The Influences of Political Affiliation and Weather-Related Impacts on Climate Change Adaptation in U.S. Cities

RACHEL M. GURNEY,[a] SISI MENG,[b] SAMANTHA RUMSCHLAG,[b] AND ALAN F. HAMLET[b]

[a] *University of Wisconsin–Madison, Madison, Wisconsin*
[b] *University of Notre Dame, Notre Dame, Indiana*

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ABSTRACT: This study examines the influences of state and local political affiliation and local exposure to weather-related impacts on local government climate change adaptation efforts in 88 U.S. cities. Although climate adaptation takes place when cities replace critical infrastructure damaged by severe weather events, little is known about the influence of political affiliation and severe weather events on climate adaptation in a broader sense. Using multiple linear regression models, this study analyzes variations in local government climate adaptation efforts as a function of local gