specific facet of the above questions.

My first chapter presents a study designed to investigate whether historical climatic variation has influenced past electoral behaviors. The theory draws on the extensive economic and retrospective voting literature, coupled with recent findings on the effects of temperature on economic and psychological outcomes to provide one primary hypothesis: experiencing climatic stress, through a host of social mechanisms, may induce voters to be less likely to cast their ballots for incumbent political parties. My historical investigation provides empirical evidence that hotter temperatures have historically resulted in poorer incumbent party performance across a large set of countries' constituency-level elections. When I couple these historical functional relationships with projections for distributional shifts in constituencies' future climates, I find that climate change may make it more difficult for officeholding parties to retain democratic power, possibly speeding rates of democratic turnover in the future. These effects are likely to be most acute in poorer, already hotter nations.

My second chapter starts with the common assumption that developing nations will be able to enact climate mitigation and adaptation policies with the tailored development funds that are given to them by foreign donors and international agencies. For example, the United Nation's Green Climate Fund is slotted to provide billions of dollars of targeted climate aid to developing countries in Sub-Saharan Africa by 2020 [48]. Woven into these proposals is the assumption that – if given the funds – African politicians will be able to enact long-run policies designed to mitigate and adapt to the effects of climate change. However, there are important theoretical reasons this assumption may prove invalid. While it is indeed the case that climate change is likely to most harm Sub-Saharan Africa [49, 50, 51, 52, 53, 54], at least initially, there are also reasons that African voters may not desire policies designed to address long-run climatic threats. For example, the low-levels of economic development on the continent leave the average African living on the equivalent of under five dollars per day [55]. At such low levels of income, short-term needs can eclipse future considerations [56]. These harsh economic realities have led to an African electoral politics characterized by the provisioning of immediate benefits – rather than policy promises – in exchange for votes [57]. Voters and thus political candidates may have little tolerance on average for policies that are slotted to produce benefits that will not be fully seen for decades. Further, like in developed nations, political time horizons and incentives for responsiveness rather than preparedness may make addressing the issue politically difficult [58].

Across two experimental studies and a series of qualitative politician interviews, I find evidence that voters in multiple Sub-Saharan nations may prefer policies with more immediate benefits to longer-run climate policies. I also find that politicians in both Malawi and South Africa appear to understand acutely their constituents' reticence to support climate action. While further study is needed, my investigation indicates that simply assuming that if money is available climate action will occur may be a dangerous approach to adaptation policy.

My third chapter focuses on individual climate-related political behaviors in the United States, a nation whose voters are highly polarized around the topic [59]. This study originated from a simple insight: many appeals to behavior aimed at addressing climate change place emphasis on individuals' personal responsibility for the problem, with the assumption that emphasizing such personal responsibility helps motivate action by de-emphasizing the collective aspects of the climate problem. However, emphasizing personal responsibility might also produce other, less helpful, psychological responses [25]. Thus it isn't clear that one of the most common approaches to climate advocacy was producing the intended effects. To examine whether personal responsibility was indeed effective at motivating individual political behavior, I worked with the National Audubon Society and their membership to examine whether priming personal versus collective responsibility (versus a control), would be more effective at motivating action in support of climate advocacy. I coupled the Audubon sample with a series of replication experiments on Amazon's Mechanical Turk. From these studies a repeated finding emerged: emphasizing personal responsibility appeared to be no more effective than the control condition on average, while highlighting collective responsibility for climate change reliably produced pro-climate behaviors and intentions, behaviors that persisted for multiple days after treatment.

When combined, my studies indicate three important insights into the politics and political effects of climate change. First, the political effects of climate change may be multifarious. When human physiological, psychological, and economic well-being is disrupted, the cascading alterations in political behavior may produce everything from altered vote choice, to protest, to migration, to violent civil conflict. There are many questions in this realm that remain entirely unaddressed. Second, the strategy behind climate change policy must be closely tied to the knowledge that political scientists have accumulated through the study of various political-economic systems. While there are limits to the environmental stressors that humans can adapt to [60], strategic policy can lesson many of the adverse effects [61]. However, if policy assumptions are not checked with likely political realities, failed policy implementation could easily result. Finally, at the core of the entire climate challenge rests an enormous collective action problem [62]. Motivating individuals to act on this challenge may be tricky, and traditional approaches may not turn out to be the most effective. Further study of how individuals are motivated to support climate action, especially in politically crucial countries like the United States, is vitally important.

Ultimately, my studies represent a first cut at towering questions that will take much more than a dissertation to answer. When the results of my chapters are combined, one fact becomes clear: the political effects of climate change may be as omnipresent as the political challenges society will face in adequately addressing the problem.

Chapter 1

Climate change may speed democratic turnover

1.1 Abstract

The electoral fate of standing politicians depends heavily upon voters' well-being. Might climate change – by amplifying threats to human well-being – cause standing democratic politicians and parties to lose office more frequently? Here I conduct the first-ever investigation of the relationship between temperature, electoral returns, and future climate change. Using data from over 1.5 billion votes in over 4,800 electoral contests held in 19 countries between 1925 and 2011, coupled with meteorological data, I show that annual temperatures above 16°C-21°C (60°F-70°F) markedly decrease officeholders' vote share. I combine these empirical estimates with an ensemble of climate models to project the impact of climate change on the fate of future officeholders. Forecasts indicate that by 2099 climate change may reduce average standing party vote share by over five percentage points in nations with already weak democratic institutions, causing incumbent parties and their politicians to lose office with increasing frequency. These findings indicate that exogenously driven democratic turnover may be the most regular and pervasive potential impact of climate change on political systems.

1.2 Introduction

Reductions in voter well-being regularly cause democratic politicians to lose office. This is because voters consider their own well-being and the well-being of those around them when deciding how to cast their ballots [63]. When voters are doing well they more frequently vote for their standing politicians [64]. When voters are doing poorly, whether economically or psychologically, they vote for political challengers at higher rates [65]. Importantly, scholars have determined that climate change is likely to undermine future economic [30] and psychological [25] well-being. Might climate change – by reducing citizens' well-being – induce voters to cast out their incumbent politicians at increasing rates in the future?

That diminished voter well-being can produce electoral losses for standing politicians is one of the most extensively documented findings in political science [66]. Most studies focus on the ways that economic outcomes can affect ballot choices, with the conclusion that reductions in macroeconomic performance often precede incumbent politicians' electoral losses [67, 68, 69, 70, 71, 72]. Tufte (1978) articulated this relationship as a basic principle of politics: "When you think of economics, think elections; when you think of elections, think economics" [73]. Yet, alterations in well-being not directly tied to the formal economy can also shape voter behaviors. Harmful events such as hurricanes [74, 75], tornadoes [76], floods [77, 78, 79], and droughts [80, 81, 82] have also shaped the outcome of historical electoral contests. Even more minor reductions in psychological well-being, such as the loss of a favored sports team, have been linked to fewer ballots cast for standing politicians [83].

Climate change induced warming is likely to reduce future economic well-being [84, 85, 86] in both rich [30, 27] and poor [28] countries, in part by reducing individual productivity [26], and is likely to amplify the incidence and severity of extreme weather events [87, 88, 89]. Future warming may also undermine human psychological well-being through mechanisms directly tied to increases in temperature extremes, such as worsened emotional states [90, 22]. These projected impacts of global climate change include many of the exact weather and climate-induced stressors that have historically caused incumbent democratic politicians to lose votes. Thus, a changing climate may indeed induce citizens to cast out their incumbent politicians with increasing rapidity. Yet, while this hypothesis flows readily from over a century of literature, this study is the first to explore it.

Here I conduct a multi-national investigation of the relationship between historical temperatures and constituency-level electoral outcomes and link these findings to predictions of future climatic changes. I examine four questions. First, have exogenous increases in temperature harmed the historical vote share of officeholding democratic parties? Second, do the effects of hotter temperatures vary by level of economic development or by density of agriculture? Third, might climate change alter constituency-level vote share in the future? Finally, which countries may see the highest future increases in warming-induced democratic turnover?

1.3 Temperature and changes to incumbent vote share

To investigate if hotter temperatures have indeed reduced historical incumbent party vote share, I employ a dataset of constituency-level electoral returns based on over 1.5 billion votes cast in over 4,800 electoral contests held in 19 countries between 1925 and 2011 [91]. I link these data to constituency spatial boundaries to map historical monthly meteorological conditions onto each electoral constituency [92] (see *Appendix: Data Description* and *Appendix: Map of Constituency Boundaries*). The theoretical relationship of interest is the total causal effect of constituency-level average annual temperature in the year prior to an election on changes in the vote share of major incumbent party politicians. I empirically model this relationship as:

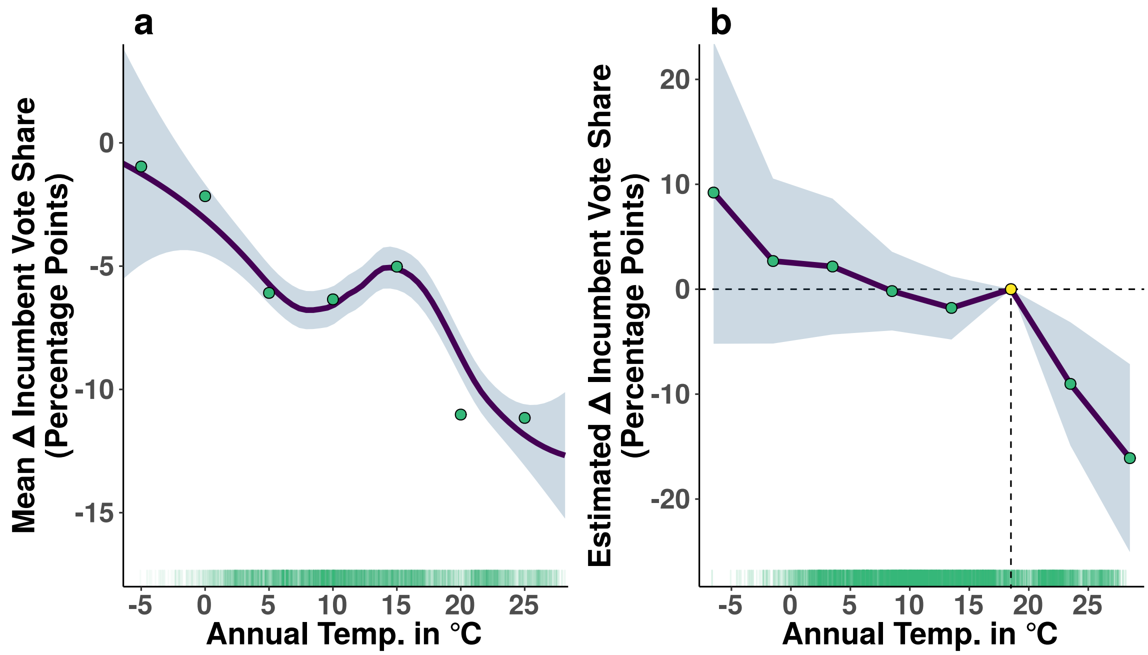

Figure 1.1: Changes to incumbent party vote share decline with increases in annual temperature. Panel (a) depicts the relationship between average temperature in the year prior to an election and changes in the constituency-level vote share of national lower house incumbent politicians from 1,256 constituencies across 19 countries between 1925 and 2011. Points represent the average change in incumbent vote share for each 5°C annual temperature bin. The line represents a loess smoothing of the raw data. Panel (b) draws from the estimation of the fixed effects model in Equation 1.1 and plots the predicted change in vote share associated with each 5°C temperature bin. As annual temperature increases beyond 16-21°C (60-70°F), changes to incumbent vote share become markedly negative. Shaded error bounds represent 95% confidence intervals.

$$\Delta Y_{it} = f(temp_{it}) + precip_{it} + \alpha_i + \zeta_m + \gamma_t + \nu_{jt} + \epsilon_{it} \tag{1.1}$$

I control for precipitation ($precip_{it}$) as it is correlated with temperature but could independently cause changes in voter behaviors [93] (though excluding precipitation does not notably alter parameter estimates, see *Appendix: Main Effect*). In this time-series cross-sectional model, i indexes electoral constituencies, j indexes countries, m indexes election months, and t indexes election years. ΔY_{it} represents the change in vote share of the incumbent party ($Y_{it} - Y_{it-1}$), defined as the party that won the plurality of votes in that constituency in the prior election [94]. Taking this first difference removes from the data potentially confounding secular factors – like strength of incumbent party – that may evolve incrementally in each electoral constituency over time [30].

The main independent variable of interest, $temp_{it}$, represents the average temperature over the twelve months prior to an election held in month m for constituency i in country j and year t (see *Appendix: Temperature and Precipitation*). The relationship of interest is represented by $f()$, which I implement empirically using indicator variables for each 5°C annual temperature bin, allowing for flexible estimation of a non-linear relationship [95, 26] between temperature and alterations in incumbent party vote share (the functional form remains similar across the use of 2°C or 1°C temperature bins, see *Appendix: Alternative Temperature Bins*).

Unobserved geographic or temporal factors may influence electoral outcomes in a way that correlates with temperature. For example, voters may be better off on average in constituencies that have better legal institutions, in certain months of the year, or in years with better global economic performance. To ensure that these factors do not bias estimates of the effect of temperature on incumbent party vote share, I include in Equation 1.1 three terms, α_i, ζ_m, and γ_t, that represent constituency, electoral month, and calendar year of election indicator variables, respectively. These variables control for all constant unobserved characteristics for each constituency and for each election month and year [96]. Further, there may be unobserved, country-specific factors that influence changes in political outcomes over time [30]. In order to control for these potential confounds I include ν_{jt} in Equation 1.1, representing country-specific year indicator variables (results are robust to the use of continent-specific year indicators instead, see *Appendix: Time and Location Controls*). The identifying assumption, consistent with the literature [97], is that annual temperature is as good as random after conditioning on these fixed effects. The estimated model coefficients on temperature terms can thus be interpreted as the causal effect of temperature on changes in incumbent vote share [30, 97, 95, 41].

I adjust for within-constituency and within-year correlation in ϵ_{it} by employing heteroskedasticity-robust standard errors clustered on both constituency and year [98] (the results are also robust to accounting for spatial and serial dependence [99, 100], see *Appendix: Spatial and Serial Correlation*). I exclude non-climatic control variables from Equation 1.1 because of their potential to generate bias – a phenomenon known as a 'bad control' [30, 41] – in the parameters of interest. Because of heterogeneous constituency sizes, I weight the regression in Equation 1.1 by the number of votes cast in each constituency election. Finally, I omit the 16°C-21°C (60-70°F) temperature indicator variable when estimating Equation 1.1. This range contains as its midpoint the average temperature associated with optimal well-being (65°F) [101]. I thus interpret the parameter estimates of $f(temp_{it})$ as the change in incumbent party vote share associated with a particular temperature range relative to this baseline category.

The results of estimating Equation 1.1 for the effects of temperature on changes to incumbent party vote share indicate that after controlling for time, location, and country-specific trends, annual temperatures above 21°C (70°F) significantly reduce incumbents' electoral performance (see Figure 1.1, panel (b) and *Appendix: Regression Tables* for full estimation results). For example, annual temperatures in the range of 21°C-26°C reduce incumbent vote share by over nine percentage points relative to the 16°C-21°C baseline (coefficient: -9.024, p: 0.003, n: 4,880) while constituency annual temperatures above 26°C reduce incumbent vote share by over sixteen percentage points (coefficient: -16.100, $p<0.001$, n: 4,880) (of note, these results remain highly significant even after Bonferroni correction for each temperature bin included in the regression [102], see *Appendix: Bonferroni Correction*).

A 5°C increase in temperature – the average increase predicted under the RCP8.5 scenario for 2099 as compared to 2010 – that produced a reduction in incumbent vote share of over nine percentage points could be politically substantial. Examining the constituencies in the 16°C-21°C temperature range indicates that 31% of historical elections had parties that won by less than this nine point margin. In two party constituencies in this range – where electoral swings are mechanically equal to twice the reduction in incumbent vote share – 41% of historical elections would have been altered by a nine percentage point reduction in the winning party vote share. Thus, the effects of hotter annual temperatures on changes in vote share are of a magnitude that is highly politically meaningful and would have resulted in substantial alterations to the historical democratic process if applied to past electoral returns (see *Appendix: Frequency of Close Elections*).

1.4 Income and agriculture

The above estimates represent the average effect of temperatures on changes to incumbent party vote share across all constituencies in the sample. However, democratic constituencies may vary in their response to increasing temperatures. For example, politicians and voters in rich countries may be better able to respond and adapt to the social stressors associated with hotter temperatures, while politicians and voters in poor countries may lack the resources needed to smooth temperature shocks and thus experience more notable decreases in well-being [28, 30]. Moreover, not all voters in rich or poor countries are likely to be equally affected by the costs of exposure to hotter temperatures. For example, voters in agricultural areas may experience more direct and costly effects of hotter annual temperatures than do voters in areas less reliant on agriculture for their overall well-being [30, 49]. This leads to the second question, do the effects of hotter temperatures vary by level of economic development or by density of agriculture?

To examine whether richer or poorer countries' voters are more sensitive to amplifications in temperature, I stratify the sample by median country-level incomes (measured in per-capita purchasing power parity units) and estimate Equation 1.1 for both rich and poor country subsamples [97, 30]. Figure 1.2, panel (a), shows that the effect of annual temperatures greater than 21°C on changes to incumbent party vote share in rich country constituencies is negative, though this effect is significant only at the $p<0.10$ level (coefficient: −13.677, p: 0.084, n: 3,933). Panel (b) of figure 1.2 shows that the effect of annual temperatures greater than 26°C on changes to incumbent party vote share in poor country constituencies is also negative and is highly statistically significant (coefficient: −15.162, p: 0.004, n: 947). Thus both in

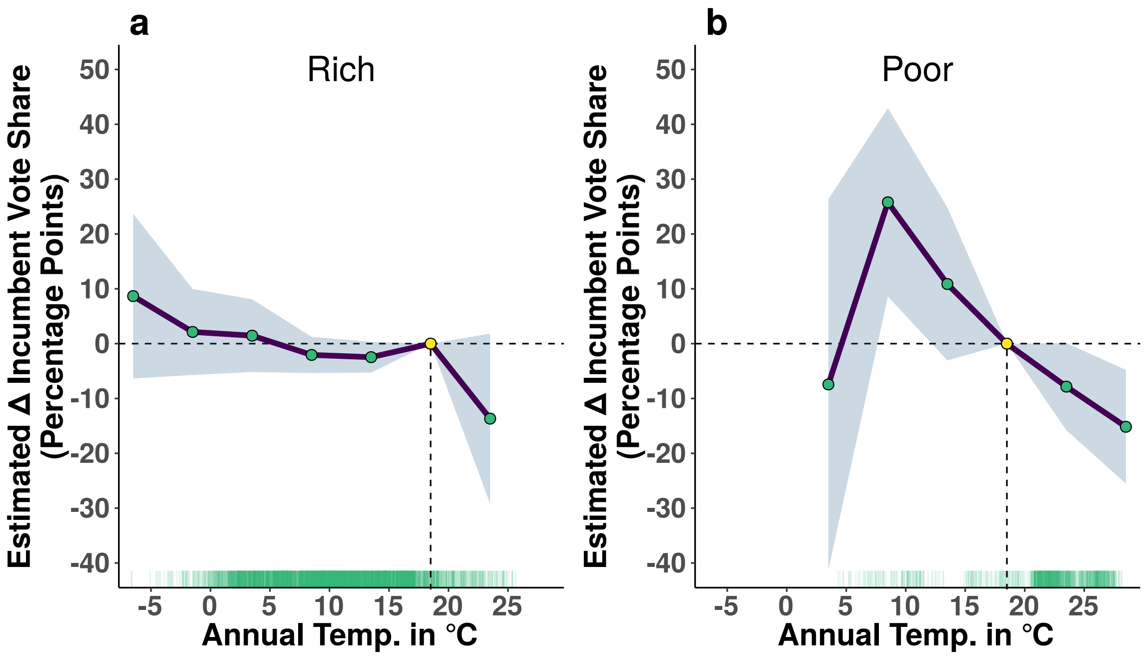

Figure 1.2: Hot temperatures produce negative changes in incumbent vote share in both rich and poor countries. Panel (a) plots the predicted changes in incumbent party vote share associated with estimating Equation 1.1 on the sample of above-median income countries in the data and panel (b) plots this relationship for constituencies in countries falling below median income [30]. Past 21°C (70°F), changes to incumbent vote share decline for both sets of countries, though rich country reductions are significant only at the p<0.10 level. Shaded error bounds represent 95% confidence intervals.

richer and poorer countries I find evidence indicating declines in incumbent party vote share due to an increase in temperature above 21°C, suggesting that higher incomes may not substantially mute the impact of warming on electoral outcomes (see *Appendix: Rich and Poor*). This is consistent with the observation that increasing temperatures reduce economic well-being in both rich and poor nations [30, 27, 28].

Using data on remote-sensed crop-cover [103] to split constituencies along the median of percent of croplands, I repeat the above procedure to examine whether agricultural constituencies demonstrate differential electoral responses to increasing temperatures as compared to non-agricultural constituencies (see *Appendix: Agricultural and Non-Agricultural*). Figure 1.3, panel (a), shows that the effect of annual temperatures greater than 26°C on changes to incumbent party vote share in non-agricultural constituencies is markedly negative, though this effect is estimated with higher variance and fails to gain significance at standard thresholds (coefficient: −18.175, p: 0.130, n: 2,281). Panel (b) of figure 1.3 shows that this effect in agricultural constituencies is also negative and is statistically significant (coefficient: −14.847, p: 0.010, n: 2,271). Thus both agricultural and non-agricultural constituencies' coefficient estimates suggest a decline in incumbent party vote share due to an increase in temperature above 21°C. These findings are consistent with the observation that increasing temperatures reduce both agricultural and non-agricultural economic growth [30].

Combining these insights, I split the sample along rich and poor countries' agricultural and non-agricultural constituencies and estimate Equation 1.1 in each sub-sample (see *Appendix: Income and Agriculture*). Figure 1.3, panel (a), shows that the effect of annual temperatures greater than 21°C on changes to incumbent party

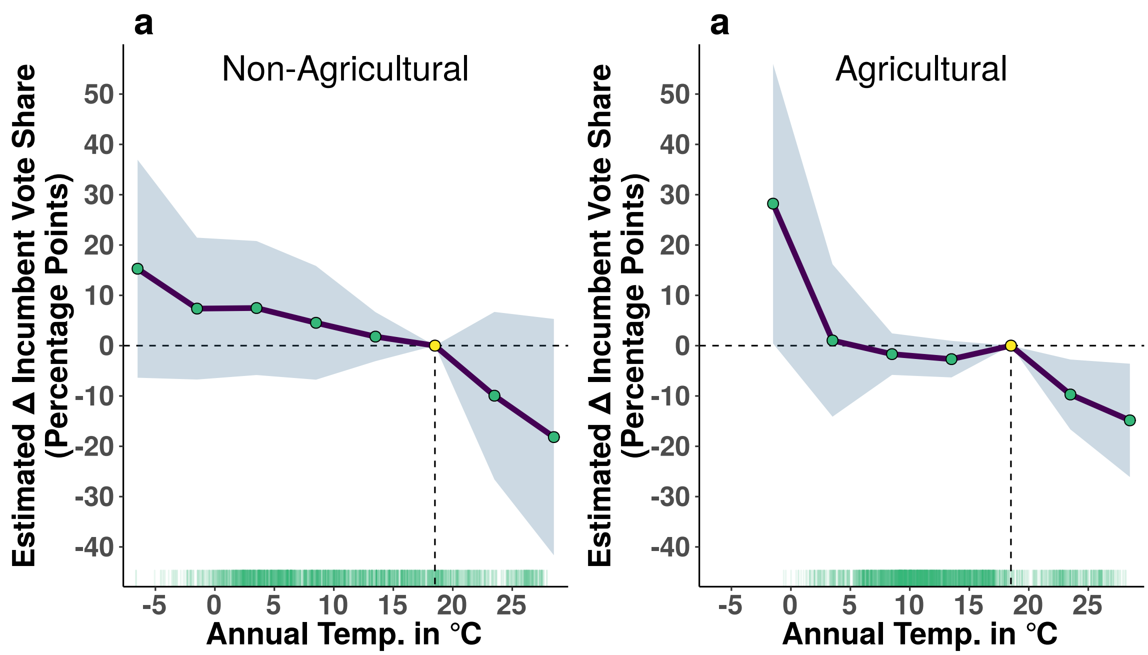

Figure 1.3: Increases in temperature produce negative changes in incumbent vote share in both non-agricultural and agricultural constituencies. Panel (a) plots the predicted changes in incumbent party vote share associated with estimating Equation 1.1 on the sample of constituencies with below-median percentage of remote-sensed agricultural croplands and panel (b) plots this relationship for constituencies with above-median percentages of crop cover. As temperatures increase across both, changes in incumbent vote share decline. Past 21°C (70°F), changes in incumbent vote share decline for both sets of constituencies, though the declines in non-agricultural constituencies fail to gain significance. Shaded error bounds represent 95% confidence intervals.

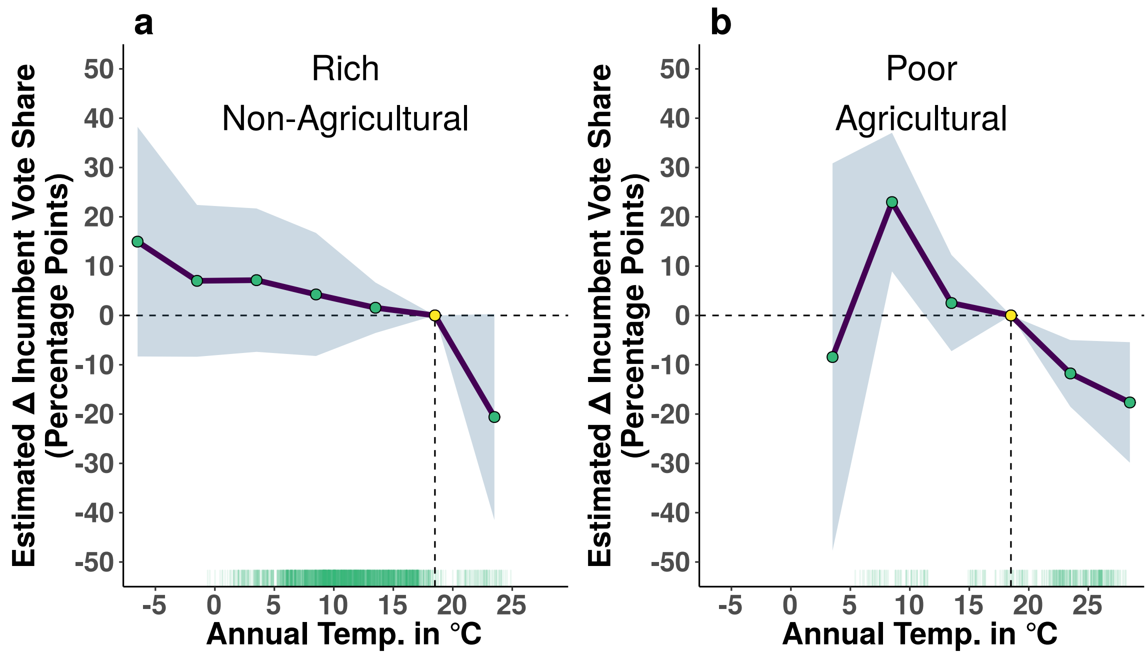

Figure 1.4: Rich country non-agricultural and poor country agricultural constituencies show large electoral effects of temperatures. Panel (a) plots the predicted changes in incumbent party vote share associated with estimating Equation 1.1 on the sample of rich country constituencies with below-median percentage of remote-sensed agricultural croplands and panel (b) plots this relationship for poor country constituencies with above-median percentages of crop cover. Vote share in rich non-agricultural areas displays a significant reduction in incumbent vote share in response to increases in annual temperature above 21°C (70°F), though this result is only significant at the p<0.10 level. Poor country agricultural constituencies also exhibit marked and significant alterations in vote share in response to shifts in temperatures. Shaded error bounds represent 95% confidence intervals.

vote share in rich country non-agricultural constituencies is negative, though this effect is significant only at the $p<0.10$ level (coefficient: -20.604, p: 0.053, n: 2,006). Panel (b) of figure 1.3 shows that this effect in poor country agricultural constituencies is also negative and is highly statistically significant (coefficient: -11.760, $p<0.001$, n: 344). The regression models suggest the decline in incumbent party vote share due to an increase in temperature above 21°C is thus driven primarily by non-agricultural constituencies in rich nations and by agricultural constituencies in poor nations. These results may implicate differential causal political mechanisms underlying the relationship between temperature and vote shares in rich versus poor nations and suggest an important area for future research.

1.5 Constituency forecast

The historical data indicate that past temperatures have likely altered historical electoral outcomes in meaningful ways. Further, climate change is likely to produce positive shifts in annual temperature distributions in the future [104] (see Figure 1.5, panel (a)). Positive shifts in annual temperatures above 21°C may acutely reduce incumbent party vote share in the future, increasing the rate at which incumbent democratic parties and their politicians lose office. These facts lead to the third question: might climate change alter constituency-level vote share in the future?

To examine this question, I calculate projected average annual temperatures for 2050 and 2099 from NASA Earth Exchange's (NEX) bias-corrected, statistically downscaled temperature forecasts drawn from 21 of the CMIP-5 ensemble models run on the RCP8.5 emissions scenario (see *Appendix: Climate Model Data*). I couple these predicted temperatures with the historical estimate of the relationship between

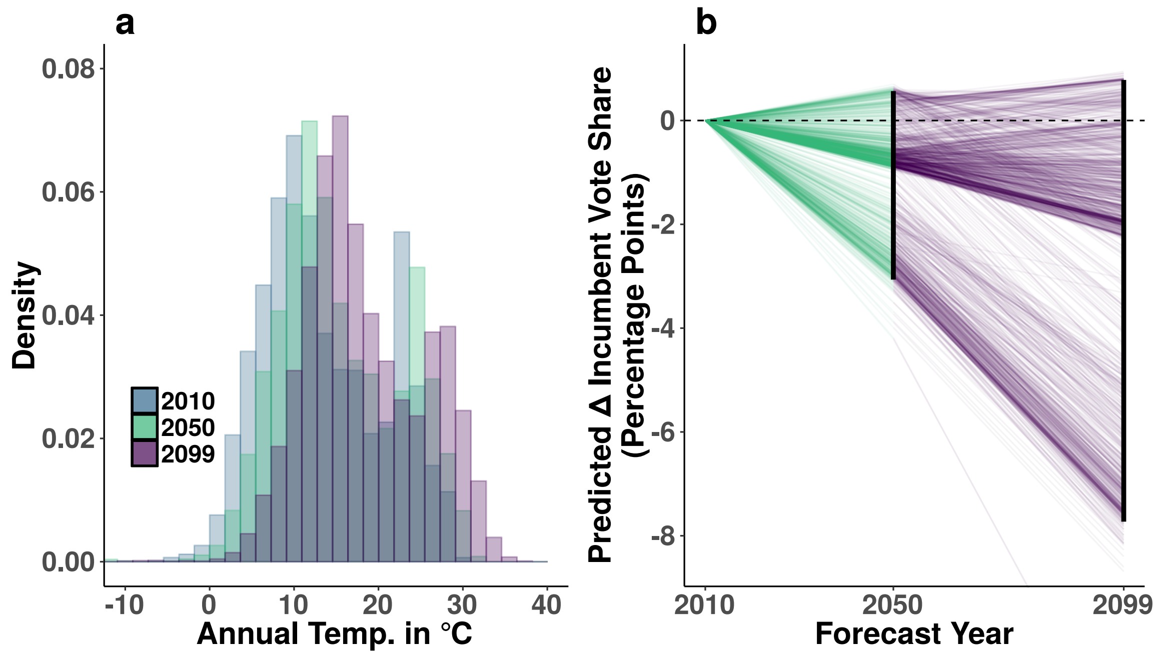

Figure 1.5: Climate change may speed democratic turnover via reductions to incumbent party vote share. Panel (a) depicts the distributions of annual temperature calculated from 21 downscaled climate models for the constituencies in the sample in 2010, 2050, and 2099. Annual temperatures increase in both magnitude and variation by 2050 and 2099 as compared to 2010. Panel (b) depicts the constituency-level forecasts for the impact of climate change on alterations in incumbent vote share in the future. To incorporate downscaled climate model uncertainty, I calculate an estimated change for an ensemble of 21 climatic models for each of the 1,256 constituencies, producing 26,376 estimates for both 2050 and 2099. I take the constituency average of these estimates, plotting the change between 2010 and 2050 with green lines and the predicted change between 2050 and 2099 with purple lines. The black vertical lines indicate the 2.5th to 97.5th percentile range across the average constituency estimates. As can be seen, currently hotter constituencies may experience markedly more negative changes to incumbent party vote share.

annual temperatures and changes in incumbent party vote share – employing a spline regression model that closely matches the results from Equation 1.1 – to calculate a forecast of possible alterations in future vote share due to climate change for each constituency across each downscaled climate model (see *Appendix: Constituency-Level Forecast*).

I define the constituency-level forecast of the predicted change in incumbent party vote share due to climate change by 2050 (V_{i2050}) as:

$$V_{i2050} = \overline{\Delta \hat{Y}_{ki2050} - \Delta \hat{Y}_{ki2010}} \tag{1.2}$$

and for the change from 2010 to 2099 (V_{i2099}) as:

$$V_{i2099} = \overline{\Delta \hat{Y}_{ki2099} - \Delta \hat{Y}_{ki2010}} \tag{1.3}$$

Where k indexes the 21 specific climate models and i indexes the constituencies. Further, $\Delta \hat{Y}_{ki}$ represents the fitted values derived from the a spline fit of the downscaled climate model data using the functional form from the estimated parameters of Equation 1.1 for 2050 and 2099 (see *Appendix: Main Forecast Model*). Of note, the results remain similar under the use of the fitted values from Equation 1.1 directly (see *Appendix: Alternative Forecast Model*). Using a full ensemble of climate models allows for incorporating uncertainty regarding the underlying climatic forecasts into the change in incumbent vote share predictions [95, 97].

Figure 1.5 panel (b) plots the forecast results. Each of the 1,256 constituencies in the sample has a mean prediction across all of the 21 downscaled climate models. The first quartile predicted reduction in incumbent vote share by 2099 is -5.8 percentage points while the median reduction is -1.9. Constituencies with higher historical annual temperatures experience the largest predicted future declines in incumbent vote share while cooler constituencies may experience more mild declines to even slight increases in vote share. However, the predicted negative impacts of climate change are over thirteen times greater in magnitude than are the positive impacts (the maximum mean prediction by 2099 among sample constituencies is 0.95 percentage points while the minimum mean prediction is -12.43 percentage points).

1.6 Country forecast

Some nations are hotter than others on average. This fact, coupled with the observation that the effects of temperature on changes to incumbent vote share are non-linear, with most acute effects observed at higher temperatures, leads to the fourth question: which countries may see the highest future increases in warming-induced democratic turnover?

Figure 1.6 plots country-level forecast results for 2050 and 2099, respectively. Bars for each country represent the average prediction across all of the 21 climate models across each of the constituencies within that country (see *Appendix: Country-Level Forecast*). Countries that have higher spatial variation in annual temperatures – such as the United States and Argentina – have a higher range of underlying constituency forecasts. Importantly, countries with higher average historical temperatures – such as Zambia, Brazil, and Colombia – may experience the most significant future reductions in incumbent vote share.

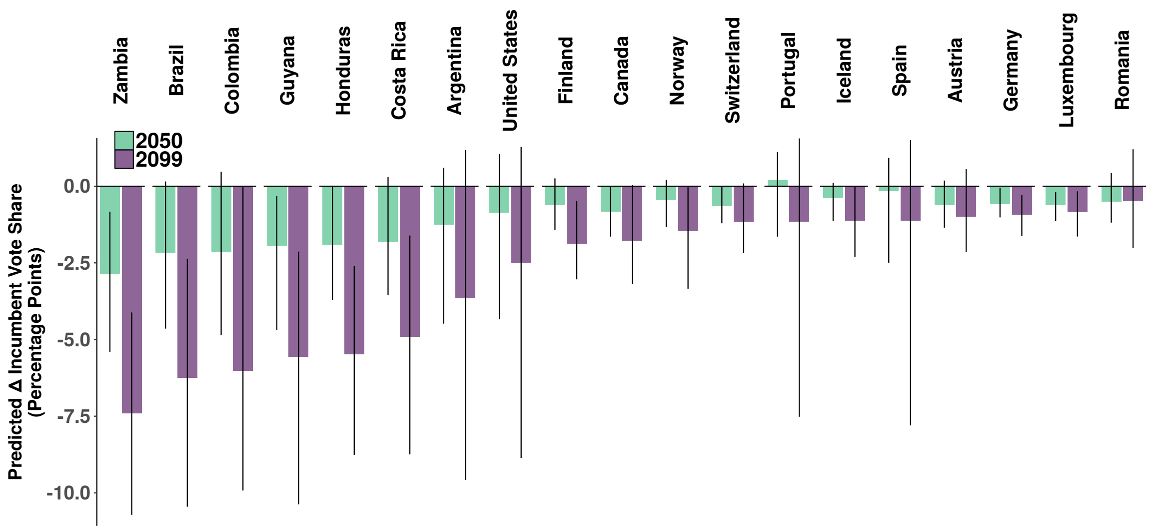

Figure 1.6: Climate change may increase the frequency of democratic turnover most in warmer, poorer nations. This figure depicts the country-level averages across the 26,376 constituency-level climate model forecasts for the impact of climate change on alterations to future incumbent vote share by 2050 and 2099. As can be seen, countries with constituencies that experience presently hotter annual temperatures – countries that include many of the poorest countries in the sample – are likely to experience the greatest climate-induced increase in democratic turnover. To incorporate both downscaled climate model uncertainty and intra-country variance, I present the 2.5th to 97.5th percentile range of the 21 climate models across each country's set of constituencies via the black vertical lines. Countries with greater intra-country variance in historical annual temperatures, like the United States, have a larger range of future constituency-level predictions.

1.7 Discussion

Voting is central to modern politics. It provides the primary means of democratic participation, shapes politicians' incentives, and regulates the nature of policies. The available evidence indicates that climate change may alter voting patterns in the future, increasing incumbent electoral losses and speeding rates of democratic turnover.

There are several considerations important to the interpretation of these results. First, while I have data from over a billion votes cast across more than a thousand constituencies, optimal data would also include countries not within the present sample. Of special import would be countries with high average annual temperatures, like those in Sub-Saharan Africa. The lack of available spatial data on such countries' historical electoral boundaries limits the current sample. Second, because I spatially average temperature and precipitation values to the constituency-level, measurement error may exist between average climatic conditions and those that voters actually experienced, possibly attenuating the estimated magnitude of the effects [105]. Third, these estimates are based exclusively on annual temperature and precipitation. Because climate change is likely to increase extreme weather events like tornadoes [106], and because such events can also reduce incumbent vote share [76], these results may underestimate the full impact of climate change on future democratic turnover. Finally, it is possible that voters may adapt to altered future climates with political behaviors not seen in the historical data.

Ultimately, turnover – when directly related to politician performance – is vital to well-functioning democracy [107]. However, the empirical results I present here indicate that democratic turnover might increase as a result of climatic events outside the control of individual politicians. This exogenously driven political turnover may shorten democratic time horizons, inducing parties and their politicians to focus on short-run policies at the expense of important longer-run strategies [58]. This pattern may have a particularly deleterious impact on climate mitigation, as its long-run benefits are unlikely to be observed from one election to the next. Moreover, the uncertainty induced by increasing rates of democratic turnover can directly upset macroeconomic outcomes [108, 109]. Even more starkly, turnover in nations with weak democratic institutions can upend political stability. If incumbents in weak democracies foresee a greater risk of losing office, they sometimes employ electoral fraud and pre-electoral violence to maintain power [110, 111]. If these methods fail, incumbents' loss occasionally precipitates post-electoral violence that can in turn induce broader civil conflict [112, 113]. These insights, when coupled with the empirical findings above, suggest climate change may alter the nature of democratic politics in costly ways in the future.

1.8 Appendix

1.8.1 Map of constituency boundaries

Figure 1.7 displays the constituency boundaries included in the analysis.

1.8.2 Data description

Political variables

I obtain constituency level electoral data from the Constituency Level Electoral Archive (CLEA). This is the most comprehensive global archive of constituency

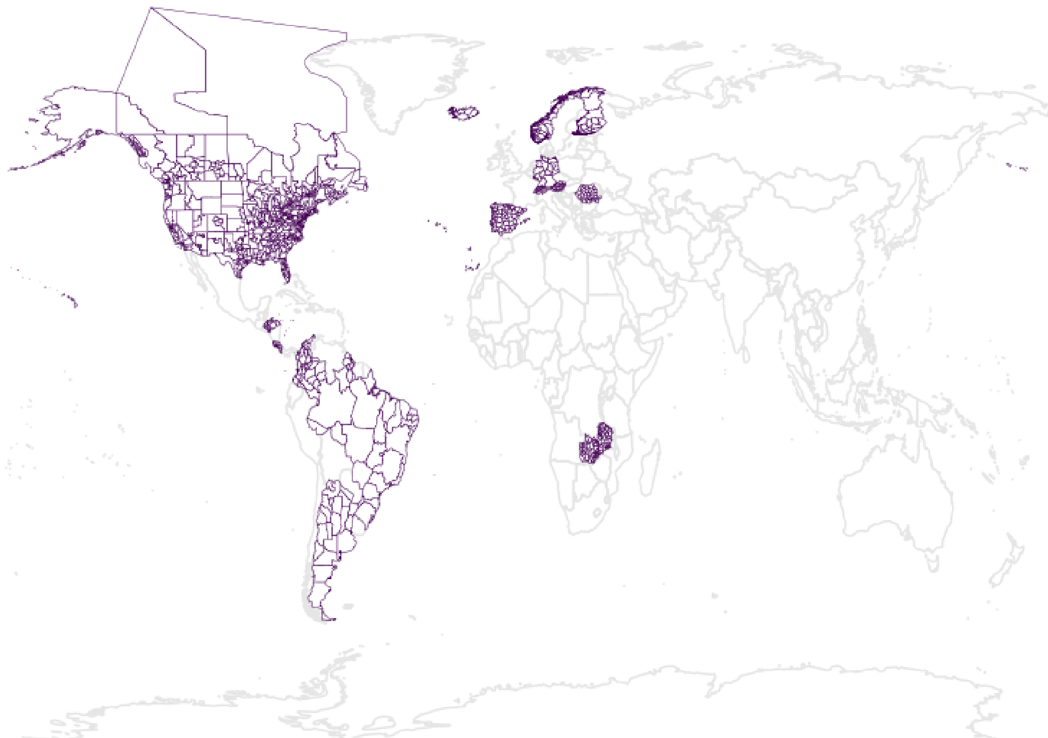

Figure 1.7: Plot of Constituency Boundaries. The constituencies included in the analysis have broad coverage across 19 countries, with unbalanced temporal coverage from 1925-2011.

level historical electoral returns for countries' national lower house. For each constituency within each country, the archive lists the month and year in which that election occurred. It also lists, for each party, the basis of the primary dependent variable: the party share of the constituency vote total. The dataset can be obtained here http://www.electiondataarchive.org/ and the codebook can be obtained here http://www.electiondataarchive.org/variables.html.

In order to map climatic data onto political variables, one needs a broad set of spatial electoral district boundaries. Until recently this was unavailable. A new product, the Geo-Referenced Electoral Database (GRED) has been released by the same researchers that produce CLEA. The GRED data represent – by far – the most comprehensive publicly accessible database of constituency spatial boundaries.

The GRED data contain a cross-sectional snapshot of constituency level electoral boundaries for a given country-year. Unfortunately, electoral boundaries change over time. Thus for any given country, the boundaries in GRED may be valid for only one election, for only a few elections, or, in some cases, for all of a country's elections. To determine which boundaries were valid for which country-years, I consulted the constituency boundary history for each country in the GRED data, keeping only those elections from CLEA for which the GRED boundaries are valid. The GRED data can be accessed here http://www.electiondataarchive.org/datacenter-gred.html.

CLEA data provides the share of the constituency vote total for each party running in a country's lower-house national legislative elections. The main dependent variable is the change in constituency vote share (from $t-1$) in election t of the party that won the majority of that constituency's vote in election $t-1$. This approach is consistent with previous literature that incorporates data from multiple electoral systems[1].

Most elections in the data are relatively competitive (the median major incumbent party vote share across constituencies is 46%). This can be seen in Figure 1.8, panel (b). The median change in incumbent party vote share is -4 percentage points.

Election years, constituencies, and votes

Because of the nature of electoral boundaries that regularly change in some countries and remain relatively fixed in others, the electoral boundary data enables use of longer periods of elections for some countries and shorter periods for others. Of additional note, because a year of data must be used in order to calculate constituency-level incumbents from the first period, I lose the first year of each new electoral boundary to calculating the dependent variable. Table 1.1 displays the number of years that each country enters the sample.

Further, constituencies vary in geographic size across countries. Some countries, like the United States, use smaller districts for their lower house elections than do other countries, like Brazil, who use larger geographic units. Table 1.1 also displays the number of unique constituencies that enter the sample for each country.

Table 1.1: Sample details

Country	Years	Constituencies	Obs.	Total Votes
Canada	3	308	739	3.441e+07
Colombia	3	33	83	2.413e+07
Costa Rica	14	7	98	1.437e+07
Finland	13	15	166	3.073e+07
Germany	5	16	56	1.743e+08
Argentina	9	24	110	8.213e+07
Guyana	5	10	30	587520
Honduras	6	18	108	2.572e+07
Iceland	10	8	88	1.351e+06
Austria	5	43	173	1.924e+07
Luxembourg	17	4	53	3.304e+07
Norway	15	19	285	3.368e+07
Portugal	12	20	197	5.42e+07
Romania	3	41	62	1.695e+07
Spain	10	52	465	1.984e+08
Switzerland	3	26	66	5.275e+06
Brazil	5	27	128	3.6e+08
United States	5	435	1645	3.878e+08
Zambia	3	150	328	3.877e+06

Temperature and precipitation

CRU meteorological data

I employ the gridded global temperature and precipitation data produced by the Climatic Research Unit (CRU)[2]. This is one of the most frequently utilized datasets in the economic and social analysis of the impacts of the climate on social phenomena[3]. These data are on a 0.5x0.5 grid and are monthly from 1901 to 2013. Using the *raster* package in **R** and employing the San Diego Supercomputer Center's Gordon supercomputer, I spatially averaged the grid cells to constituency boundaries for each historical month.

Annual temperature

I calculate the year prior to election temperature variable as:

$$Temp._{jt} = \overline{12\ Months\ Prior\ to\ Election\ Temp._{jt}}$$

where j is constituency and t is election year. Temperature is measured in °C. Using yearly mean temperature is consistent with the literature on the effects of climate on aggregate economic output[4–6]. The distribution of these anomalies can be seen in Figure 1.9, panel (a) while temperature over time can be seen in Figure 1.10, panel (a).

Annual precipitation

To calculate the annual sumtotal precipitation variable, I calculate the 12 months preceding an election's total precipitation:

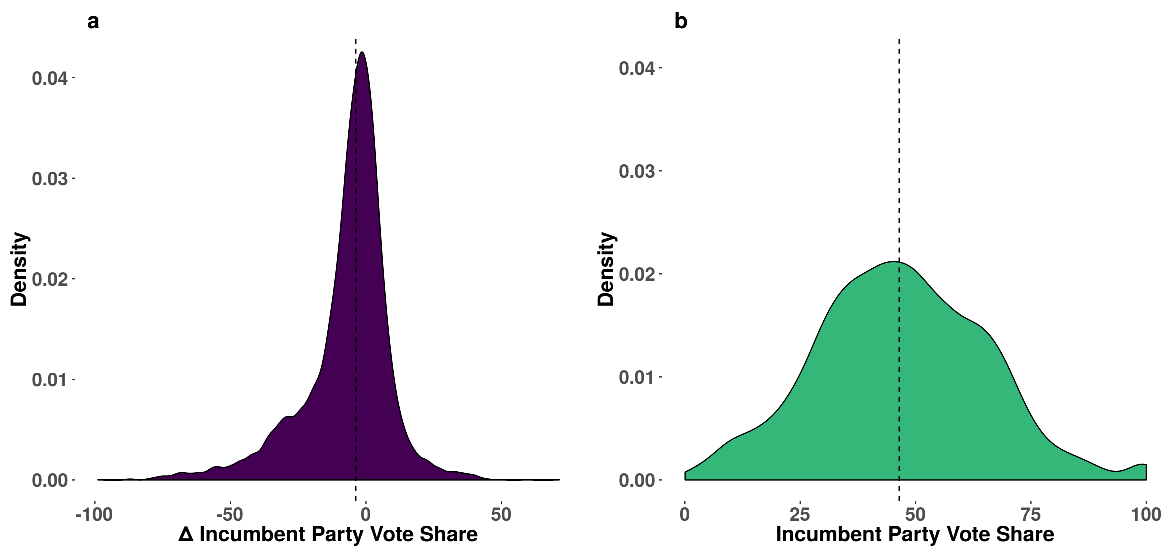

Figure 1.8: Density plot of changes to major incumbent party constituency vote share and level of incumbent party vote share. Dashed lines represent medians of the respective distributions.

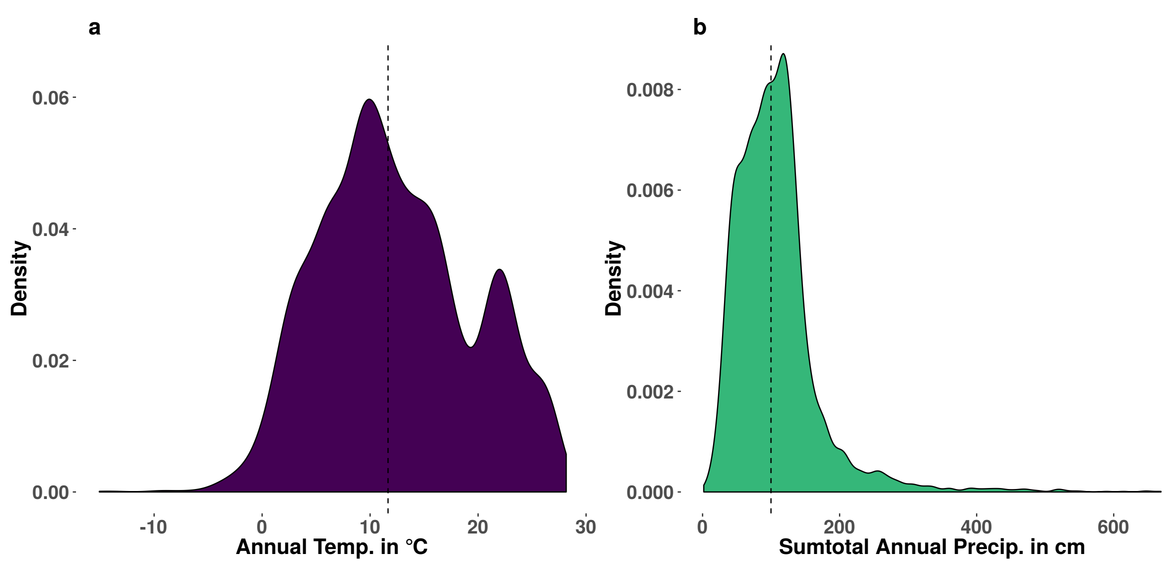

Figure 1.9: Density plots of annual temperature and precipitation variables.

$$Sumtotal\ Precip._{jt} = \Sigma 12\ Months\ Prior\ to\ Election\ Prcp._{jt}$$

where again j is constituency and t is election year.

Precipitation is measured in cm. The distribution of precipitation can be seen in Figure 1.9, panel (b) while annual precipitation over time can be seen in Figure 1.10, panel (b).

Climate model data

NASA NEX bias-corrected spatially downscaled climate forecast data

For the forecast, I employ bias-corrected spatially downscaled (BCSD) climate forecast data from 21 global circulation model temperature and precipitation outputs in the CMIP5 model comparison project[7], using the RCP 8.5 emissions scenario[8]. These datasets consisted of daily level 0.25x0.25 grid cells for total precipitation and maximum and minimum temperatures (which were averaged to create the average temperature forecasts). The years span 2010-2099, though because of the size of these data, I select the years 2010, 2050, and 2099 for analysis. Again using the *raster* package in **R** and employing the San Diego Supercomputer Center's Gordon supercomputer, I spatially averaged the NEX BCSD grid cells to constituency boundaries. The NEX BCSD data can be obtained from https://cds.nccs.nasa.gov/nex-gddp/.

1.8.3 Regression tables

Main effect

In this section I present the regression table associated with the regression from Equation 1 in the main text. The unit of analysis is the constituency-year, with analysis weighted by the number of votes cast in each constituency-election. The dependent variable throughout is the change in the vote share of the party that won the highest number of votes in the last constituency election – the constituency incumbent party[1]. The main independent variable is annual average temperature in the twelve months prior to the election. The main model results are presented in model (1) of Table 1.2.

Model (2) includes a squared precipitation term to check for a non-linear relationship, Model (3) includes controls for the month prior to election temperature and precipitation, Model (4) includes squared month prior meteorological variables to check for non-linear relationships, and Model (5) excludes all these controls, including only temperature. As can be seen, the results on the annual temperature bins remain consistent with the removal/inclusion of these controls. Because of the potential for precipitation to serve as an omitted variable – biasing coefficient estimates – I report the estimates of model (1) in the main text.

Time and location controls

The main specification employs constituency, year, election month, and country-specific year indicators to partial out the potentially confounding effects of location, time, and country-specific trends on the estimated annual temperature coefficients[6]. However, the results are robust to altering these specifications[9]. Table 1.3 presents

Table 1.2: Annual temperature, precipitation, and change in incumbent vote share

	DV: Change in Incumbent Party Vote Share				
	(1)	(2)	(3)	(4)	(5)
$AnnualT \in (-\infty, -4]$	9.212	9.334	8.572	8.610	9.100
	(7.352)	(7.274)	(7.139)	(7.761)	(7.314)
$AnnualT \in (-4, 1]$	2.686	2.747	2.446	2.207	2.601
	(4.013)	(3.999)	(4.085)	(4.310)	(4.012)
$AnnualT \in (1, 6]$	2.164	2.262	1.992	1.691	2.108
	(3.304)	(3.276)	(3.467)	(3.584)	(3.303)
$AnnualT \in (6, 11]$	−0.179	−0.072	−0.367	−0.561	−0.224
	(1.915)	(1.867)	(1.987)	(2.072)	(1.917)
$AnnualT \in (11, 16]$	−1.783	−1.712	−1.863	−1.888	−1.803
	(1.538)	(1.543)	(1.671)	(1.724)	(1.528)
$AnnualT \in (21, 26]$	−9.024***	−8.993***	−8.906***	−8.858***	−8.897***
	(2.999)	(2.978)	(2.985)	(2.991)	(3.005)
$AnnualT \in (26, \infty]$	−16.100***	−16.558***	−16.105***	−15.943***	−15.803***
	(4.569)	(4.760)	(4.669)	(4.756)	(4.465)
Annual Precip.	−0.008	−0.038	−0.015	−0.015	
	(0.014)	(0.033)	(0.015)	(0.016)	
Annual Precip.^{2}		0.0001			
		(0.0001)			
Month Temp.			−0.531	−0.240	
			(0.488)	(0.386)	
Month Precip.				−0.012	
				(0.013)	
Month Temp.^{2}			0.072	0.073	
			(0.075)	(0.108)	
Month Precip.^{2}				−0.0001	
				(0.001)	
Constituency FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Election Month FE	Yes	Yes	Yes	Yes	Yes
Country:Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4,880	4,880	4,880	4,880	4,880
R^2	0.453	0.453	0.454	0.454	0.453
Adjusted R^2	0.215	0.215	0.216	0.216	0.215
Residual Std. Error	6,106.697	6,105.695	6,102.489	6,102.820	6,106.203

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parentheses clustered on constituency-year

the results of alternative specifications (with model (6) replicating the model from Equation 1 in the main text). The results are consistent across controlling for only constituency fixed effects (model (2)), controlling for only constituency and year fixed effects without election month or flexible country trends (model (3)), the exlusion of country-specific trends (model (4)), the replacement of country-specific year trends with continent-specific year trends (model (5)), and to controlling for all constituency, year, election month, and country-specific potentially unobserved, constant confounds (model (6)), same as main text Equation 1). Because the latter specification is most conservative, I select it as the main model as given by Equation 1 in the main text.

Bonferroni correction

In this section I present the regression table associated with the regression from Equation 1 in the main text, calculating Bonferroni corrections for the p-values on the eight meteorological coefficients in the model. This is a conservative procedure for dealing with the potentially inflated family-wise error rate associated with multiple hypothesis testing for each coefficient on each bin in this non-linear specification[10,11]. Nonetheless, after Bonferroni correction, temperatures above the $AnnualT \in (16, 21]$ bin still retain significance at p$<$0.05. Table 1.4 presents this regression. Of note, the p-value on the $AnnualT \in (21, 26]$ coefficient after Bonferroni correction is 0.021 and is 0.003 for the $AnnualT \in (26, \infty]$ coefficient.

Linear and polynomial specifications

The main specification employs temperature bins to flexibly estimate the non-linear relationship between temperature and changes in incumbent party vote

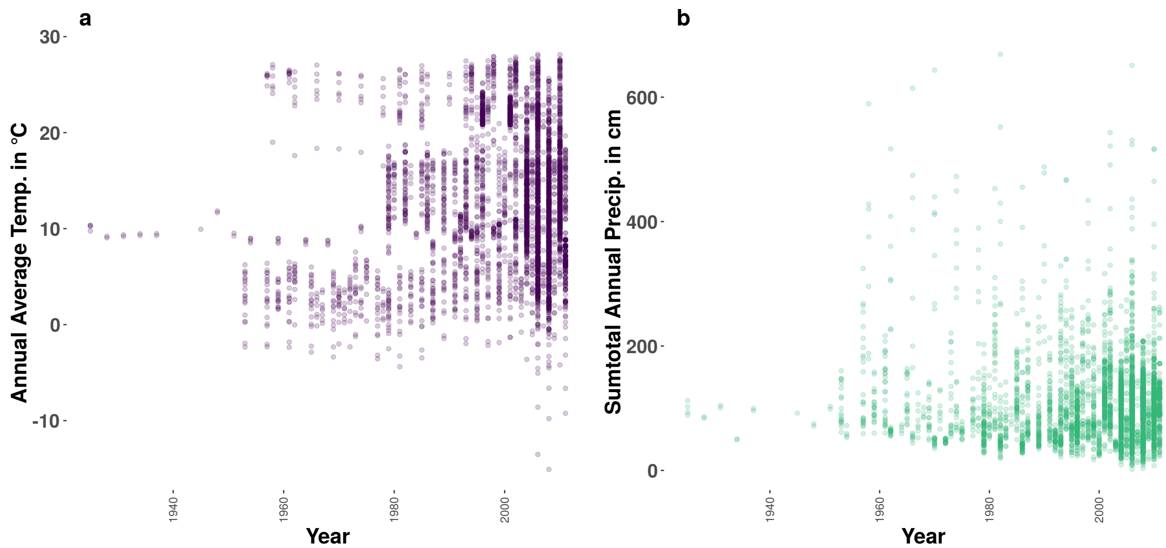

Figure 1.10: Plots of average temperature and sumtotal precipitation by year.

Table 1.3: Alternative time and location fixed effects

	DV: Change in Incumbent Party Vote Share					
	(1)	(2)	(3)	(4)	(5)	(6)
$AnnualT \in (-\infty, -4]$	−1.375	12.445**	8.279	8.052	11.346	9.212
	(1.118)	(5.829)	(7.751)	(7.450)	(7.132)	(7.352)
$AnnualT \in (-4, 1]$	−0.807	10.709**	3.106	3.046	4.845	2.686
	(1.374)	(5.452)	(5.266)	(4.751)	(3.870)	(4.013)
$AnnualT \in (1, 6]$	−2.674**	7.929*	3.006	3.140	3.482	2.164
	(1.156)	(4.083)	(4.124)	(3.732)	(3.336)	(3.304)
$AnnualT \in (6, 11]$	−4.303**	3.085	1.294	0.946	0.471	−0.179
	(1.842)	(3.704)	(3.116)	(2.581)	(2.333)	(1.915)
$AnnualT \in (11, 16]$	−5.340***	−0.735	−0.581	−0.843	−1.148	−1.783
	(1.276)	(2.172)	(2.646)	(2.215)	(1.924)	(1.538)
$AnnualT \in (21, 26]$	−4.293***	−10.405***	−9.464***	−9.336***	−8.560***	−9.024***
	(1.538)	(2.988)	(2.931)	(3.022)	(2.967)	(2.999)
$AnnualT \in (26, \infty]$	−7.107***	−15.212***	−14.782***	−14.500***	−15.281***	−16.100***
	(1.680)	(4.562)	(4.575)	(4.879)	(4.769)	(4.569)
Annual Precip.	−0.005	0.001	−0.007	0.003	0.002	−0.008
	(0.008)	(0.013)	(0.011)	(0.011)	(0.014)	(0.014)
Constituency FE	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes
Election Month FE	No	No	No	Yes	Yes	Yes
Continent:Year FE	No	No	No	No	Yes	No
Country:Year FE	No	No	No	No	No	Yes
Observations	4,880	4,880	4,880	4,880	4,880	4,880
R^2	0.007	0.315	0.410	0.424	0.444	0.453
Adjusted R^2	0.005	0.076	0.191	0.207	0.212	0.215
Residual Std. Error	6,874.297	6,625.284	6,199.136	6,136.871	6,118.891	6,106.697

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parentheses clustered on constituency-year

Table 1.4: Bonferroni corrected p-values for main specification

	DV: Change in Incumbent Party Vote Share
$AnnualT \in (-\infty, -4]$	9.212
	(7.352)
$AnnualT \in (-4, 1]$	2.686
	(4.013)
$AnnualT \in (1, 6]$	2.164
	(3.304)
$AnnualT \in (6, 11]$	−0.179
	(1.915)
$AnnualT \in (11, 16]$	−1.783
	(1.538)
$AnnualT \in (21, 26]$	−9.024**
	(2.999)
$AnnualT \in (26, \infty]$	−16.100***
	(4.569)
Annual Precip.	−0.008
	(0.014)
Constituency FE	Yes
Year FE	Yes
Election Month FE	Yes
Country:Year FE	Yes
Observations	4,880
R^2	0.453
Adjusted R^2	0.215
Residual Std. Error	6,106.697

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parentheses clustered on constituency-year

share. Table 1.5 presents the results of alternative specifications of temperature, with temperature entering linearly (model (1)) and then entering with progressively higher order polynomials (models (2-4)). Fourth order polynomials (model (4)) gain marginal significance, as their functional form most closely approximates the functional form of Figure 1, panel (a) in the main text. However, because of the imposition of parametric functional form and the relative complexity of interpreting the marginal effects and standard errors associated with fourth order polynomials, I prefer the flexible non-linear estimation provided by Equation 1 in the main text[3,12].

Spatial and serial correlation

In the main text results, I report standard errors that allow for within-constituency and within-year correlations in the error term[13–15]. The use of standard errors clustered in this manner is common in the existing literature that examines the potential for climate change to alter social outcomes[6,16,17]. However, temperature and, to a lesser extent, precipitation are often spatially correlated. Thus, it is important to check to see if the inferential results are substantially affected by accounting for possible temporal and spatial correlation of the errors[3].

To flexibly account for both spatial dependence and serial dependence within constituencies, I implement nonparametric estimation of the variance-covariance matrices, producing heteroskedasticity, serial correlation, and spatial correlation robust (Conley) standard errors[18–20].[1] This method allows for contemporaneous spatial correlations between constituencies whose centroids fall within a wide limiting proximity (1,000 kilometers) to one another. Of note, the Conley code allows for

[1] I thank Darin Christensen and Thiemo Fetzer for providing the basic **R** code – in turn derived from Solomon Hsiang's code[20] – that I modified to calculate Conley errors.

Table 1.5: Linear and polynomial specifications

	DV: Change in Incumbent Party Vote Share			
	(1)	(2)	(3)	(4)
Annual Temp.	−1.072	0.385	−3.840	−2.364
	(0.852)	(2.862)	(2.624)	(1.804)
Annual Precip.	−0.007	−0.010	-0.014^{*}	-0.017^{**}
	(0.007)	(0.006)	(0.008)	(0.008)
Annual Temp.^{2}		−0.056	0.314	−0.161
		(0.109)	(0.215)	(0.169)
Annual Temp.^{3}			−0.009	0.025^{*}
			(0.007)	(0.015)
Annual Temp.^{4}				-0.001^{*}
				(0.0004)
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Election Month FE	Yes	Yes	Yes	Yes
Country:Year FE	Yes	Yes	Yes	Yes
Observations	4,880	4,880	4,880	4,880
R^2	0.450	0.450	0.451	0.452
Adjusted R^2	0.211	0.212	0.213	0.214
Residual Std. Error	6,120.332	6,120.031	6,115.173	6,109.540

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Standard errors in parentheses clustered on constituency-year

Table 1.6: Conley spatial standard errors

	DV: Change in Incumbent Party Vote Share	
	Multiway SE	Conley SE
	(1)	(2)
$AnnualT \in (-\infty, -4]$	8.279	8.279
	(7.751)	(6.444)
$AnnualT \in (-4, 1]$	3.106	3.106
	(5.266)	(4.302)
$AnnualT \in (1, 6]$	3.006	3.006
	(4.124)	(3.234)
$AnnualT \in (6, 11]$	1.294	1.294
	(3.116)	(2.982)
$AnnualT \in (11, 16]$	−0.581	−0.581
	(2.646)	(1.923)
$AnnualT \in (21, 26]$	-9.464^{***}	-9.464^{***}
	(2.931)	(3.067)
$AnnualT \in (26, \infty]$	-14.782^{***}	-14.782^{***}
	(4.575)	(4.686)
Annual Precip.	−0.007	−0.007
	(0.011)	(0.018)
Constituency FE	Yes	Yes
Year FE	Yes	Yes
Observations	4,880	4,880
R^2	0.410	0.410
Adjusted R^2	0.191	0.191
Residual Std. Error	6,199.136	6,199.136

Note: *p<0.1; **p<0.05; ***p<0.01
Spatial HAC Conley standard errors use 1,000km bandwidth.
SEs in model (1) are clustered on constituency and year.

only two sets of fixed effects, so in the examinations of spatial dependence I include constituency and year fixed effects only, excluding election month and country-specific year fixed effects.

The results of calculating the standard errors for the main text regression in this manner – using a 1,000km constituency centroid-to-centroid cutoff and allowing for full serial correlation – are presented in Table 1.6. As can be seen, the Conley standard errors are only slightly larger than the standard errors clustered on constituency and year, and resultant p-values are still highly significant on temperature bins greater than 21°C. Of important note, the median distance from a constituency's centroid to the nearest centroid of its neighboring constituency is 55 kilometers. Over 99% of constituencies' centroids fall within 1,000km of the centroid of their nearest neighbor.

Rich and poor

In this section I present the regression tables associated with the regression from the main text that splits Equation 1 by rich versus poor countries (countries above or below the global average per-capita income in 1980, similar to how Burke et. al (2015) conduct their split using median income in 1980[6]). 'Rich' countries in this split are: Canada, Finland, Germany, Iceland, Austria, Luxembourg, Norway, Portugal, Spain, Switzerland, and the United States. 'Poor' countries in this split are: Colombia, Costa Rica, Argentina, Guyana, Honduras, Romania, Brazil, and Zambia. As can be seen, the sample of elections from rich countries is over four times as large as that from poor countries. Table 1.7 presents the results of these regressions. Though the sample size is smaller for poor countries, the effects of hot temperatures across constituencies in these nations still gain significance at standard levels. The coefficients on the temperature bin above 21°C in rich countries is negative but gains significance only at the $p < 0.10$ level.

Agricultural and non-agricultural

In this section I present the regression tables associated with the regression from the main text that splits Equation 1 by agricultural versus non-agricultural constituencies (constituencies above or below the median of percentage of average remote-sensed croplands[21]). Table 1.8 displays the number of unique constituencies that are classified as either agricultural or non-agricultural for each country in the sample, excluding Zambia. Remote sensing technologies perform poorly at acurately classifying agricultural lands in Sub-Saharan Africa[22], and thus I omit Zambia from the main agricultural analysis.

Table 1.7: Regressions splitting by poor vs. rich countries

	DV: Change in Incumbent Party Vote Share	
	Poor Countries	Rich Countries
	(1)	(2)
$AnnualT \in (-\infty, -4]$		8.668
		(7.664)
$AnnualT \in (-4, 1]$		2.133
		(4.003)
$AnnualT \in (1, 6]$	-7.442	1.458
	(17.238)	(3.387)
$AnnualT \in (6, 11]$	25.776^{***}	-2.061
	(8.767)	(1.684)
$AnnualT \in (11, 16]$	10.875	-2.468^{*}
	(7.112)	(1.433)
$AnnualT \in (21, 26]$	-7.841^{*}	-13.677^{*}
	(4.058)	(7.912)
$AnnualT \in (26, \infty]$	-15.162^{***}	
	(5.287)	
Annual Precip.	-0.018	0.010
	(0.015)	(0.026)
Constituency FE	Yes	Yes
Year FE	Yes	Yes
Election Month FE	Yes	Yes
Country:Year FE	Yes	Yes
Observations	947	3,933
R^2	0.676	0.345
Adjusted R^2	0.438	0.086
Residual Std. Error	6,627.654	6,021.438

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parentheses clustered on constituency-year

Table 1.8: Number of ag. and non-ag. constituencies by country

Country	Ag. Constituencies	Non-Ag. Constituencies
Argentina	6	18
Austria	22	21
Brazil	8	19
Canada	147	161
Colombia	15	18
Costa Rica	6	1
Finland	1	14
Germany	15	1
Guyana	2	8
Honduras	13	5
Portugal	14	6
Spain	44	8
Switzerland	18	8
United States	213	222

Table 1.9 presents the results of regressions that split the sample by agricultural versus non-agricultural constituencies. Of note, as can be seen in models (3) and (4) that include Zambia, the results are not particularly sensitive to the inclusion or exclusion of Zambian elections, even though agriculture is measured with high-error in the country. Because of the relatively low level of agricultural intensification in Zambia[21], all of its constituencies are classified as non-agricultural (due to mismeasurement mentioned above). Hot temperatures in agricultural constituencies produce significantly more negative changes in incumbent party vote share. Hot temperatures in non-agricultural constituencies are also associated with reduced vote share, though these effects do not gain significance.

Income and agriculture

In this section I present the tables associated with the regression from the main text that splits Equation 1 by non-agricultural constituencies from rich countries versus agricultural constituencies from poor countries. I also investigate the differential effects between rich country agricultural constituencies and poor country non-agricultural constituencies. Table 1.10 displays the number of unique constituencies that are classified as either poor agricultural, rich agricultural, poor non-agricultural, or rich non-agricultural for each country in the sample.

Table 1.9: Regressions splitting by non-ag. vs. ag. constituencies

	DV: Change in Incumbent Party Vote Share			
	Non-Ag.	Ag.	Non-Ag, Zambia	Ag., Zambia
	(1)	(2)	(3)	(4)
$AnnualT \in (-\infty, -4]$	15.288		15.305	
	(11.053)		(11.208)	
$AnnualT \in (-4, 1]$	7.366	28.221**	7.384	28.221**
	(7.192)	(14.173)	(7.295)	(14.173)
$AnnualT \in (1, 6]$	7.477	1.029	7.493	1.029
	(6.794)	(7.728)	(6.892)	(7.728)
$AnnualT \in (6, 11]$	4.540	−1.685	4.552	−1.685
	(5.769)	(2.107)	(5.850)	(2.107)
$AnnualT \in (11, 16]$	1.795	−2.680	1.795	−2.680
	(2.486)	(1.854)	(2.519)	(1.854)
$AnnualT \in (21, 26]$	−9.947	−9.706***	−9.412	−9.706***
	(8.494)	(3.546)	(8.439)	(3.546)
$AnnualT \in (26, \infty]$	−18.175	−14.847***	−17.646	−14.847***
	(11.982)	(5.746)	(12.081)	(5.746)
Annual Precip.	−0.028	0.007	−0.029	0.007
	(0.038)	(0.020)	(0.038)	(0.020)
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Election Month FE	Yes	Yes	Yes	Yes
Country:Year FE	Yes	Yes	Yes	Yes
Observations	2,281	2,271	2,609	2,271
R^2	0.387	0.512	0.401	0.512
Adjusted R^2	0.103	0.270	0.099	0.270
Residual Std. Error	5,843.705	6,754.601	5,572.362	6,754.601

Note: *p<0.1; **p<0.05; ***p<0.01

Standard errors in parentheses clustered on constituency-year

Table 1.10: Ag./non-ag. constituencies by rich and poor countries

Country	Rich Ag.	Poor Ag.	Rich Non-Ag.	Poor Non-Ag.
Austria	22	0	0	0
Canada	147	0	0	0
Finland	1	0	0	0
Germany	15	0	0	0
Luxembourg	4	0	0	0
Portugal	14	0	0	0
Spain	44	0	0	0
Switzerland	18	0	0	0
United States	213	0	0	0
Argentina	0	6	0	0
Brazil	0	8	0	0
Colombia	0	15	0	0
Costa Rica	0	6	0	0
Guyana	0	2	0	0
Honduras	0	13	0	0
Romania	0	41	0	0
Austria	0	0	21	0
Canada	0	0	161	0
Finland	0	0	14	0
Germany	0	0	1	0
Iceland	0	0	8	0
Norway	0	0	19	0
Portugal	0	0	6	0
Spain	0	0	8	0
Switzerland	0	0	8	0
United States	0	0	222	0
Argentina	0	0	0	18
Brazil	0	0	0	19
Colombia	0	0	0	18
Costa Rica	0	0	0	1
Guyana	0	0	0	8
Honduras	0	0	0	5
Zambia	0	0	0	150

Table 1.11 presents the results of regressions that split the sample by rich country agricultural constituencies versus poor country agricultural constituencies (models (1-2)) as well as by rich vs. poor country non-agricultural constituencies (models (3-4)). Because of above mentioned issues with measurement of croplands in Zambia, I exclude it from these analyses. As can be seen, agricultural constituencies in poor nations exhibit the largest significant negative response to high temperature shocks. Of note, high temperatures in non-agricultural constituencies in rich nations also produce negative changes in incumbent vote share, though this effect is only significant at the $p < 0.10$ level.

1.8.4 Alternative temperature bins

In this section I vary the size of the temperature bins associated with model (1) of Table 1.2, the main specification, ensuring the reference category still contains 18.5°C (65°F). Bin sizes of 2°C and 1°C each demonstrate reductions in vote with increasing annual temperatures. Splitting the bin sizes smaller than 5°C reduces the number of observations within each bin and increases associated standard errors. Because each 5°C bin includes more constituencies in each bin from a variety of countries, I choose 5°C bin sizes for the main specification. These results can be seen in Figure S5

1.8.5 Frequency of close elections

To evaluate the size of the effect of estimated electoral swings, I use the full Constituency Level Electoral Archive (CLEA) for each country in the main dataset, which provides a broader accounting of historical elections than does the sample that

Table 1.11: Regressions splitting by rich/poor, ag./non.ag

	DV: Change in Incumbent Party Vote Share			
	Rich Ag.	Poor Ag.	Rich Non-Ag.	Poor Non-Ag.
	(1)	(2)	(3)	(4)
$AnnualT \in (-\infty, -4]$			14.967	
			(11.883)	
$AnnualT \in (-4, 1]$	31.583**		7.016	
	(13.710)		(7.854)	
$AnnualT \in (1, 6]$	4.100	−8.436	7.155	
	(7.232)	(20.040)	(7.418)	
$AnnualT \in (6, 11]$	−3.289**	22.985***	4.255	7.172
	(1.441)	(7.171)	(6.366)	(8.583)
$AnnualT \in (11, 16]$	−2.991*	2.517	1.561	5.358
	(1.785)	(4.983)	(2.612)	(4.573)
$AnnualT \in (21, 26]$	0.435	−11.760***	−20.604*	4.428
	(8.963)	(3.453)	(10.654)	(6.676)
$AnnualT \in (26, \infty]$		−17.645***		−3.936
		(6.236)		(12.618)
Annual Precip.	0.030	−0.012	−0.023	−0.044
	(0.038)	(0.020)	(0.028)	(0.136)
Constituency FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Election Month FE	Yes	Yes	Yes	Yes
Country:Year FE	Yes	Yes	Yes	Yes
Observations	1,927	344	2,006	268
R^2	0.335	0.816	0.393	0.374
Adjusted R^2	0.031	0.620	0.129	−0.392
Residual Std. Error	6,686.736	7,537.541	5,393.705	10,101.550

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors in parentheses clustered on constituency-year

is constrained by the availability of spatial electoral boundaries. The CLEA dataset has 59,171 total constituency-election observations for the countries included in this analysis.

To see whether the magnitude of the marginal effect of temperature increases on vote share has the potential to be politically meaningful, I examine the number of constituency-level elections with historical temperatures between 16°C and 21°C whose returns were closer than the nine percentage point reduction in the change in incumbent vote share associated with a shift between this baseline category of 16°C-21°C to the 21°C-26°C range. Of important note, an incumbent's loss of vote share means – mechanically – that challenging parties will receive a boost of some fraction of the lost vote share in that constituency. In the case of constituencies with only two main parties competing for power, a nine percentage point reduction in incumbent vote share produces an eighteen percentage point swing in vote share. In the full historical electoral data 19% of all constituencies have only two parties while 39% have either only two or only three parties.

Of constituency-level elections in constituencies with annual temperatures between 16°C and 21°C, 31% had parties that won by nine percentage points or less, the marginal effect of moving from the 16°C-21°C baseline bin to the 21°C-26°C bin, or the effect of a 5°C average increase in annual temperature – approximately the average increase projected by 2099 by climate models for these constituencies as compared to the 2010 baseline (more precisely, 4.5°C under the RCP8.5 emissions scenario). In electoral contests with only two parties, the effect of a nine percentage point reduction in vote share is amplified into an eighteen percentage point electoral swing. In the historical data, 41% of two-party constituencies in this temperature range were won by

18 percentage points or less. Ultimately, the sizable effects associated with increases in annual temperature projected by 2099 have the potential to alter the outcomes of a large portion of future electoral contests.

1.8.6 Forecast details

Main forecast model

The primary specification from Equation 1 in the main text uses annual temperature bins to non-linearly estimate the relationship between temperature and changes to constituency-level incumbent party vote share (the results of estimating this equation can be seen in Table 1.2). One option to conduct a forecast with future climate model data would be to directly employ the estimated coefficients from model (6) of Table 1.2 in the forecast. Doing so would have the conservative effect of assigning future temperature values that fall outside of the support of the historical distribution to the maximum bin in the historical data. However, employing this method would also have a number of drawbacks. First, the underlying historical temperature distribution is not perfectly smooth, given the cross-country variations in temperature regimes. Because bin-width in Equation 1 is 5°, constituencies whose average temperature was just greater than 21°C (70°F) would be assigned the coefficient associated with the 21-26°C bin until future temperatures increased beyond 26°C. Thus, many constituencies might show zero effect of future climatic changes simply because their full predicted warming this century might not push them into the next higher temperature bin. The second drawback to this approach relates to the conservativeness associated with assigning future values of temperature to the maximum historical temperature coefficient. One may reasonably expect that the effects of temperature on human economic, psychological, and physiological well-being will not remain flat as future temperatures exceed historical maximums. Thus using only binned coefficient values may be an overly conservative approach.

To address these issues, I build a linear spline function that matches the functional form revealed by connecting the midpoints of the historical temperature bins to one another. This has the advantage of allowing constituencies to increase or decrease linearly between the midpoints from Equation 1. It also has the added benefit of allowing for linear extrapolation of historical relationships to novel future temperatures, and is thus likely to more accurately reflect human exposure to heightened temperatures. I fit the coefficient on year prior sumtotal precipitation to future predicted precipitation data and include it in the fitted values of the forecast. The spline function used is depicted by the red line in Figure S6.

Alternative forecast model

In this section I depict the results of employing the estimated coefficients from Equation 1 directly – coupled with climate model predictions – to conduct the forecast. As can be seen in the replication of Figure 5 from the main text, in Figure S7, the average constituency prediction is for a decrease of -1.71 percentage points in incumbent party vote share. Because some constituencies do not completely shift from one temperature bin to another, their change from 2010 to 2050 to 2099 is largely determined by changes in annual precipitation, given by the negative linear slope on annual precipitation from Equation 1. Even with this forecasting procedure, the average climate change induced reduction is negative as constituencies are pushed into higher temperature regimes.

I replicate Figure 6 from the main text in Figure S8. The set of countries likely to see the greatest reductions remains the same, though the error bars increase as a result of increased intra-country variance due to the coarser bin function of Equation 1 as compared to the spline forecast.

Constituency-level forecast

To conduct the forecast plotted in Figure 5 in the main text, I first calculate the 2010, 2050, and 2099 average maximum temperature, minimum temperature, and precipitation forecasts from all 21 of NASA's NEX GDDP bias corrected statistically downscaled (BCSD) climate models[23] (drawn from the CMIP5 model ensemble[7] using the RCP8.5 'business-as-usual' model scenario[8]). This gives me a yearly average value for each grid cell across the globe. Since the NEX data do not provide average temperatures directy, I take the average between maximum and minimum temperatures as the yearly average temperature. Next, I extract – using spatial weighting – both the annual temperature and sumtotal annual precipitation forecasts to the constituency boundaries in the historical data for each of 2010, 2050, and 2099. These forecasts then represent the constituency-levl annual climate model projections across all 21 climate models in the NEX data.

I then employ the fitted spline model from *Appendix: Main Forecast Model* to calculate the fitted values associated with the historical model for each future year for each of the 21 BCSD climate models. Then, for each constituency-year and model, I subtract the fitted values in 2050 from the baseline period of 2010 and then take the marginal difference from 2050 to 2099. This procedure results in an estimated change in incumbent party vote share due to climate change for each constituency-year, for each climate model. I then take the average for each constituency across the 21 models and present these values in panel (b) in the main text Figure 5.

Country-level forecast

To calculate forecasts at the country level for 2050 and 2099, I again employ the spline fit from *Appendix: Main Forecast Model* to calculate the difference in fitted values for each constituency, for each climate model. In this forecast, I calculate the difference between 2050 and 2010 and between 2099 and 2010, respectively. I then, for each country in the data, take the average predicted change across all of a country's constituencies in a given future year and use this as the country-level prediction in Figure 6 in the main text.

The black error bars in this plot represents the 2.5th to 97.5th percentile range of constituency-level predictions across all climate models within a country. Countries that have larger error bars have greater climatic heterogeneity within in them and/or increased climate model uncertainty regarding changes to their future temperature and precipitation distributions.

1.9 Acknowledgements

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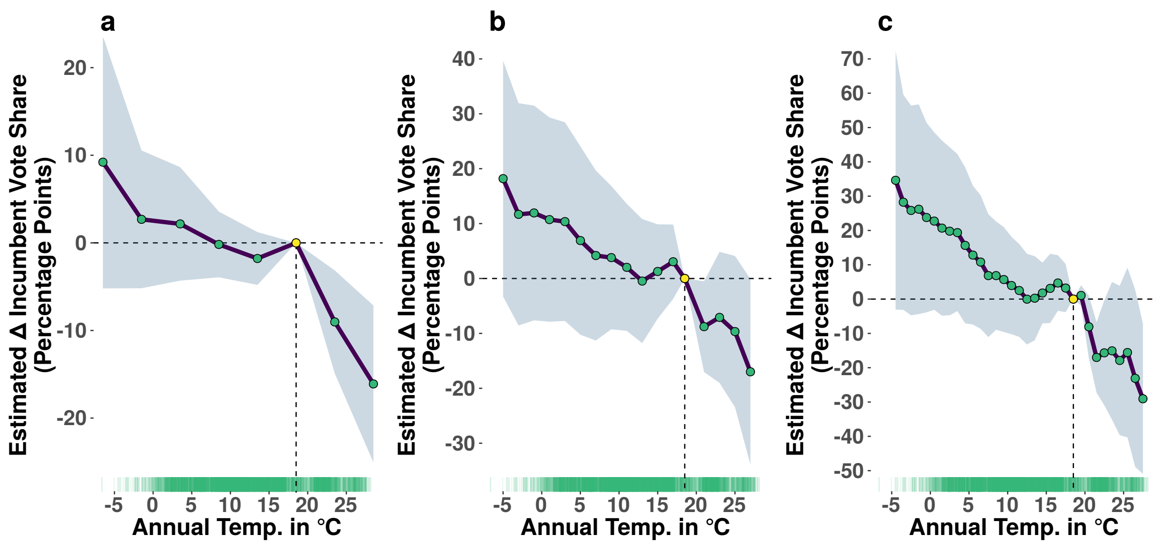

Figure 1.11: The purple line with green points in each panel plots the same relationship as seen in Figure 1, panel (b) in the main text (which is replicated in panel (a) of this figure). In panel (b) bin size is reduced to two degrees Celsius. In panel (c) bin size is reduced to one degree Celsius. As can be seen, there is close correspondence between the functional forms in each, with changes in incumbent party vote share becoming more negative with increases in temperature.

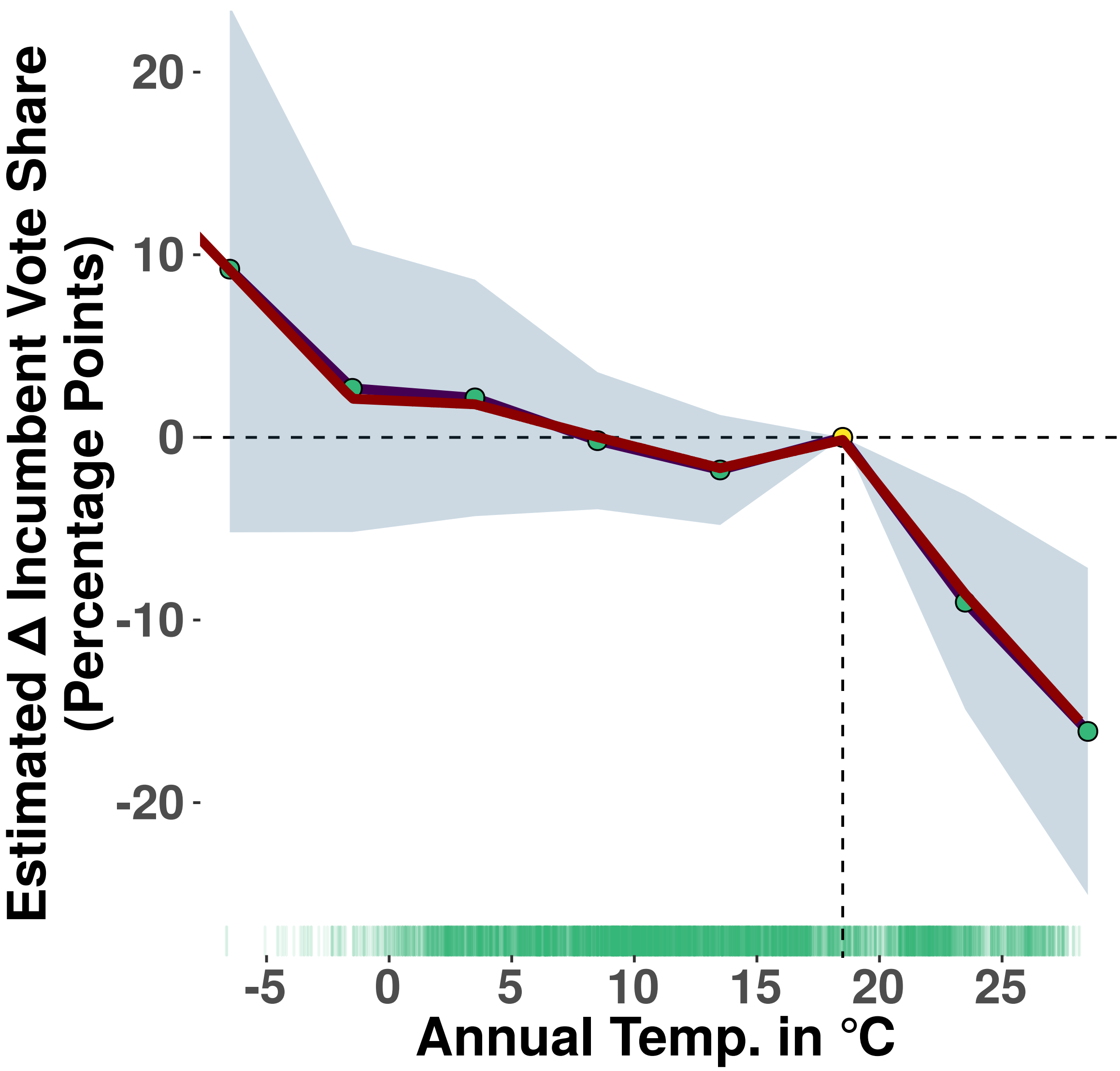

Figure 1.12: The purple line with green points plots the same relationship as seen in Figure 1, panel (b) in the main text. The red line depicts the functional form produced by the defined linear spline. As can be seen, there is close correspondence between the slopes between the linear spline function and the midpoints of the temperature bins from Equation 1.

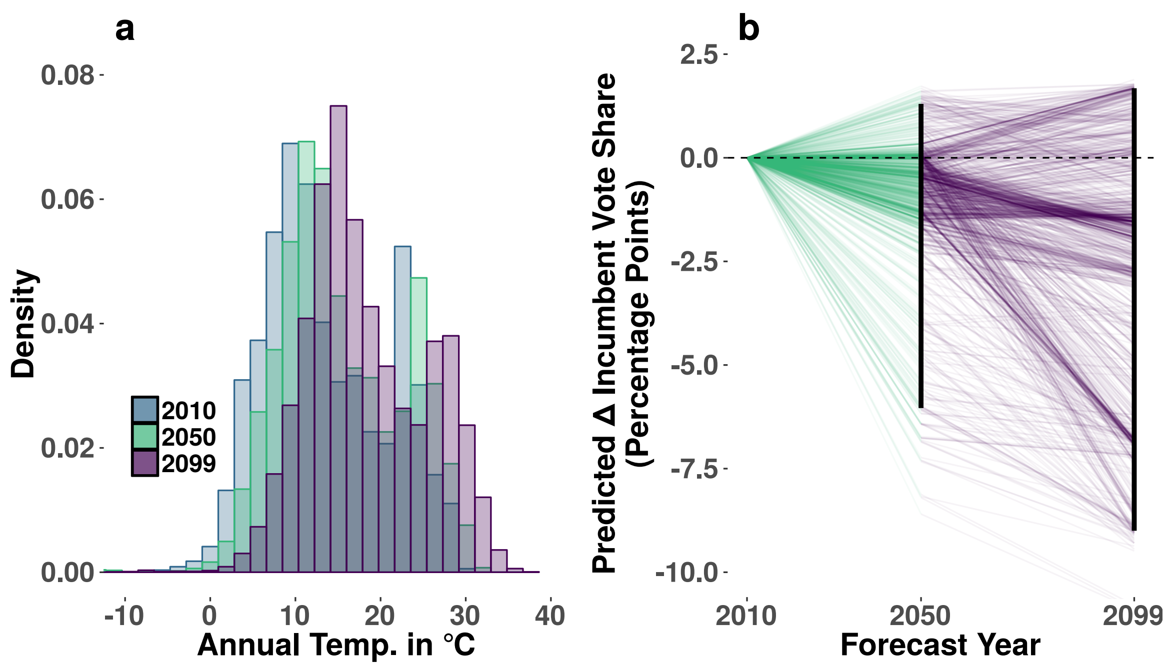

Figure 1.13: This figure reproduces Figure 5 from the main text, employing the estimated coefficients from Equation 1 directly to conduct the future forecast. As can be seen, because many constituencies do not completely shift from one temperature bin to another, their change from 2010 to 2050 to 2099 is largely determined by changes in annual precipitation, given by the negative linear slope on annual precipitation from Equation 1. However, as can be seen, even with this forecasting procedure, the median constituency is expected to see a notable reduction in incumbent party vote share due to future climate change as constituencies are pushed into different temperature regimes on average.

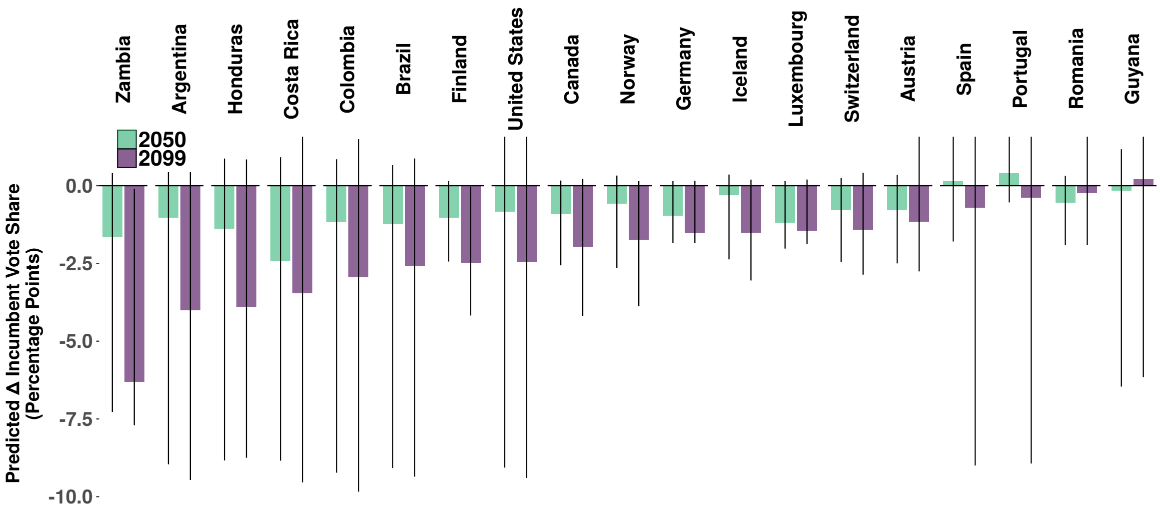

Figure 1.14: This figure reproduces Figure 6 from the main text, employing the estimated coefficients from Equation 1 directly to conduct the future forecast. Because many constituencies do not completely shift from one temperature bin to another, their change from 2010 to 2050 to 2099 is largely determined by changes in annual precipitation, given by the negative linear slope on annual precipitation from Equation 1. This results in a high intra-country range in predicted constituency changes to incumbent vote share, as represented by the error bars in this figure. However, as can be seen, even with this forecasting procedure, the countries predicted to be most affected by future warming, as well as the magnitude of these average predictions at the country level, remain similar.

Chapter 2

African voters indicate lack of support for climate change policies

2.1 Abstract

Will African voters support climate change policies? By 2020, the United Nations' Green Climate Fund intends to provide tens of billions of dollars per year to African nations to support climate adaptation and mitigation policies. It is widely assumed that citizens of African nations will support implementation of these climate policies. We observe the opposite result. In this article – across two experimental studies – we find evidence that African politicians who commit to climate change policies may lose electoral support. Electorally important swing voters with weak party affiliations are least likely to support party statements about climate change. Interviews with standing African elected officials corroborate our experimental findings. The combined results suggest voter preferences may hinder the successful implementation of climate change policy in Africa.

2.2 Introduction

> "Climate change is not a winning electoral strategy. It's not. Not at all."
>
> – South African District Councillor

Climate change poses a dire threat to African well-being [52, 50, 53]. Recognizing this, the United Nations Green Climate Fund intends by 2020 to distribute billions of dollars of climate finance per year to African nations to support climate change adaptation and mitigation policies [114]. These long-run policies are designed to attenuate the severity of climate change's impacts on the continent over the coming decades [48]. Successfully translating these funds into African climate resiliency is vital.

Unfortunately, there are numerous political barriers to enacting climate change policies on the continent. African democracies are characterized by poor political performance, high levels of corruption, and relatively low levels of political stability [115]. Holding office in Africa tends to be an efficient way for politicians to become wealthy at the expense of their citizenry [116]. Politicians may simply steal funds earmarked for climate resilience policies for their own use or may allocate these funds only to have them diverted to projects unrelated to climate change or embezzled by subordinates [117, 118]. Even if climate resilience funds are successfully allocated by one politician, there is little guarantee that the results of the next election will not see the funds subsequently stripped [119]. Such politician-driven corruption is typically cited as the primary challenge to African climate policy implementation [120].

Depictions like these assume African citizens desire climate policies and that negligent or corrupt politicians might produce failures in policy implementation. However, African voters may not prefer the implementation of policies required to build resilience to a changing climate. The low-levels of economic development on the continent leave the average African living on the equivalent of under five dollars per day [55]. At such low levels of income, short-term needs eclipse future considerations [56]. These harsh economic realities have led to an African electoral politics characterized by the provisioning of immediate benefits – rather than policy promises – in exchange for votes [57]. Gifts of corn, rice, chickens, and t-shirts buy votes in many African elections [111]. These factors combine to make campaigning on and enacting policies with widespread and long-term benefits a poor political strategy in many African democracies [115] (for more detail see *Appendix: Policy and Elections in Africa*).

Here we report on the results from two experimental studies combined with data from interviews with standing African politicians. We draw the first set of results from large-scale campaign-related surveys we conducted in four districts of Malawi on the day prior to the country's 2014 presidential and parliamentary elections. The second set of results come from – to our knowledge – the inaugural use of Amazon's Mechanical Turk (MTurk) to study African political attitudes. We draw our qualitative data from interviews with office-holding Malawian and South African politicians.

With the data from these studies we examine four questions. First, might African voters reward politicians who emphasize climate change policies? Second, which voters – strong partisans or electorally important swing voters – are most affected by climate change policy messaging? Third, does including climate change policy as one item on a menu of other important policies on their policy platform increase support for African politicians? Fourth, do African voters believe that politicians espousing climate change policy are more likely to win office than those without climate policy platforms? Finally, we intersperse interview data throughout the following sections to examine African politicians' opinions on each of the above questions.

2.3 Voter support for climate policy platforms

> "Most people in Malawi don't know much about climate change. If you talk of climate change, you are guaranteed to lose votes."
>
> – Malawian Member of Parliament

Might African voters reward their politicians for emphasizing climate change policies? To assess this first question, we conducted a large experiment embedded in a survey of Malawian voters on the day prior to Malawi's 2014 presidential and parliamentary elections. The areas of Malawi we selected – highlighted in Figure 2.1 –

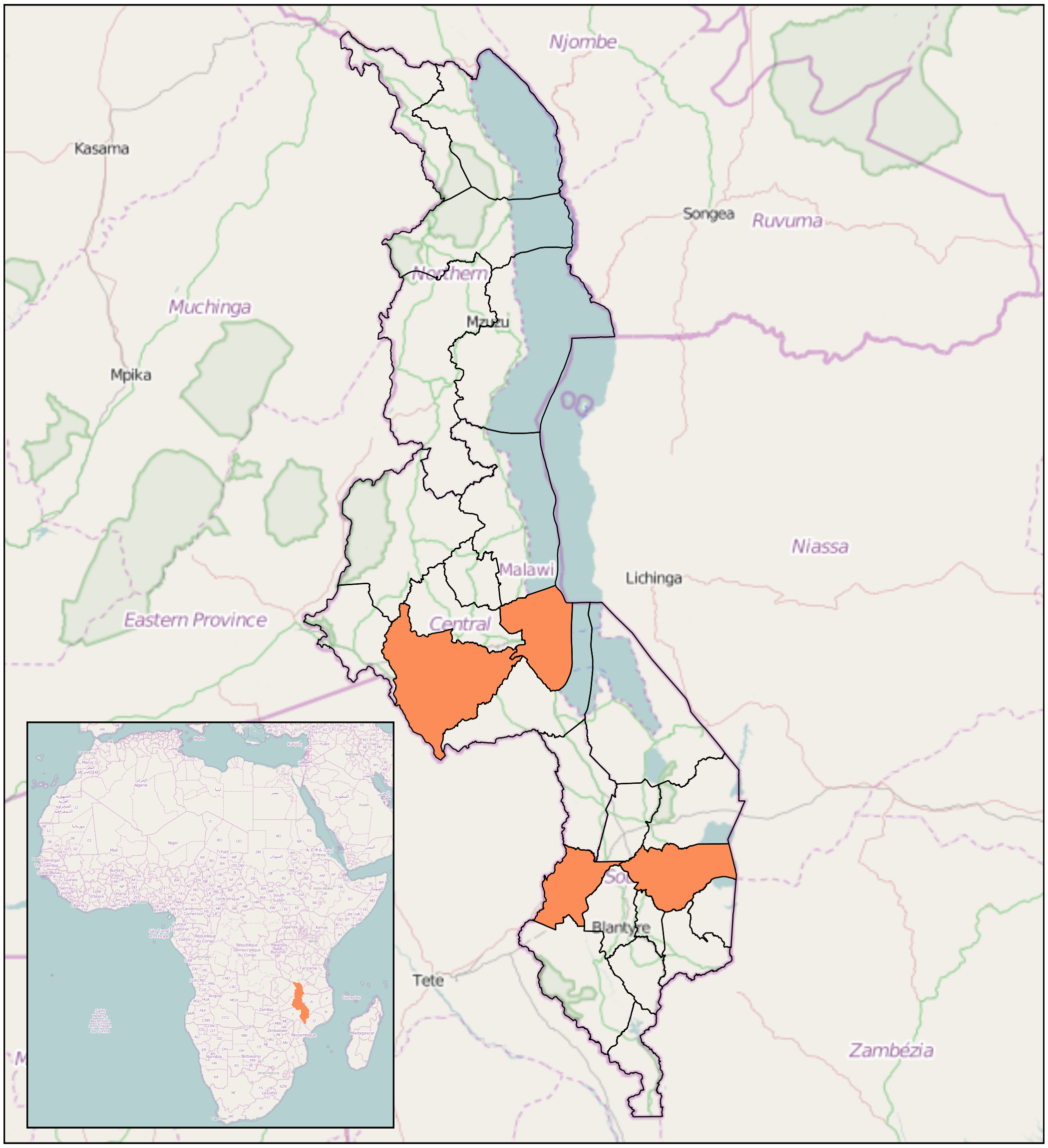

Figure 2.1: Map of Malawi election study district locations. We conducted our Malawi election study across four Malawian electoral districts – Lilongwe, Neno, Salima, and Zomba – that vary along demographic, political, and economic factors. These districts provide a broad sampling of Malawian voters (see *Appendix: Malawi District Descriptions*).

represent diverse economic and demographic sectors of Malawi and are highly similar to many areas of other African nations (see *Appendix: Malawi District Descriptions*).

If there is an African nation where climate change policy is likely to be politically beneficial, it is Malawi. Malawi is a peaceful nation, elections are generally free and fair, and open political discussion and debate is relatively common [121] (see *Appendix: 2014 Malawian Elections* for more details). The country is also highly rural and relies heavily on agricultural income, leaving it likely to be acutely affected by a changing climate [122, 49].

Our experiment randomly assigned Malawian voters in our survey to receive one of three experimental conditions. Experiments within the context of surveys, or 'survey experiments', randomly assign subjects to distinct information conditions and evaluate differences in responses across these conditions. They are frequently employed in the social sciences [123, 124] and have been shown to alter both actual and reported behaviors [125, 126]. In our experiment, we randomly assigned each subject to receive either (a) a *Short-Run Climate Policy* or (b) a *Long-Run Climate Policy* information condition in the style of common campaign messaging or to receive (c) the *Control* condition of no additional policy information. We designed our treatments to mimic the style of Malawian parties' campaign messaging surrounding the election. We present the experimental conditions' wording, delivered in Malawi's Chichewa language, below.

Short-Run Climate Policy *"Climate change makes farming harder, harming all Malawians. [Respondent's preferred party] will immediately assist struggling farmers."*

Long-Run Climate Policy *"Climate change makes farming harder, harming all Malawians. [Respondent's preferred party] will improve the farming sector to make future farming easier."*

Control The control condition received no additional policy information.

Prior to administering the experimental conditions, our enumerators filtered out non-voters, obtained respondents' preferred party, and measured the level of support respondents held for this preferred party – information that is freely given to researchers and polling firms in Malawi [127]. After the receipt of treatment, participants were given a handful of intervening questions to provide distance between the two points at which we measure our outcome variable. On the last question of the survey, participants were again asked how affiliated they felt with their preferred party.

We take the difference in pre-treatment and post-treatment party support as our primary outcome measure. Similar measures of voter support have corresponded closely to actual reported vote choice [128, 129]. We present the language of this question – delivered in Chichewa – below.

Party Support *How affiliated are you with [respondent's preferred party]? 1) Indifferent; 2) Some; 3) A Lot; 4) Very Much; 5) Completely*

In the Malawi voter sample (n=2,772), random assignment to the short-run climate change policy party platform produced no significant change in party support compared to the control condition (see Figure 2.2). However, assignment to the long-run climate change policy party platform produced a significant decrease in average change in party support as compared to the control condition (two-sided t-statistic: 2.083, p-value: 0.037, Cohen's d: 0.10). Thus, informing subjects that their preferred parties intended to implement long-run climate adaptation policy pushed respondents to express less support for their preferred party.

The negative effects associated with the climate policy treatments in the Malawian experiment in Figure 2.2 are precisely estimated and small in magnitude. Nonetheless, they are substantively important [130]. A common – if tacit – assumption

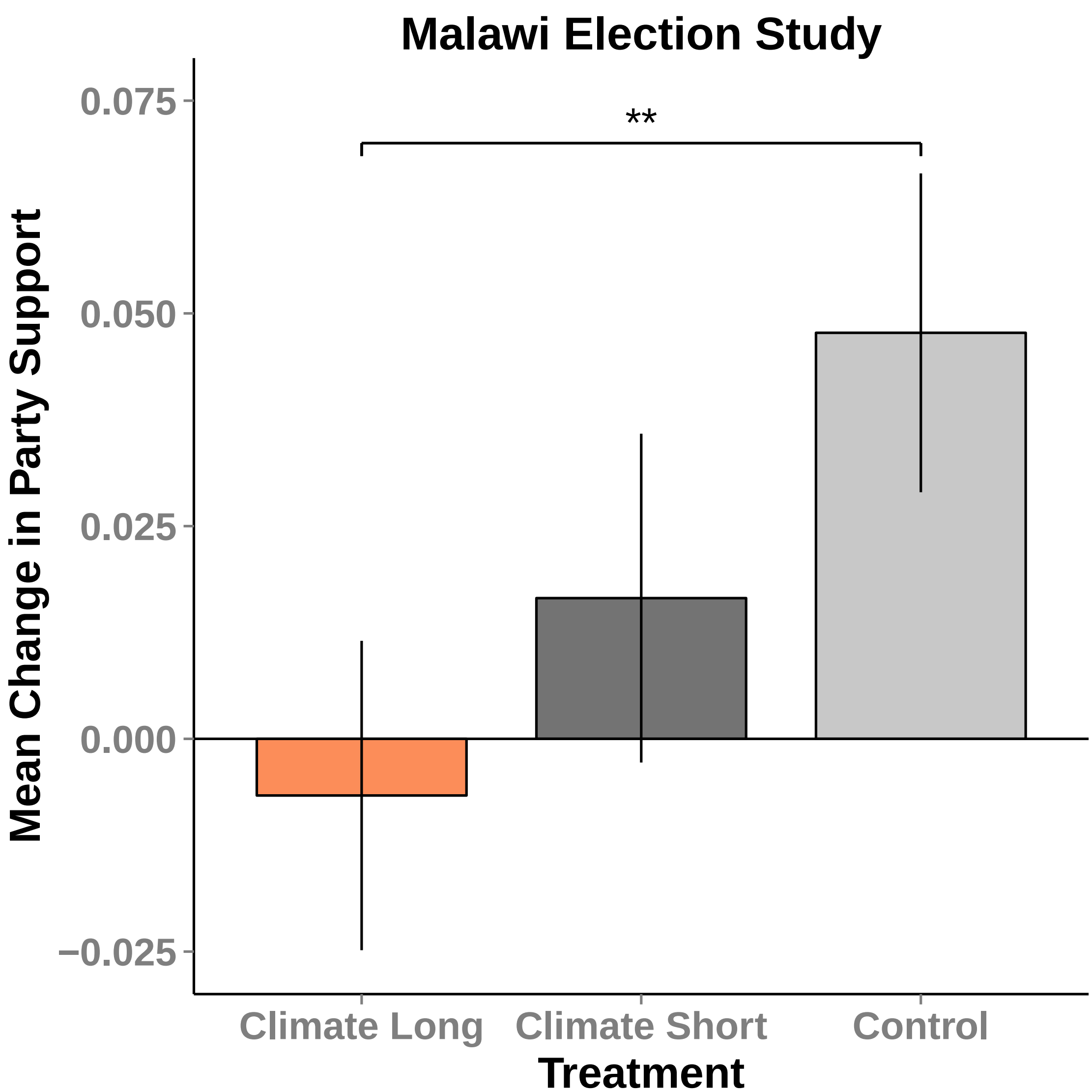

Figure 2.2: Long-run climate change policy treatment decreases voter support for their preferred party. This figure depicts the mean change in support for respondents' preferred parties pre-treatment to post-treatment across treatment groups in the Malawian 2014 elections study (n=2,772). Error bars are SEM. Two stars indicate significant difference at the p=0.05 level. Respondents exposed to the long-run climate change policy platform information had significantly lower changes in support than did the control condition.

among policy organizations is that implementation of climate change policy will be supported or even rewarded by African citizens [131]. This assumption, coupled with the fact that our experimental design presented information about what parties proactively intended to do without noting the potential substitution costs of such policy, produces the expectation that our climate policy treatments should have increased party support. Our experimental results clearly indicate that voters did not reward politicians – and may have punished them – for adopting a climate change policy platform within the context of our experiment.

2.4 Heterogeneous effects among voters

> "Voters won't support the issues that really deal with climate change."
>
> – South African District Councillor

Political party attachments are typically stable and can be difficult to sway [133]. As a result, those strongly attached to their preferred party might be unlikely to alter their level of support, regardless of the treatment information provided. This fact leads to our second question: which voters – strong partisans or electorally important swing voters – are most affected by climate change policy messages?

To investigate this second question, we interact the long-run climate change treatment with levels of pre-treatment party support to examine the effect of this interaction on levels of post-treatment party support (see Figure 2.3). The results of this regression indicate that voters more weakly affiliated with their preferred party are those most likely to reduce their support for that party when presented with the long-run climate change policy treatment (regression interaction coefficient t-statistic: 2.096, p-value: 0.036) (see *Appendix: Table 2.1*). This fact is important, as weakly

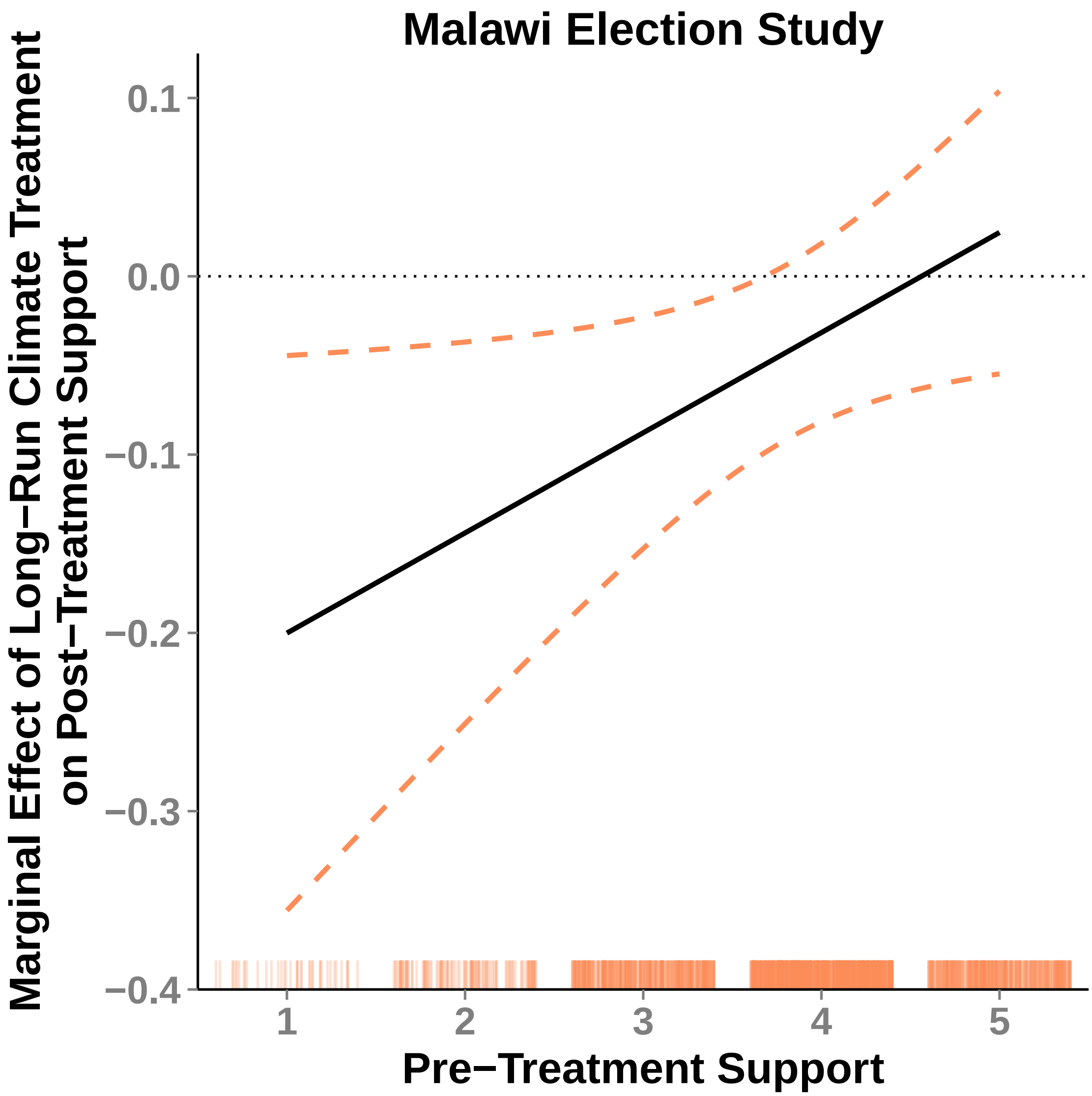

Figure 2.3: Long-run climate change policy most reduces support among weak party affiliates. This figure depicts the marginal effects from a regression of the interaction between pre-treatment party support and long-run climate change policy treatment on the post-treatment level of party support [132]. Dashed error bars represent 95% confidence intervals. The rug plot along the x-axis depicts the jittered density of pre-treatment party support measured on a 1-5 discrete scale ("Indifferent" – "Completely"), with 4 ("Very Much") being the median level of pre-treatment support. Marginal effects for weak party supporters are negative while those for strong party supporters are not significantly different from zero.

affiliated swing voters are vital for parties' electoral contests and parties are unlikely to champion policies that alienate swing voters [134].

The results from our Malawi survey experiment combine to suggest that climate change policies – rather than being advantageous to parties – may actually decrease party support and may decrease support most among electorally important swing voters. Malawian politicians, contacted after the election, supported this general conclusion. A ward councillor summarized his thoughts succinctly: "I did not emphasize climate change in my campaign. In Malawi, to win an election you need to talk about issues that affect people daily – like hunger and lack of clean water." This politician awareness was further highlighted by climate change's diminished role within Malawian parties' 2014 campaign policy platforms. For example, the Democratic People's Party, the ultimate winner of the election, mentioned climate change only three times in its over 21,000 word party manifesto, and climate change policy was virtually absent from the political debates surrounding the 2014 election.

2.5 Climate change versus other policy priorities

> "I think that – being a developing country – although it's important, climate change is not a priority here. We're still focusing on local issues and trying to do job creation."
>
> – South African District Councillor

While our results from Malawi indicate that voters may not reward their politicians for taking up climate change policy platforms, they do not tell us whether or not climate change policy is preferred to other common policy platforms in Africa. This leads to our third question: does having a climate change policy platform as one item on a menu of other important policies increase support for pro-climate African

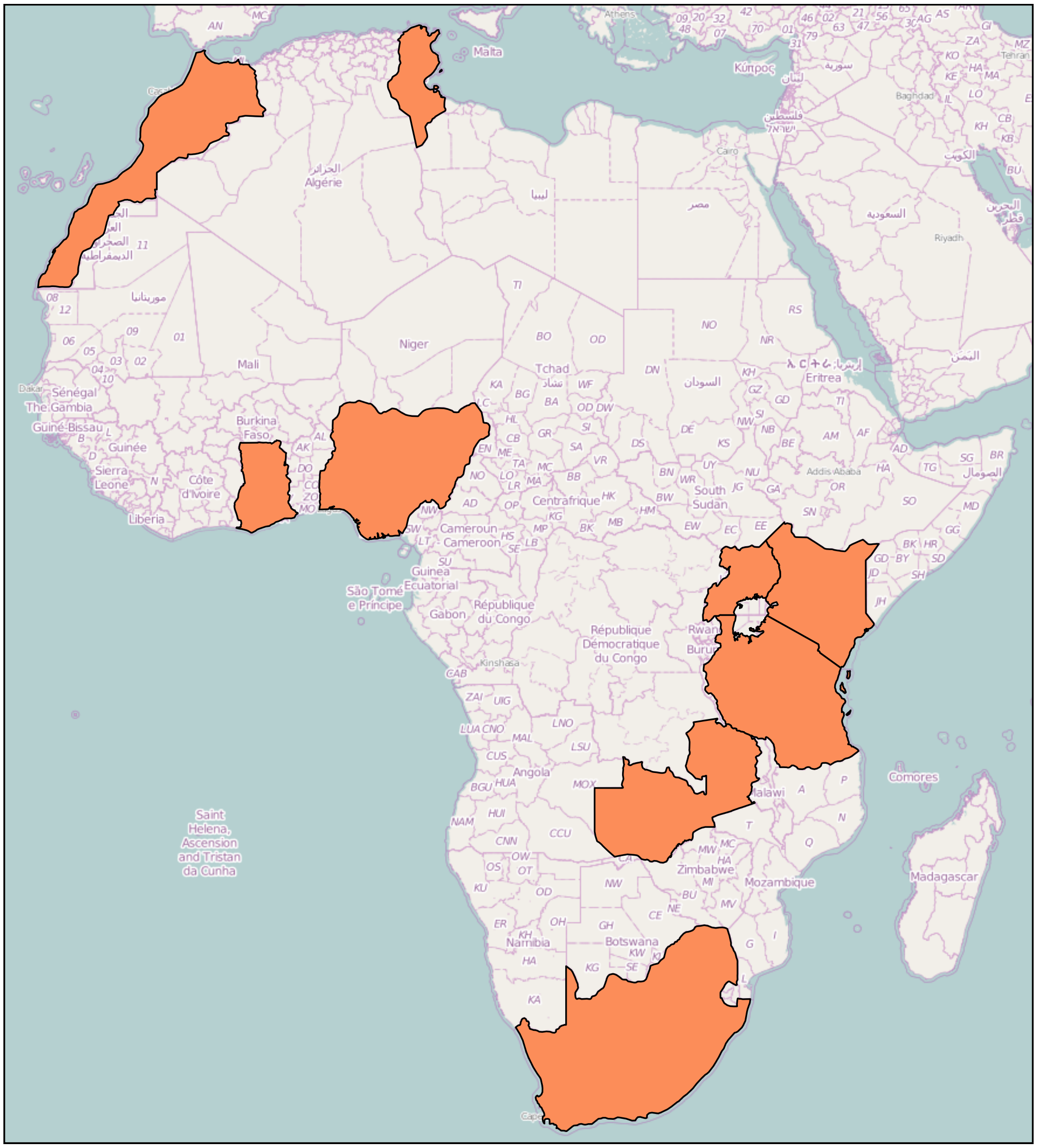

Figure 2.4: Map of African MTurk respondents' home countries. We conducted our MTurk voter experiment with respondents from across ten English-speaking African nations. Respondents from South Africa, Kenya, and Nigeria comprise the majority of the sample and all but two respondents live in Sub-Saharan Africa.

politicians?

To evaluate this question, we employed a new feature of Amazon's MTurk platform – the ability to restrict recruitment to only respondents from Africa – to study the policy preferences of Africans as they relate to climate change. We recruited 86 subjects from ten English-speaking African countries in total for the study (see Figure 2.4 for a depiction of the countries included). The number of subjects recruited is a reflection of the relative novelty of this platform – the size of the African subject pool is not yet large. We believe ours is the first use of this new opportunity to explore Africans' political opinions.

In our experiment, we presented respondents with a simulated election involving two hypothetical candidates, A and B [135]. In order to control for ballot order effects [136], we presented two distinct elections to our treatment and control groups. The first candidate, candidate A, had the same characteristics across each simulated election. In the control condition, subjects were assigned to an election where both candidates, A and B, had a platform of three policies randomly chosen from a set of the six most desired policies as indicated by Afrobarometer – a pan-African polling firm [137] – unemployment, education, poverty, healthcare, corruption, and sanitation.

In the treatment condition, candidate A again had three policies randomly assigned from the set of six desired policies. However, candidate B had a climate change policy platform: "Will work to address climate change" in addition to two randomly drawn, desired policies. We randomized policy order throughout to eliminate possible policy order effects (see *Appendix: Simulated Election Experiment* for experiment wording). After exposure to the platforms of the hypothetical African political candidates, respondents recorded their preferred candidate:

Vote Choice *Which candidate would you prefer to vote for?*

We take the difference between respondents' desire to vote for candidate B in the treatment versus control condition as our primary outcome measure. In this simulated election, when candidate B campaigned on topics not including climate policy, they received approximately 59% of the vote share (this deviation from 50% in the control is likely due to ballot order effects). However when their policy platform included climate change in the treatment election, candidate B's vote share plummeted to 32%, a large and statistically significant difference (two sided t-statistic: 2.569, p-value: 0.012, Cohen's d: 0.56). Thus, campaigning on a climate change platform significantly and substantively reduced the vote share won by that candidate as compared to campaigning on one of the alternative policies (see Figure 2.5, panel (a)).

Of note, our sample of African MTurk respondents is markedly more educated than the median African voter and thus likely to have more informed opinions regarding the threats posed by climate change [131]. Only one of our respondents indicated that they had never previously been exposed to the concept of climate change, 97% indicated the believed climate change was occurring, and 68% reported believing that climate change negatively affected their life.

This divergence in our sample's awareness and concern about climate change from the median African voter is important, as lack of knowledge about climate change was a primary reason cited by African politicians for not campaigning on climate change policy. A South African politician stated: "If you speak about climate change to rural voters, you're just speaking Greek – a language that they don't understand. They just can't relate, unless there's an effort to educate them about the importance of climate change." Our simulated election experiment indicates that even when African voters are well-educated about climate change they may still prefer their politicians to focus on policies with more immediate benefits. As a result of this markedly high level of awareness of climate change among our respondents, the vote choice effects we observe in this sample may present a lower bound; less educated African voters may punish pro-climate politicians even more acutely for campaigning on a topic they know little about.

2.6 Climate policy and electoral success

> "Voters are not concerned about climate change. They're only concerned with bread and butter issues that are affecting them on a daily basis."
>
> – South African Member of Parliament

Do our respondents – regardless of their own preference on climate policy – perceive that campaigning on climate change will harm politicians' electoral chances broadly? To examine this question, we asked our respondents their opinion on the chances of the hypothetical politicians winning a national election in their country:

> **Likely Winner** *If they were to run for leader of your country, which candidate do you think would win?*

This measure encapsulates' respondents beliefs about how their fellow citizens would respond to politicians' adoption of climate change policy platforms. In our simulated election, when candidate B campaigned on topics not including climate policy, 49% of respondents projected them to with the election (see Figure 2.5, panel (b)). However when the candidate's policy platform included climate change, only 17% of respondents projected they would win the election, a large and highly statistically significant reduction (two sided t-statistic: 3.228, p-value: 0.002, Cohen's d: 0.72). Thus, campaigning on climate policy may be even less popular among Africa's median voters than observed within our sample.

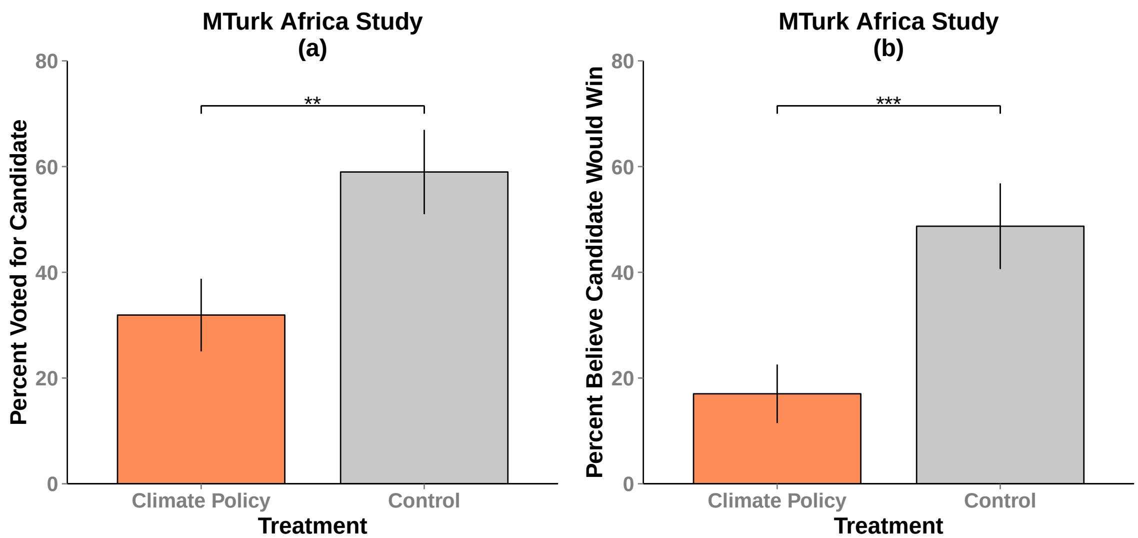

Figure 2.5: Hypothetical pro-climate African candidates receive fewer votes and are perceived as more likely to lose election. Panel (a) depicts the mean percentage of respondents' vote received by hypothetical candidates (n=86). In the control task, respondents chose between two candidates with three randomized policy platforms that did not include climate change policy. The treatment task presented one of the candidates as supporting climate change policy as one of their three policy platforms. Panel (b) presents the mean percentage of respondents' belief that the candidates would win the hypothetical election. Error bars are SEM. Three stars indicate significant difference at the p=0.01 level.

2.7 Discussion

> "We never talked about climate change in our campaign. You can't talk about climate change in an election here. Why would you?"
>
> – Malawian Member of Parliament

Across two experimental studies we find that African voters are unlikely to reward – and may significantly punish – politicians for campaigning on climate change policy platforms. Respondents also indicated that they believe it is unlikely that pro-climate politicians would win election over candidates campaigning on more common policy issues. Interviews with standing politicians in both Malawi and South Africa corroborate these findings: every politician we interviewed suggested that campaigning on or enacting climate change policy at the expense of focusing on more pressing, immediate concerns could lead to their electoral demise. The quotes interspersed throughout this article represent a sampling of these opinions.

There are a number of reasons why campaigning on climate policies could be electorally costly to African politicians. The first might be that African voters have more pressing economic needs and expect their politicians to provide clientelistic benefits addressing these immediate needs, a concern relayed by politicians. Or – as evidenced by our MTurk experiment – even if voters do care about both longer-run policy and the threats posed by climate change, climate change policy may be low on the list of policy priorities. This could be due to a lack of knowledge of the likely severity of climate impacts [138] or because voters prefer politicians to focus on other policy priorities like corruption abatement or education.

What are some of the policy implications of these findings? First, it is widely accepted that the primary goal of politicians in democratic nations is to win elections

[139]. For this reason, policies highlighted in electoral campaigns in Africa – if policies are discussed at all – must each bring clear electoral benefits. If African politicians deem that campaigning on climate policy hurts their electoral chances, they will be less likely to pursue such policies at all and may instead divert climate finance funds to other strategies aimed at more effectively winning votes [120].

If climate change policies are unlikely to win votes, then such policies are unlikely to be enacted. Ultimately, it is vital to account for the domestic politics that will determine the success or failure of climate policies in developing nations [140]. From the evidence available, it appears that African voters may not prefer their politicians to focus on climate adaptation policies. It also appears that African politicians are aware of their voters' climate preferences. These facts combine to indicate that domestic African political realities may undermine international attempts to improve African climate resilience.

2.8 Methods

The fieldwork for our Malawi election survey experiment consisted of a month in Malawi spent orchestrating the details of the day-before-election survey. Upon arrival, we hired local enumerator managers recommended by our contacts at the National Statistical Office of Malawi. Our managers assisted us with planning, designing, and translating of the surveys and survey experiments into Chichewa, the primary language of Malawi. Each enumerator manager forward and backward translated each question and treatment to ensure accuracy.

With the assistance of the enumerator managers, we recruited and trained 131 survey enumerators to deploy on the day prior to the election in four different districts of the country – Lilongwe, Neno, Salima, and Zomba. We selected these districts to capture a broad sample of Malawians: urban and rural, varied socioeconomic strata, and diverse local political environments. Our enumerators employed a random walk strategy to recruit passerby voters in public areas throughout these districts, ensuring no subjects would be sampled more than once. In our sample, forty-eight percent of recruited subjects were female, thirty-seven percent were farmers, and the typical age of respondents was between 31 and 45 years.

To conduct the MTurk simulated election experiment, we opted to allow MTurk respondents who recorded their residence as falling within an English-speaking African nation to take our survey. The survey itself was administered via Qualtrics' online survey software platform, and random assignment to experimental condition was performed via Qualtrics' randomization tool.

Our sample size goal for this experiment was 200 respondents. In total, 208 individuals completed some portion of our survey. However, the MTurk platform's location screening capabilities are limited, as they are based upon self-report. Fortunately, Qualtrics records the country of origin of the IP address of respondents. We were able to use Qualtrics country data to screen out all likely non-African respondents from the sample, leaving 86 respondents whose IP address originated within Africa and who answered our main outcome variables. Non-African respondents in our initial sample were primarily located within the United States.

Finally, to conduct our interviews we followed up via the telephone with twelve politicians whose contact information we had garnered over the course of our fieldwork in Malawi and South Africa, respectively. In these interviews, we questioned politicians on their opinions regarding the likely success of climate change policies in their countries, and whether or not they would consider campaigning on climate change in upcoming elections. These interviews averaged ten minutes in length.

2.9 Appendix

2.9.1 Policy and elections in Africa

In many African countries the effectiveness of policy promises as a campaign strategy cannot be taken for granted. Policy promises must compete with two other forces determining votes: ethnicity and clientelism. Many African voters vote along ethnic lines. Those from majority ethnic groups vote for candidates and parties from their own ethnic group whereas those from minority ethnic groups vote for candidates and parties favored by the leaders of their minority ethnic group [141, 142]. Scholars have proposed several possible mechanisms guiding this choice. Horowitz (1985) [143] puts forth the "expressive voting hypothesis," arguing that voters in Africa express their ethnicity by voting, essentially reducing the act of voting to an ethnic headcount. Others argue that voters, especially those in low-information environments common in Africa, anticipate receiving more favorable treatment from co-ethnics, and therefore vote for them [144, 142, 145], a slightly different argument from the hypothesis that co-ethnics simply share policy preferences and therefore vote together [146, 145, 147]. Posner (2004) [148] argues that ethnic cleavages in Africa are a product of colonial boundaries, and that the relative size of ethnic groups can be used by political elites to efficiently gather support. Regardless of the reason, ethnicity heavily influences voting in Africa and directly competes with the policy promises of candidates [149, 150, 151, 146]. Policy promises that benefit all ethnicities equally –

like broad-based climate adaptation and mitigation measures – can be particularly unpopular, as the ethnicities in power often prefer for the benefits of power to accrue to their own group.

Clientelism is another aspect of many African democracies that renders policy promises less effective as a campaign strategy. Clientelism is generally defined as the exchange of goods or services in exchange for political support. The *quid pro quo* aspect of the exchange is key to clientelism. Whereas policy promises in a campaign pledge a benefit to voters in the future, clientelism frequently offers a pre-electoral benefit to voters, often in the form of a tangible item. In Africa, clientelism is a widespread campaign strategy for many parties [57, 152, 111], and its benefits range from a bag of rice to clothing to money. Wantchekon (2003) [153] experimentally varied the campaign promises of parties in Benin, finding that clientelistic promises were more effective than promising broadly beneficial policy and that policy promises actually predicted a decrease in party support in the North of the country. Vincente (2014) [154] finds that an information campaign designed to educate voters about the problems of clientelism decreased vote buying, but also decreased turnout and increased support for candidates running for re-election (the incumbent politician). He concludes that clientelism may undermine the focus on policies in African elections but it also may increase participation and provide opportunities for non-incumbents to enter politics.

2.9.2 Malawi elections study

2014 Malawian elections

In many ways, the Malawian elections of 2014 were typical African elections. Clientelism has been an ongoing force in Malawi's elections [155]. Politics in Malawi have been influenced by ethnic ties in the past [148], but this trend seems to be declining, with 2009's election less dominated by voting along ethnic or regional lines [156]. A decline in this trend opens the door for campaign promises based on policy, though policy promises must still compete with the immediate benefits provided to voters by clientelism.

Elections in Malawi are relatively free and fair. As is common in African democracies, there are instances of electoral fraud, but this fraud is not significant enough to sway the outcome of elections [157, 121]. This implies that campaigns in Malawi have the potential to sway voters if selected and executed well. Electoral institutions in Malawi are similar to much of Africa. It is characterized as an electoral democracy, with a President and members of the legislature (Members of Parliament) elected in first-past-the-post electoral units in which several parties field candidates and one is elected [141]. In the 2014 election, four candidates were viable for the presidency: Joyce Banda of the People's Party, Atupele Muluzi of the Malawi Congress Party, Peter Mutharika of the Democratic Progressive Party, and Lazarus Chakwera of the United Democratic Front. Mutharika won the presidency with 36.4% of the vote. At the legislative level, Malawi elected Members of Parliament in 193 constituencies, and in local government, Councilors were elected out of 462 wards.

2.9.3 Malawi district descriptions

Our survey sampled citizens in four districts of Malawi: Lilongwe, Salima, Zomba, and Neno. These districts were selected bearing in mind our theoretical population: voters in a developing African democracy affected by climate change. To ensure the sampled population of voters represents this theoretical population, the selected districts share three features: presence of both urban and rural areas, heavy reliance on the agricultural sector, and politically competitive constituencies.

Aside from these shared characteristics, the populations in these districts are different from one another and represent different segments of African voters. Lilongwe District, in the Central Region, houses Malawi's capital city of Lilongwe. Voters in this district tend to be more politically aware and involved than voters in other districts, especially in the capital city itself. Literacy is high, employment is high, and the district has a larger percentage of homes with iron rooftops and access to electricity, two important proxy measures of wealth in the African context [158, 159]. Lilongwe is the largest district in Malawi by population and by area, and is densely populated. It borders Zambia, which makes it a hub for cross-border commerce and exchange. Finally, Lilongwe is reliant on agriculture, with maize and tobacco being the primary crops.

Zomba, in the Southern Region, is generally similar to Lilongwe but is different in critical ways. It also has relatively high levels of literacy, employment, and wealth [158, 159]. It is also a large and densely populated border district, though not as large nor as densely populated as Lilongwe. Rather than dominated by government offices, Zomba houses the most prestigious educational institution in the country, Chancellor College. This shifts the culture of the district from one embedded in politics to one embedded in knowledge generation. Another departure from Lilongwe District is that Zomba is one of the few districts actively engaging in pond fishing, in addition to extensive fishing in Lake Chilwa. This access to fishing reduces the district's reliance on crop farming.

Salima, in the Central Region, is similar to Zomba in that it has access to Lake Malawi, where fishing is widespread. However, it is not a border district, and it houses a smaller, poorer, and less literate population without extensive government or educational institutions. Finally, Neno, in the Southern Region, is also not a border region and is also poorer, and less literate [158, 159]. It is the smallest district in Malawi, and was only recently formed in 2003. Similar to Lilongwe, the population of Neno relies heavily on crop farming, as there is no body of water to facilitate fishing.

Collectively, these districts provide a sample of African voters living in areas at different points along the socioeconomic, educational, political, and agricultural spectra.

Like other areas of Sub-Saharan Africa, Malawi is projected to suffer acutely from the consequences of a changing climate [122]. The four districts we included in our survey are each likely to experience costly climate impacts. For the non-border districts, transportation costs may likely increase. For the districts most heavily reliant on rain-fed agriculture, economic production may lag [50]. We believe that the districts we surveyed provide a good sampling of climate-vulnerable Malawians similar in many ways to other climate-vulnerable Sub-Saharan Africans.

Table 2.1: Malawi election experiment interaction regression

	DV: Post-Support
Long-Run Clim.	-0.26^{**}
	(0.11)
Pre-Support	0.80^{***}
	(0.02)
Long-Run Clim.*Pre-Support	0.06^{**}
	(0.03)
Constant	0.82^{***}
	(0.07)
Observations	1,865
R^2	0.67
Adjusted R^2	0.67
Residual Std. Error	0.54
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Interaction regression

We present the main text interaction regression for the test of heterogeneous effects of treatment in the Malawi experimental study in Table 2.1.

2.9.4 MTurk Africa study

Simulated election experiment

In this section, we present examples of our simulated election experiments administered via the Qualtrics platform (with subject recruitment via MTurk). Our experiment randomized the selection of *Candidate A*'s three policies, selecting from a set of six policy statements: "Promises to lower unemployment.", "Aims to reduce poverty.", "Will improve healthcare access.", "Will expand access to clean water.", "Will broaden quality education.", and "Challenges corrupt practices." Two of *Candidate B*'s policies were similarly randomly selected from these six policy statements. The third was "Will work to address climate change." The order of policies for each candidate was also randomized to prevent item order effects.

We present an example of the control condition hypothetical election in Figure S3 and present an example of the treatment condition hypothetical election in Figure S3.

2.10 Acknowledgements

This chapter is co-authored with Brigitte Zimmerman and is currently under peer review. This work was supported by the National Science Foundation (Grant Nos. DGE0707423, 0903551, and 1424091 to N.O. and 1000107731 and 1160515 to

Figure 2.6: Malawian election workers in Lilongwe on the day of the 2014 election.

Next, act as if today is election day and you are about to cast a vote for the leader of your country. Below you are presented with two candidates, A and B. Please read their promises and then select the candidate for whom you would prefer to vote.

Candidate A	**Candidate B**
Will broaden quality education.	Challenges corrupt practices.
Promises to lower unemployment.	Will expand access to clean water.
Challenges corrupt practices.	Promises to lower unemployment.

Which candidate would you prefer to vote for?

Figure 2.7: Simulated electoral contest, control condition

B.Z.) and by the Center for Effective Global Action (to N.O. and B.Z.). We thank B. Chimatiro and J. Mkandawire for their fieldwork assistance and J. Burney, K. Ferree, C. Gibson, D. Hughes, R. Migliorini, and members of the UCSD Human Nature Group for their helpful comments.

Next, act as if today is election day and you are about to cast a vote for the leader of your country. Below you are presented with two candidates, A and B. Please read their promises and then select the candidate for whom you would prefer to vote.

Candidate A	**Candidate B**
Aims to reduce poverty.	Will expand access to clean water.
Will expand access to clean water.	Will work to address climate change.
Challenges corrupt practices.	Will broaden quality education.

Which candidate would you prefer to vote for?

Figure 2.8: Simulated electoral contest, treatment condition

Chapter 3

Collective responsibility amplifies mitigation behaviors

3.1 Abstract

How can individuals be convinced to act on climate change? It is widely assumed that emphasizing personal responsibility for climate change is effective at increasing pro-climate behavior whereas collectively framing the causes of climate change diffuses responsibility and dampens the incentive for individual action. We observe the opposite result. Here we find, across three experiments, that emphasizing collective responsibility for the causes of climate change increases pro-climate monetary donations by approximately 7% in environmental group members and by 50% in the general public. Further, highlighting collective responsibility amplifies intent to reduce future carbon emissions. In contrast, focusing on personal responsibility for climate change does not significantly alter donations to climate change advocacy or the intent for future pro-climate behavior. These effects replicate and persist multiple days after treatment.

3.2 Introduction

Many climate messages appeal directly to the individual's role in emission reductions. For example, a Sierra Club newsletter touts "Five Simple Things You Can Do About Global Warming This Year." Subsequent newsletters ask "How Green is your Laundry?", "How Green is your PC?", and "How Green is Your Vacation?" [160]. This style of messaging, aimed at evoking feelings of personal responsibility, is common in advocacy organizations' climate outreach. However, eliciting behavioral change is tricky [161, 162]. Along with the practical linking of climate cause, effect, and ameliorative action, personal responsibility messages may produce other, less helpful responses. Guilt, denial, sadness, and cognitive dissonance are all associated with recognizing one's own role in the climate problem [25]. While in some situations these factors can be motivating, in others they can be acutely demotivating [163, 164, 161, 62]. Thus, placing emphasis on personal responsibility might encourage behavioral change that protects the environment [165, 166, 167, 168, 169]. On the other hand, it could be ineffective or even have the reverse effect [170, 171].

Here we report on the results from three separate experiments including participants from the National Audubon Society's membership as well as members of the general public. With the data from these studies we examine four main questions. First, does placing emphasis on the collective versus personal causes of climate change produce more pro-climate behavior among environmentalists? Second, are the effects observed in a sample of environmentalists consistent with the effects observed in a general public sample? Third, do treatment-induced behavioral changes meaningfully persist over time? Fourth, do the effects of treatment on intended climate actions, a measure of desired future behavioral change, mimic the observed effects on actual behavioral change?

3.3 Behavioral change among environmentalists

The first question we investigate is whether emphasizing collective rather than personal responsibility for climate change is more effective at changing climate-related behaviors in environmentalists. To assess this question, we conducted an experiment embedded in an online survey emailed to affiliates of the National Audubon Society, a large wildlife conservation organization. These members are similar to many other conservationists and environmentalists across the country, who are in turn the

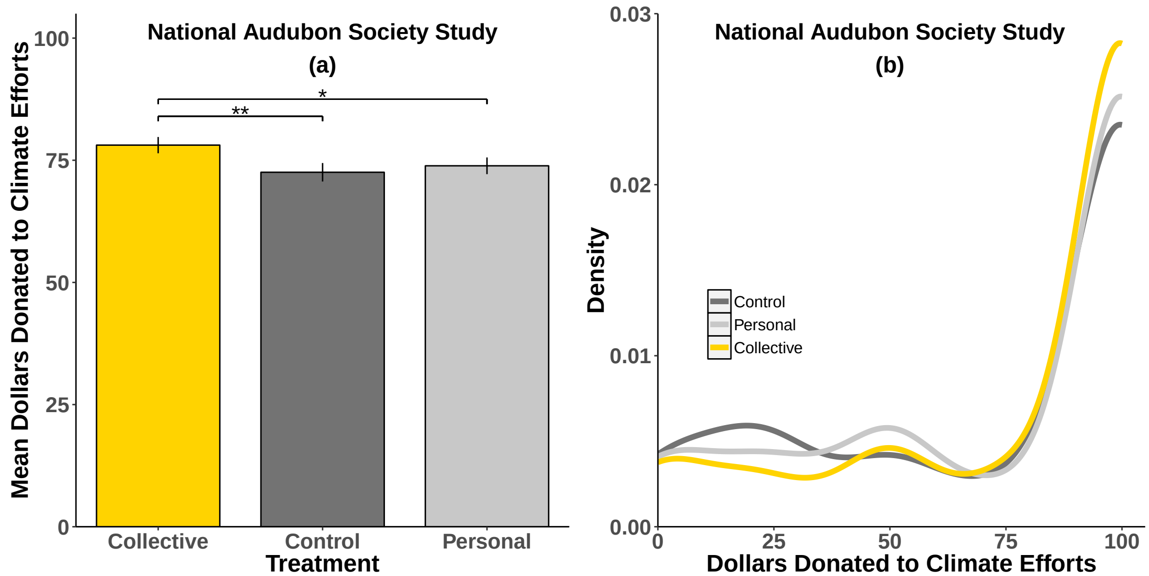

Figure 3.1: Collective treatment increases donations among environmentalists. Panel (a) depicts the mean donations across treatment groups in the National Audubon Study (n=1,215). One star indicates significant difference at the p=0.10 level while two stars indicate a significant difference at the p=0.05 level. Error bars are SEM. Panel (b) consists of kernel density plots of donations for each of the three experimental groups. Audubon affiliates gave a high amount of their potential winnings to Audubon across all conditions.

individuals most frequently targeted with climate change advocacy messages. Our experiment assigned respondents who volunteered to complete our survey to receive either a treatment priming task of personal or collective responsibility for climate change or to receive a control task.

Experiments within the context of surveys, or 'survey experiments', randomly assign subjects to distinct information conditions and evaluate differences in responses across these conditions. They are frequently employed in the social sciences [123, 124] and have been shown to alter both actual and reported behaviors [126, 125]. In our experiment, we randomly assigned each subject to receive either (a) a *personal responsibility* or (b) a *collective responsibility* essay writing task designed to prime these concepts or to receive (c), the *daily routine* essay task as a control [172]. Essay tasks are common experimental tools used to focus respondents' attention on a particular concept or emotion [173]. We designed our treatments to produce reflection on the personal or collective causes of climate change. We present the essay conditions' wording below (see *Supplementary Information (SI): Essay content* and *Appendix: Collective content* for details on the essay responses).

> **Personal** *"In what ways do you cause climate change? You personally produce climate-change-causing emissions in a variety of ways. You may drive your car, fly on airplanes, and/or use fossil-fuel energy for heating or cooling, as examples. In the space below, please write a short paragraph about the ways you as an individual produce climate-change-causing emissions. How commonly do you engage in these behaviors? This paragraph should take you approximately 3-4 minutes to complete."*

> **Collective** *"In what ways is climate change caused? Climate-change-causing emissions are collectively produced in a variety of ways. Transportation – in the form of cars and airplanes – and the use of fossil-fuel energy for heating or cooling are examples. In the space below, please write a short paragraph about the sources of climate-change-causing emissions. How common are these sources? This paragraph should take you approximately 3-4 minutes to complete."*

Control *"In what ways do you go about your day? You likely have daily routines that you follow. You may brush your teeth every morning and evening, have a cup of coffee with breakfast, or exercise in the afternoon, as examples. In the space below, please write a short paragraph about your regular routine. How commonly do you engage in these behaviors? This paragraph should take you approximately 3-4 minutes to complete."*

After administering the experiment, we measured subjects' costly decision to donate to Audubon's climate change efforts.

Donations *In this survey, 1 out of 100 people will win $100 (yes, we're really going to give out cash). If you win, how many dollars of the $100 would you like us to pay to the Audubon Society, supporting Audubon's climate change efforts? You will receive $100 minus whatever you instruct us to pay.*

In the Audubon sample (n=1,215), random assignment to the personal responsibility essay task produced no significant difference in donations compared to the control condition (see Figure 3.1, panel (a)). However, assignment to the collective responsibility essay task produced a significant increase in average dollars donated – $5.55 more than the control condition (heteroskedasticity robust OLS t-statistic: 2.207, p-value: 0.028, Cohen's d: 0.16; see *Appendix: Table 3.1* for a table of the regression results presented in the main text) [174]. This translates into a 7% increase in donations relative to the control group. The collective task also elevated donations in comparison to the personal task, significant at the p=0.10 level (heteroskedasticity robust OLS t-statistic: 1.776, p-value: 0.076, Cohen's d: 0.12). Priming subjects to consider the collective causes of climate change pushed respondents to give more in support of climate action. Conversely, reminding respondents of their personal role in contributing to climate change led to no significant change in behavior relative to the control condition.

Figure 3.1, panel (b) highlights the overall high level of willingness of the Audubon sample to donate to climate change efforts. This willingness is likely driven by general support for the National Audubon Society among its members, coupled with members' high level of belief in climate change. Ninety-four percent of Audubon respondents reported believing that the climate was changing, with over 80% believing the changes are caused primarily by human activities. These factors produced a median donation across all treatments of $100; the median respondent desired to give all their potential winnings to Audubon.

3.4 Behavioral change among the general public

Audubon members are overwhelmingly willing to take pro-climate action, with the median donation among Audubon members falling at the highest possible amount. Further, because the median donation amount across all experimental conditions in the Audubon study is equal to the max potential donation, a ceiling effect in that study may prevent observation of the full potential effect of the treatment. These points, coupled with the importance of replication in the social sciences [175] and of reaching non-environmentalist audiences with pro-climate advocacy, raised an important question: could the effects of the experiment be replicated in the general population?

To investigate this second question, we embedded the same experiment in a survey with respondents drawn from Amazon's Mechanical Turk (MTurk) [176, 177]. Like the Audubon study, our experiment again assigned respondents to receive either the personal or collective responsibility for climate change prime or the control task. We presented subjects with the same donations outcome measure used in the Audubon

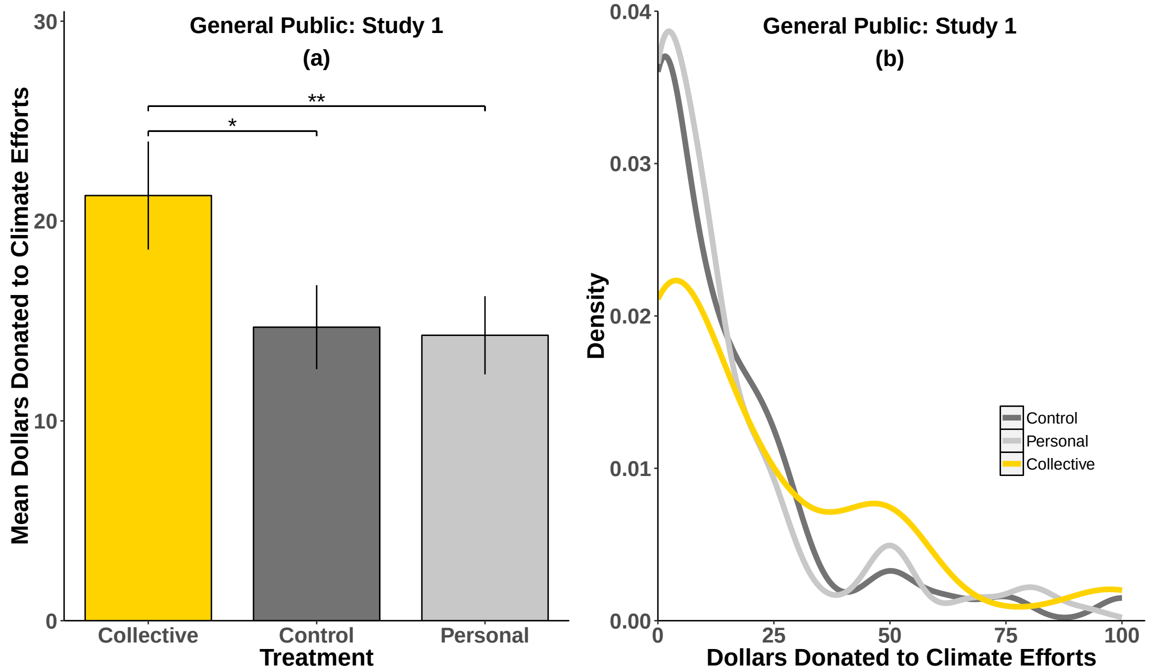

Figure 3.2: Collective treatment increases donations among the general public. Panel (a) depicts the mean donations across treatment groups in the first study with workers from Amazon's Mechanical Turk (n=304). Error bars are SEM. Panel (b) consists of kernel density plots of donations for each of the three experimental groups. As compared to Audubon affiliates, MTurk subjects gave a notably lower amount of their potential winnings to the National Audubon Society across all conditions.

study. Unlike the Audubon study, all MTurk participants were compensated for their study participation via the MTurk platform.

Like the Audubon study, those assigned to the personal essay task donated an average amount that did not significantly differ from the control condition (see Figure 3.2, panel (a)). However, as with the Audubon study, participants assigned to the collective responsibility condition gave significantly more. The collective subjects gave a significant \$7 more than the personal treatment (heteroskedasticity robust OLS t-statistic: 2.106, p-value: 0.036, Cohen's d: 0.30). Unlike the Audubon study, this was a substantially greater increase – 49% – over the other treatment arms. The collective treatment gave \$6.60 more than the control on average, though this is only significant at the p=0.10 level (heteroskedasticity robust OLS t-statistic: 1.933, p-value: 0.054, Cohen's d: 0.28). The subjects drawn from MTurk differed from the Audubon sample slightly in their climate change related opinions. Around 85% reported believing that climate change was occurring and a slightly lower percentage reported believing that climate change was primarily anthropogenically driven. The high level of climate change belief is consistent with previous findings on the political orientations of MTurk workers [177]. Perhaps most significantly, the participants had no preexisting connection to Audubon. As a result, with a median donation of approximately \$10, MTurk subjects in this study gave substantially less on average than did Audubon affiliates (Figure 3.2, panel (b)).

Because we designed the MTurk study to evaluate the same experiment using the same outcome measure from our Audubon study, we can use meta-analysis techniques to gain added insight into the our inference that the collective task outperforms both the control and personal treatment conditions. To conduct this test, we pool the data from both experiments, adding a fixed effect that controls for study specific characteristics [178]. Performing this analysis, we find that the collective treatment again significantly increases donations above both the control condition (heteroskedasticity robust OLS t-statistic: 2.698, p-value: 0.007) and the personal condition (heteroskedasticity robust OLS t-statistic: 2.355, p-value: 0.018) (see *Appendix: Pooled analysis* for additional details).

Thus the results from both of these studies combine to suggest that personal appeals, especially ones that relate to personal responsibility for climate change, may be notably less effective both with environmentalists and the general public than collective responsibility appeals.

3.5 Persistence of behavioral changes

Yet, the ultimate goal of climate advocacy is to convince individuals to change their climate-related behaviors repeatedly into the future [179]. This point invites our third question, whether individuals exposed to our collective treatment are still likely, days later, to give more to the cause of climate change advocacy.

To investigate this question, we followed up with our sample of MTurk workers from the general population, inviting them to take a follow up survey. Of the 304 original subjects, 78% completed the follow up. The median time to completion of the follow up was two days from the original survey completion date. In this survey we repeated our donation outcome measure, with additional raffle money awarded. The originally observed main effect of treatment on donations persisted (Figure 3.3, panel (a)). Subjects who originally received the collective treatment again gave a statistically significant $6.80 more than did those subjects who received the personal

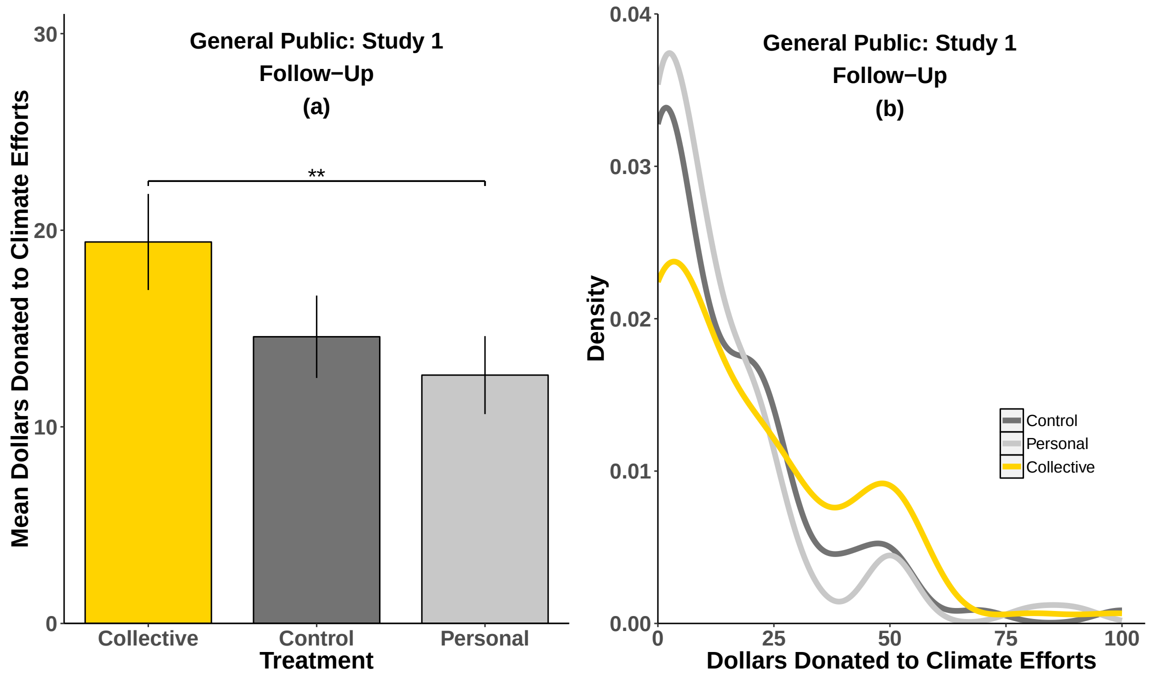

Figure 3.3: Effects persist multiple days after treatment. Panel (a) depicts the mean donations across treatment groups in the follow up of the first MTurk subjects (n=238). The follow up rate was 78%. Error bars are SEM. Panel (b) consists of kernel density plots of donations for each of the three experimental groups. The donation distributions in the follow up closely mirror the original donation distributions.

treatment (heteroskedasticity robust OLS t-statistic: 2.16, p-value: 0.031, Cohen's d: 0.34). This represents a 54% increase in follow up donations among the collective group compared to the personal group.

The distributions of the follow up donations closely mirror the original donation distributions with a median change of donation amount of $0.00 and a mean change in donation amount of -$0.08 (see Figure 3.2, panel (b) as compared to Figure 3.3, panel(b)). This lack of change of the median respondent is driven by the fact that 84% of respondents who gave $0.00 in the first donation measurement again gave $0.00 in the follow up measurement. Ultimately, most people's subsequent donation behavior remained consistent with their earlier treatment-induced donations (see *Appendix: Figure S3*).

3.6 Changes in attitudes about climate-related behaviors

In addition to the replicable, persistent effects of the collective responsibility treatment on actual behaviors, our fourth question asks whether the experiment could similarly alter behavioral *intent* with respect to future climate-related behaviors. In our first three experiments we chose to focus primarily on actual costly climate-related behaviors [180]. However, because behavioral intent measures can provide insight into attitudinal changes that may in turn precipitate future behavioral changes, we investigated whether our experimental treatments could also alter projected future climate change behaviors. We recruited subjects who had not completed any of our prior surveys from MTurk. These subjects then participated in our experiment and

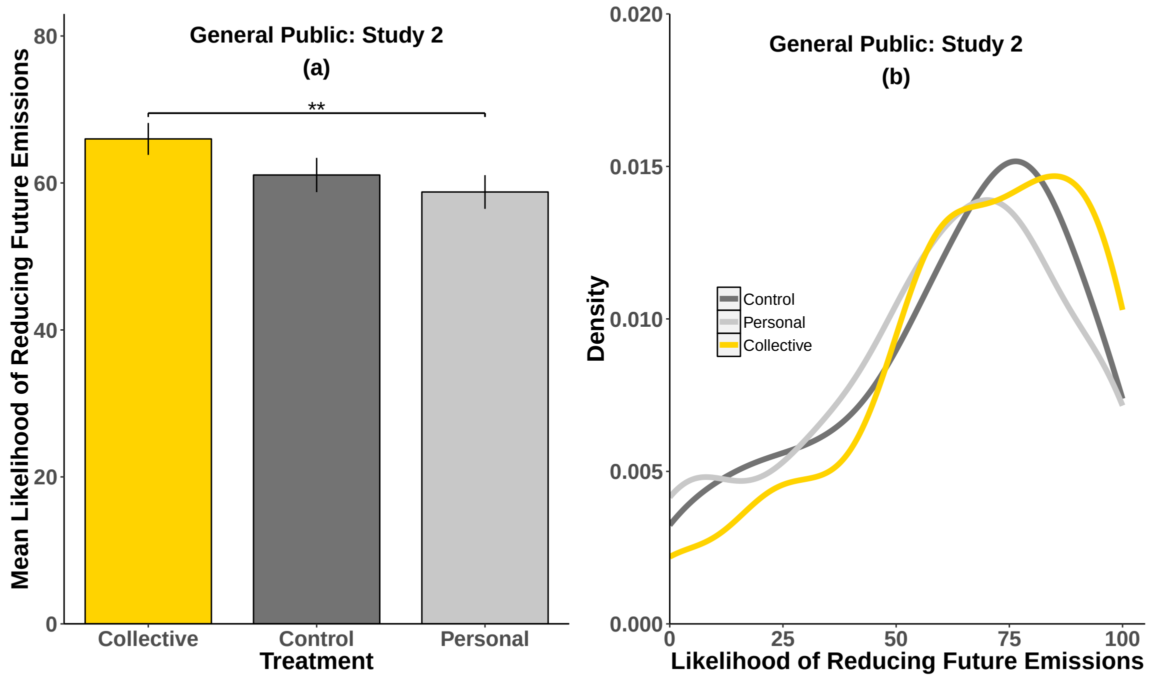

Figure 3.4: Collective treatment increases willingness to reduce future emissions. Panel (a) depicts the mean intention to reduce climate-causing behaviors across treatment groups in the second study with workers from MTurk (n=451). Error bars are SEM. Panel (b) consists of kernel density plots of emission reduction intentions for each of the three experimental groups. Participants reported a high intention to reduce future behaviors across all three groups, with the median highest in the collective treatment group.

were asked the below question, with answers recorded on a sliding scale from 0 (*very unlikely*) to 100 (*very likely*).

> **Behavioral Intent** *How likely are you to reduce your own climate-change-causing behaviors in the future?*

In this experiment (n=451), MTurk subjects assigned to the personal essay task reported an average intention to change climate-related behavior that, similar to donations in the other studies, did not significantly differ from the control condition (see Figure 3.4, panel (a)). Like donations in the previous studies, those subjects assigned to the collective responsibility condition reported significantly increased intention to reduce climate-change-causing behaviors as compared to the personal responsibility condition (heteroskedasticity robust OLS t-statistic: 2.294, p-value: 0.022, Cohen's d: 0.26). The control condition's average behavioral intention split the difference between the other two treatments. The median intention to reduce climate causing behaviors was relatively high across all groups, with the collective condition having the highest median intent score of 70 (Figure 3.4, panel (b)). Across all the treatment groups in this sample, around 86% reported believing that climate change was occurring, mirroring subjects' climate beliefs in the first MTurk experiment.

3.7 Possible explanatory mechanisms

There are several reasons why focusing on collective rather than personal responsibility could produce stronger pro-climate responses. Our data lead us to propose two possible mechanisms, though we lack definitive evidence for either. The first is the production of cognitive dissonance and subsequent reactance among personal responsibility group members. The second is the difference in construal levels for climate action animated by the personal and collective treatments, which may alter the salient motivations for taking action.

Cognitive dissonance refers to a psychological discomfort experienced by someone who holds contradictory beliefs, ideas, or values simultaneously, or who is confronted by information that conflicts with existing beliefs, ideas, or values [163]. Dissonance often drives individuals to reduce their internal conflict by either harmonizing their beliefs with their behaviors or vice versa [181]. Of note, cognitive dissonance may not present as an overt, conscious experience but may instead present primarily as physiological stress [182].

In our studies, respondents overwhelmingly reported believing in climate change. In the personal task we asked these individuals to reflect on their contributions to this global problem – to focus on behaviors likely seen as conflicting with their own concern about climate change. Efforts to decrease this dissonance could diminish pro-climate behaviors and intentions [25].

The strongest evidence that reactance motivation underlies our results is that individuals experiencing cognitive dissonance may subsequently avoid the dissonant stimulus [182]. In our first MTurk study, participants had the opportunity to avoid dissonant stimuli when asked to participate in the follow-up study examining duration effects several days later. If cognitive dissonance was driving avoidance, those who received the personal treatment should have been less likely to complete the follow up survey than were those who received the collective treatment. The data show that the personal group was less likely to follow up than the collective group, though this statistic is only significant at the $p=0.10$ level (heteroskedasticity robust OLS t-statistic: 1.783, p-value: 0.076, Cohen's d: 0.25) (see Figure S1).

Additionally, attempts to reduce cognitive dissonance might also dampen feelings of guilt about climate-change-causing behaviors in the personal responsibility group [171]. After treatment we presented subjects from the second MTurk study with a scale designed to measure current feelings of guilt [183, 184, 185]. In line with the cognitive dissonance hypothesis, we observed that the state-guilt score [186, 187] of the personal treatment group did not significantly differ from either the collective or control groups.

Construal-level theory offers a compelling alternative framework for understanding why collective responsibility could motivate climate action. In construal theory the farther an object is from direct experience, the more abstract the construal or consideration of that object [188]. In the context of our study, individuals in the personal condition may construe climate change and the subsequent questions regarding mitigation more proximally, whereas the collective condition may lead to a more distal construal. Thinking about personal responsibility, for instance, could proximize ancillary considerations associated with climate mitigation, such as the personal costs and benefits of action [189]. Proximizing climate change construals may further decrease the tendency to act on climate change if it draws attention away from broader environmental concerns less immediate to individual experience [190].

If proximizing climate change decreases the salience of these broader non-immediate environment concerns associated with climate change, inducing personal responsibility should produce muted negative emotional responses as compared to those assigned the collective essay task. Responses to a standardized emotion scale following treatment in our second MTurk study (n=451) revealed that the collective condition produced significantly higher levels of negative affect (commonly understood

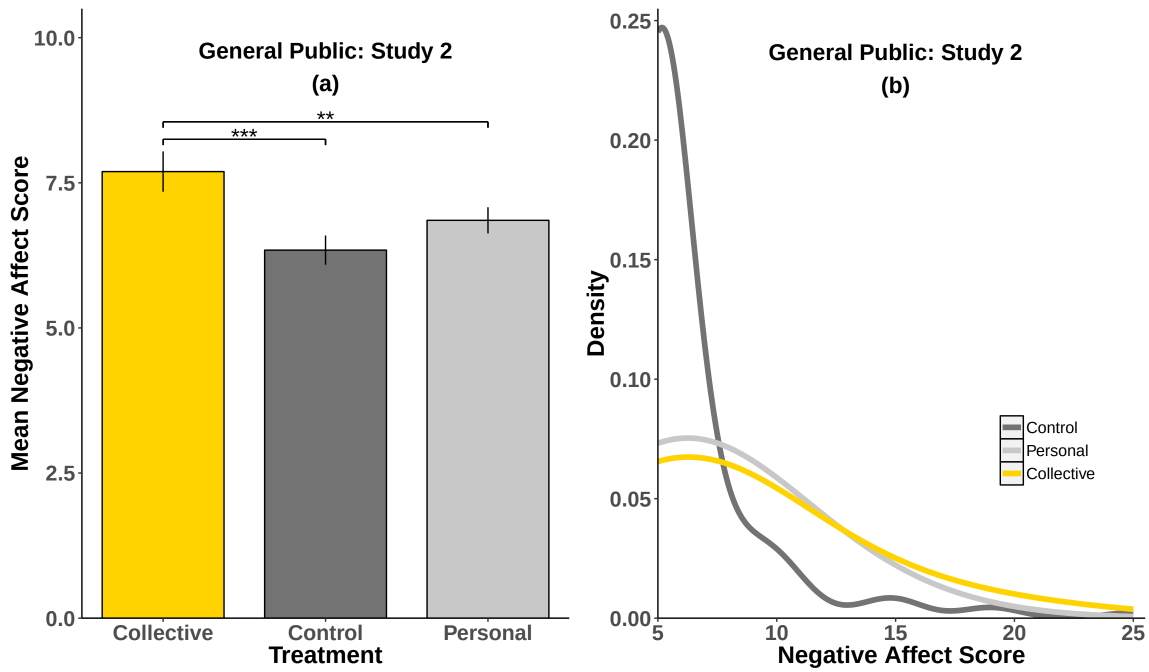

Figure 3.5: Collective treatment increases negative emotions. Panel (a) depicts the mean score on a standardized negative affect scale [191] across treatment groups in the second study with MTurk workers (n=451). Three stars indicate significant difference at the p=0.01 level. Error bars are SEM. Panel (b) consists of kernel density plots of negative affect for each of the three experimental groups, with negative affect increasing along the x-axis. Participants in the control group reported the least negative affect, while individuals given the collective responsibility treatment reported the highest level of negative emotions.

to represent fear and anxiety) than did the personal condition (heteroskedasticity robust OLS t-statistic: 2.033, p-value: 0.043, Cohen's d: 0.23) or the control condition (heteroskedasticity robust OLS t-statistic: 3.163, p-value: 0.002, Cohen's d: 0.37) (see Figure 3.5, panel (a)) [192, 191, 193]. Negative affect in the personal condition did not significantly differ from the control. This treatment-induced difference in negative affect may partially explain differences in donations. Following this logic, individuals in the collective treatment group were motivated to donate to counterbalance their negative emotions stimulated by thinking of climate change with the positive feelings associated with prosocial giving [194, 195, 196].

The purpose of this study was to test the prevailing wisdom in environmental messaging that stresses individual responsibility and action, a focus which limits our ability to causally identify mechanisms underlying the observed effect of treatment. Evidence presented here suggests that the collective prime induced greater negative emotion and less avoidant behavior than the personal condition. Neither condition created differential feelings of guilt. Both theories of cognitive dissonance and construal level are somewhat consistent with these findings. However, we are unable to make definitive claims or rule out other alternative explanations at this stage. Future studies may help to more concretely identify the psychological underpinnings of our results.

3.8 Discussion

The evidence we present suggests that emphasizing collective responsibility for climate change may be more effective at altering climate-related behaviors and attitudes. The collective responsibility treatment outperforms the control and personal responsibility treatments across multiple studies in altering both actual behavior and intentions about future behavior. The observed effects hold in both environmentalists and the general public and persist over time. The magnitude of these treatment effects, though small on an individual basis, is substantively large when put into the aggregate context of donations for climate advocacy [130]. A 7% to 50% increase in donations to climate advocacy would translate into millions of additional dollars raised each year.

While the combined results of our studies are strongly suggestive that collective responsibility may increase pro-climate action, our findings are subject to a handful of limitations and future studies may expand on these results in useful ways. First, the respondents across all of our studies believed more strongly in the occurrence of climate change than does the average U.S. citizen [197]. Understanding how individuals inclined to care about the climate may be persuaded to increase their pro-climate behaviors is important. Yet, future studies should investigate more directly how collective framings alter climate intentions among those less supportive of climate action. Second, the use of essay writing primes may limit the external validity of our findings [173]. Thus, examining how collective versus personal responsibility appeals in actual advocacy settings differentially stimulate pro-climate behavior would be useful to establish the limits of our findings. Third, our study could benefit from extending the time until follow up to examine whether effects persist over even longer periods of time. Fourth, future studies should examine the effect of asking respondents to donate already awarded funds, to see if this measure differs from the donation of probabilistically expected dollars. Finally, further study is needed to more precisely discern the psychological processes that underlie the behavioral differences we observe.

Ultimately, it is critical to understand the factors that drive individuals to change their ingrained climate-related behaviors. The evidence from our studies suggests highlighting personal responsibility for climate change provides insufficient motivation for actual behavioral change. Presenting climate change as a collective problem with ways to individually contribute to its solution proves to be more persuasive.

3.9 Methods details

We ran five separate surveys via the Qualtrics platform. For the National Audubon Society, we conducted two identical surveys contemporaneously, pooling together respondents for a total sample size of 1,215. The Audubon surveys recruited from rural and urban respondents respectively. Respondents for the Audubon study were recruited via Audubon's affiliate email list. Those who completed the Audubon study volunteered to do so. Once the Audubon surveys had completed, we conducted the first survey of respondents via the MTurk platform (n=304). After completion of that study, we conducted another survey on Qualtrics to follow up with the MTurk participants who completed the first study. These participants were again reached via the MTurk platform. Only those subjects who completed the first study were enabled to complete the follow up. Of the 304 original subjects, 238 (78.3%) completed the follow up within the five day predetermined limit for response. After the follow up study, we conducted the second main survey via the MTurk platform (n=451), our fifth survey overall, to evaluate behavioral intentions as well as the possible impacts of our treatment on respondents' emotions. Respondents across all of the MTurk studies were similarly compensated via the MTurk platform for participation in the study. We conducted no other studies related to this topic aside from those reported on here. Further, sample size was determined by the number of total respondents to the Audubon Study and was predetermined for each MTurk study, and hypothesis testing was conducted prior to the data stoppage.

On the essay tasks, Audubon participants wrote a median of 41 words, and took a median of approximately 3.5 minutes to complete the experimental task. Time to completion of the essay did not significantly vary by treatment assignment. Average essay word count was largest for the control task and did not significantly differ between the personal and collective tasks. In the first MTurk experiment, subjects wrote a median of 72 words, spending a median time of 3.2 minutes on the tasks. Respondents took longest on the collective condition, while the average time did not significantly differ between the personal and control conditions. Average essay word count was again largest for the control task and again did not significantly differ between the personal and collective tasks. Finally, the MTurk behavioral intentions subjects wrote a median of 65 words and took a median of 3.2 minutes to complete the task. Respondents took significantly longer on the collective condition than on the control, while the average time did not significantly differ between the personal and control conditions nor between the collective and personal conditions. Average essay word count was again largest for the control task and again did not significantly differ between the personal and collective tasks. Our results are robust to controlling for both essay duration and word count as well as for demographic variables (see *Appendix: Table 3.2* and *Appendix: Table 3.3*).

Our studies delivered the experimental treatments similarly across all three surveys where experiments were conducted (no experiment was conducted in the follow up MTurk study). Wording was consistent across the three administrations of treatment to achieve as exact a replication as possible. The survey opened with basic demographic questions (age, gender, zip code) followed by the experiment. Our primary outcome measures were collected immediately following treatment administration. We kept responses from those who completed the survey and answered our main outcome measures. Individuals were assigned to experimental conditions via Qualtrics' randomization tool.

3.10 Appendix

3.10.1 Follow up study drop out rates by group

Here we include a plot of the drop out rates between the first MTurk study and the follow up for that study (Figure 3.6).

3.10.2 Follow up study donation correspondence

Here we include figures for the correspondence of participants' donations between the first MTurk study and their donations in the follow up study (Figure 3.7).

3.10.3 Main text regression table

We present the regression parameters and statistics mentioned in the main text in Table 3.1. Of note we employ Huber-White heteroskedasticity robust standard errors in each of the regressions [174].

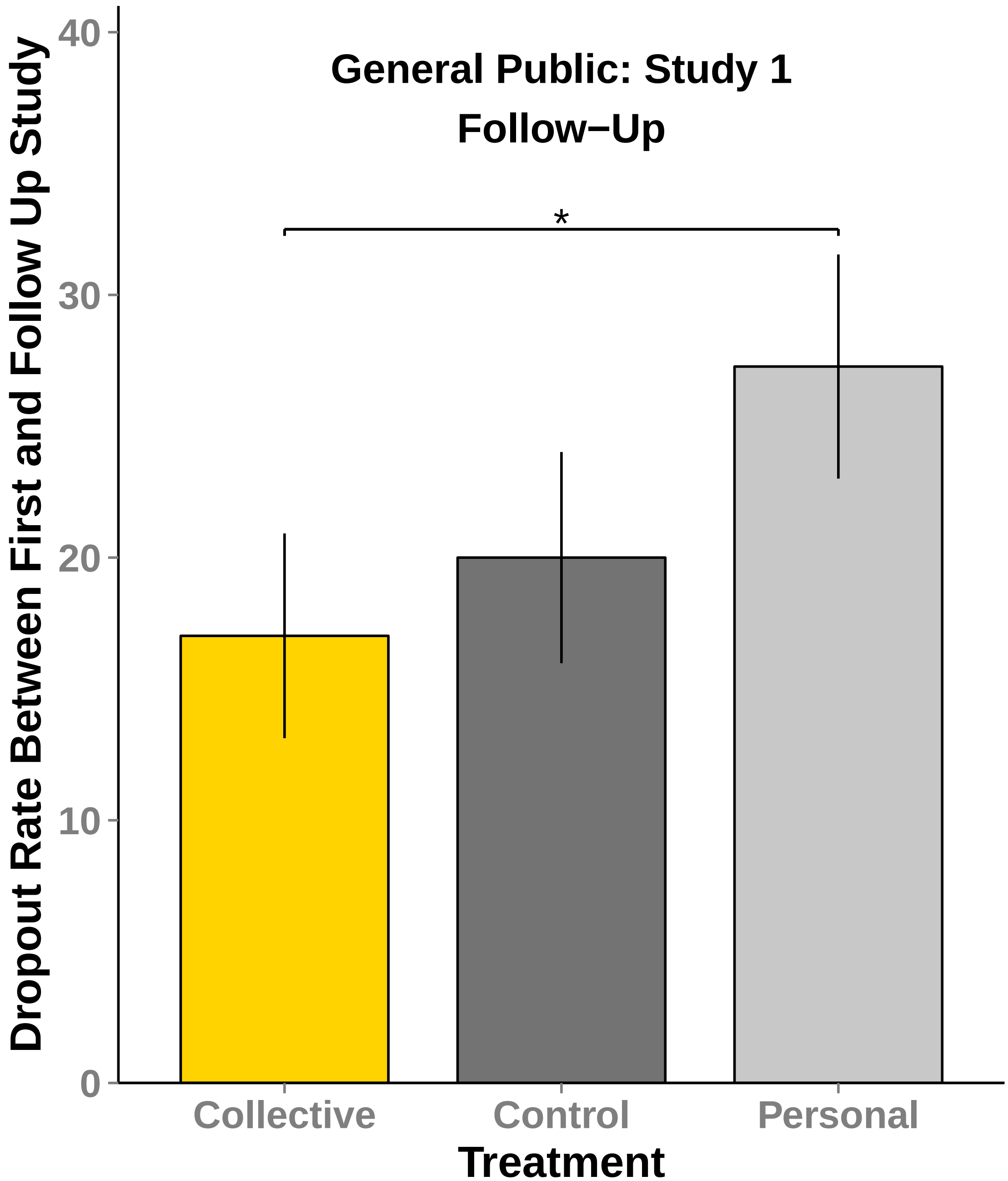

Figure 3.6: Personal treatment group respondents dropped off at higher rates than did collective group respondents. This relationship is significant at the p=0.10 level. Overall 238 out of 304 – or 78.3% – of respondents completed the follow up survey.

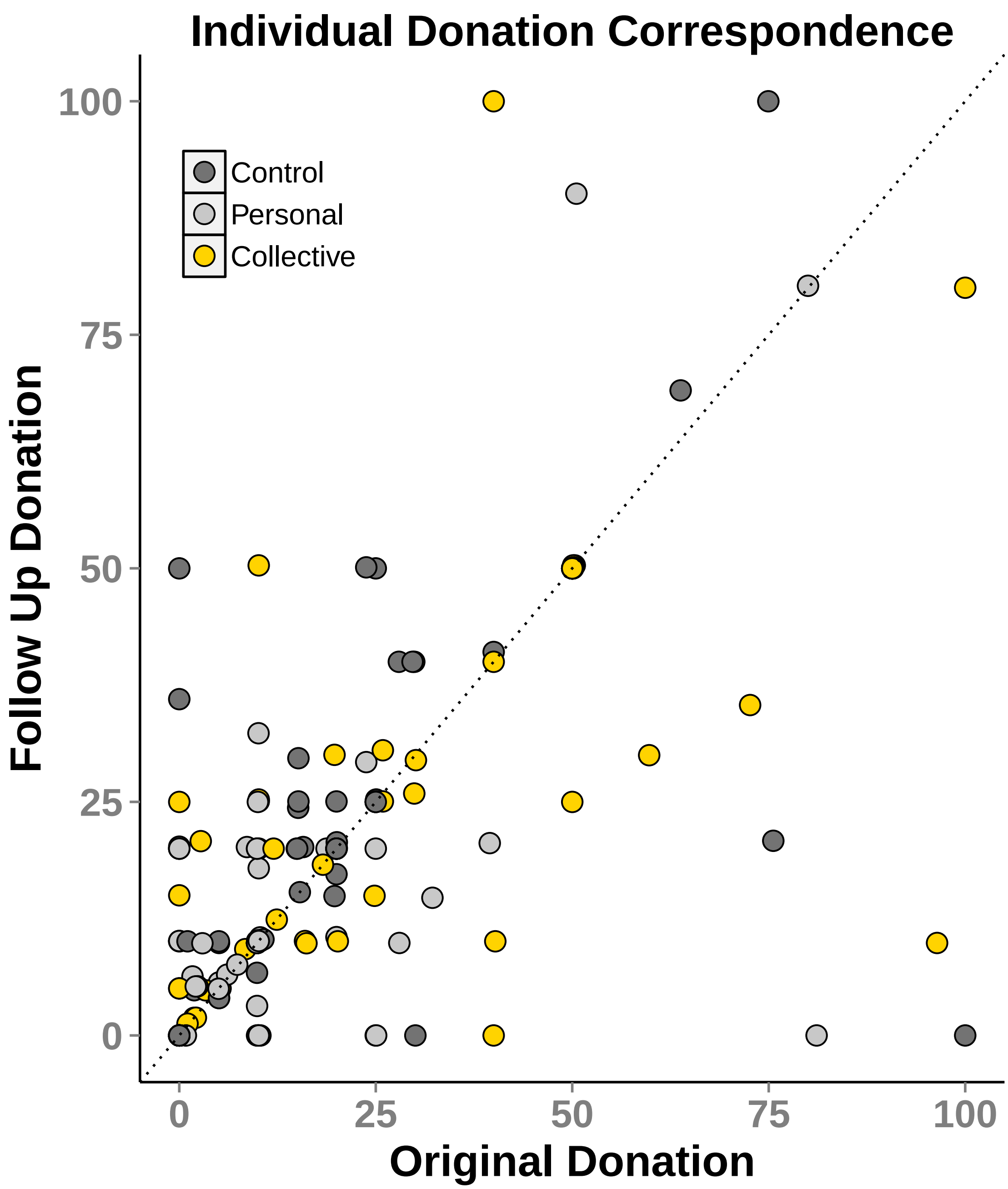

Figure 3.7: Individual donations in the follow up study track original donations closely. Individuals gave a similar amount in the follow up study (n=238) as they did in the original study (n=304). The dotted line represents perfect correspondence between pre and post donations. While some participants chose to give the same amount, many deviated slightly from this 45° line.

Table 3.1: Regression table of results presented in the main text. The results presented in the main text are from ordinary least squares regressions that employ Huber-White heteroskedasticity robust standard errors [174]. *Personal* and *Control* are indicator variables of experimental group membership. The omitted reference category is the collective experimental group.

	Dependent variable:						
	Donate		Dropout	Donate	Intent	N. Affect	Guilt
	Audubon	MTurk 1	Follow Up			MTurk 2	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Personal	-4.23^{*}	-6.99^{**}	0.10^{*}	-6.77^{**}	-7.22^{**}	-0.84^{**}	0.52
	(2.38)	(3.32)	(0.06)	(3.13)	(3.15)	(0.41)	(0.56)
Control	-5.55^{**}	-6.59^{*}	0.03	-4.82	-4.91	-1.35^{***}	-0.28
	(2.52)	(3.41)	(0.06)	(3.20)	(3.18)	(0.43)	(0.60)
Constant	78.10^{***}	21.27^{***}	0.17^{***}	19.40^{***}	65.99^{***}	7.69^{***}	21.93^{***}
	(1.66)	(2.69)	(0.04)	(2.43)	(2.17)	(0.35)	(0.42)
Observations	1,215	304	304	238	451	451	451
R^2	0.004	0.02	0.01	0.02	0.01	0.03	0.004
Adjusted R^2	0.003	0.01	0.005	0.01	0.01	0.02	-0.0000
F Statistic	2.71^{*}	2.95^{*}	1.70	2.54^{*}	2.68^{*}	5.87^{***}	0.99
Note:					*p<0.1; **p<0.05; ***p<0.01		

3.10.4 Robustness checks

Essay length and duration

One reason for the observed treatment effects in the main text could be that the different essay tasks spurred respondents to spend more time – or to write more – on some topics than others. The one consistent difference along these lines was that respondents wrote more for the control task than for the two climate change treatments. It is likely that this difference results from the ease of recalling information about one's daily routine as compared to climate change information. Our results presented in the main text are robust to controlling for both differences in essay length and duration. Table 3.2 presents the results of these regressions.

Controlling for demographics

The main text results presented in Table 3.1 are robust to the inclusion of demographic variables common across the administrations of the experiment, as can be seen in Table 3.3.

Pooled analysis

Because the Audubon study and the first MTurk study employ the same experimental treatments and the same dependent variables, we are able to employ a method from meta-analysis to further investigate the effect of the collective prime on donations as compared to the control and personal treatments. The main text results we reported, in addition to robustness checks with demographic and essay characteristic controls can be seen in Table 3.4. When all controls are included, both of our main effects gain statistical significance at the p=0.01 level.

Table 3.2: Results are robust to controlling for essay length and duration. The results presented in the main text are robust to controlling for essay word count and duration in ordinary least squares regressions that employ Huber-White heteroskedasticity robust standard errors [174]. The only finding that drops from significance is that of the personal treatment increasing dropout as compared to the collective treatment, which was previously significant at p=0.10. The omitted reference category is the collective experimental group.

	Dependent variable:					
	Donate		Dropout	Donate	Intent	N. Affect
	Audubon	MTurk 1	Follow Up		MTurk 2	
	(1)	(2)	(3)	(4)	(5)	(6)
Personal	-4.33^{*}	-6.82^{**}	0.09	-6.71^{**}	-6.88^{**}	-0.92^{**}
	(2.38)	(3.33)	(0.06)	(3.22)	(3.20)	(0.42)
Control	-6.31^{**}	-6.30^{*}	0.05	-2.89	-3.13	-1.56^{***}
	(2.53)	(3.75)	(0.06)	(3.61)	(3.39)	(0.47)
Essay Duration	-0.001^{***}	0.002	-0.0001	0.002	0.005	-0.003^{***}
	(0.0004)	(0.01)	(0.0002)	(0.01)	(0.01)	(0.001)
Word Count	0.05^{**}	-0.004	-0.001^{*}	-0.06^{**}	-0.05	0.002
	(0.02)	(0.06)	(0.001)	(0.03)	(0.04)	(0.004)
Constant	76.51^{***}	20.96^{***}	0.29^{***}	22.97^{***}	67.79^{***}	8.22^{***}
	(2.04)	(4.67)	(0.06)	(3.60)	(3.81)	(0.50)
Observations	1,212	304	304	238	451	451
R^2	0.01	0.02	0.03	0.03	0.02	0.04
Adjusted R^2	0.01	0.01	0.01	0.01	0.01	0.03
F Statistic	3.25^{**}	1.48	1.99^{*}	1.88	1.77	4.20^{***}

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3.3: Results robust to the inclusion of demographic covariates. The results presented in the main text are robust to controlling for demographic covariates common across the studies in ordinary least squares regressions. The only finding that drops from significance is that of the personal treatment increasing dropout as compared to the collective treatment, which was previously significant at p=0.10. The collective group serves as the indicator reference case in these regressions. Standard errors are heteroskedasticity robust.

	Dependent variable:					
	Donate		Dropout	Donate	Intent	N. Affect
	Audubon	MTurk 1	Follow Up		MTurk 2	
	(1)	(2)	(3)	(4)	(5)	(6)
Personal	−5.04**	−7.04**	0.09	−6.20**	−6.68**	−0.85**
	(2.40)	(3.27)	(0.06)	(2.99)	(3.17)	(0.41)
Control	−5.50**	−6.45*	0.02	−4.76	−4.34	−1.39***
	(2.53)	(3.40)	(0.06)	(3.15)	(3.20)	(0.43)
Age	0.12	−0.01	−0.004*	0.19	0.06	−0.05***
	(0.08)	(0.13)	(0.002)	(0.15)	(0.12)	(0.01)
Gender	4.06*	−0.14	0.05	−0.07	−0.28***	−0.01
	(2.23)	(2.63)	(0.05)	(2.49)	(0.03)	(0.02)
Constant	64.04***	21.89***	0.22**	12.73**	63.68***	9.25***
	(6.60)	(5.60)	(0.10)	(5.60)	(4.66)	(0.61)
Observations	1,180	303	303	238	450	450
R^2	0.01	0.02	0.02	0.03	0.02	0.05
Adjusted R^2	0.01	0.01	0.01	0.02	0.01	0.04
F Statistic	3.04**	1.44	1.68	1.91	2.21*	5.83***

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3.4: Regression table of pooled regression results presented in the main text. The pooled analysis results presented in the main text are from ordinary least squares regressions that employ Huber-White heteroskedasticity robust standard errors [174] and an indicator term that accounts for fixed study-level characteristics [178]. These statistics are presented in model (1). The results remain robust to the inclusion of essay characteristic controls, demographic controls, and both sets of controls in models (2)-(4).

	Dependent variable:			
	Donate			
	Main	Essay Controls	Demo. Controls	All
	(1)	(2)	(3)	(4)
Personal	-4.77^{**}	-4.82^{**}	-5.25^{**}	-5.35^{***}
	(2.03)	(2.02)	(2.05)	(2.04)
Control	-5.74^{***}	-6.54^{***}	-5.62^{***}	-6.41^{***}
	(2.13)	(2.15)	(2.14)	(2.17)
Essay Duration		-0.001^{***}		-0.001^{***}
		(0.0004)		(0.0004)
Word Count		0.04^{*}		0.03
		(0.02)		(0.02)
Age			0.10	0.10
			(0.07)	(0.07)
Gender			3.07^{*}	2.76
			(1.84)	(1.86)
Observations	1,519	1,516	1,477	1,475
R^2	0.34	0.34	0.34	0.35
Adjusted R^2	0.33	0.34	0.34	0.34
Note:			*p<0.1; **p<0.05; ***p<0.01	

Randomization checks

We randomly assigned subjects to *personal*, *collective*, or *control* conditions via the Qualtrics platform. Thus, given our control over the assignment protocol, subjects should be sufficiently balanced across treatment in their observable and unobservable characteristics [198]. In order to check the success of randomization we conduct a series of randomization checks and present balance tables for the common demographic and pre-treatment variables we recorded (see Tables 3.5, 3.6, and 3.7) [199].

3.10.5 Essay content

The content of the essays varied, but respondents consistently hewed to treatment instructions. Those who received the personal treatment wrote about their personal contributions to causing climate change, those who received the collective treatment wrote about the collective causes, and those who received the daily routine task wrote about their daily lives. We present word clouds derived from the essay content for each condition across the three separate studies in Figure 3.8. Word size indicates the frequency of the use of that word in the response essays.

Collective content

As a check to ensure that the collective responsibility treatment did indeed prime collective concepts more than the personal or control conditions, we code each essay for whether or not it contains the collective terms “we” or “our”. Testing for the difference in incidence of these terms across treatment conditions can provide some quantitative insight into whether or not collective essay tasks did indeed contain more collective content than the essays from other treatment arms.

Table 3.5: Audubon Study: common demographic and pre-treatment variables show balance. The percentage of respondents male, the average age, and the percentage of respondents who believe in climate change are sufficiently balanced across treatment groups in the Audubon study. No treatment groups significantly differ from the others along these covariates.

	Treatment	Pct.Male	Mean.Age	Pct.Believe
1	Personal	35.76	62.36	94.88
2	Collective	30.37	62.45	93.60
3	Control	34.59	61.15	93.87

Table 3.6: MTurk Study 1: common demographic and pre-treatment variables show balance, except for on age. The percentage of respondents male, and the percentage of respondents who believe in climate change are sufficiently balanced across treatment groups in the first MTurk study. No treatment groups significantly differ from the others along these covariates. However, the personal group was significantly younger on average (likely due to chance [200]). Table 3.3 illustrates the results are robust to controlling for these differences.

	Treatment	Pct.Male	Mean.Age	Pct.Believe
1	Control	62	35.40	87
2	Collective	57.45	35.72	84.04
3	Personal	63.64	32.55**	83.64

Table 3.7: MTurk Study 2: common demographic and pre-treatment variables show balance. The percentage of respondents male, average age, and the percentage of respondents who believe in climate change are balanced across treatment groups in the first MTurk study. No treatment groups significantly differ from the others along these covariates.

	Treatment	Pct.Male	Mean.Age	Pct.Believe
1	Personal	56.69	33.83	87.90
2	Control	56.25	33.35	83.33
3	Collective	61.22	34.32	86

Performing this test by coding an essay as one if it contains either the words 'we' or 'our' and zero otherwise, we find that in the Audubon study approximately 37% of collective treatment essays contain either 'we' or 'our' while approximately 13% of control essays contain these terms. Conducting a two-tailed t-test for the difference in average use of collective terms across conditions returns a highly significant t-statistic of 7.823. For the first MTurk study, we find that nearly 43% of collective condition essays contain the collective terms while only 17% of control essays contained such terms. This difference is also highly significant, with a t-statistic of 4.013. Finally, in the second MTurk experiment we find that approximately 37% of collective essays contained collective terms while approximately 18% of control task essays contained such terms. This difference is again highly statistically significant with a t-statistic of 3.655. Thus, the collective essay tasks produced double to triple the incidence of common words associated with collective concepts as compared to the control essay task.

We also find that across all three experiments the collective treatment essays contain statistically significantly higher rates of the collective terms than do the personal essays (Audubon collective mean: 0.37, Audubon personal mean: 0.28, t-statistic: 2.713; MTurk Study 1 collective mean: 0.43, MTurk Study 1 personal mean: 0.13, t-statistic: 4.939; MTurk Study 2 collective mean: 0.37, Mturk Study 2 personal mean: 0.15, t-statistic: 4.532). Thus the collective essay condition significantly increased use of collective terms compared to both other experimental conditions across all of our studies.

Figure 3.8: Common words across the three studies' experimental arms. Across all three studies the most common words in each experimental assignment are quite similar. While length and time varied somewhat across studies, the general content was fairly consistent.

3.11 Author contributions

N.O. designed the experiment, analyzed the data, produced figures and tables, and drafted the manuscript and supplementary information. S.M.G. edited the manuscript and supplementary information. Both authors developed the research question.

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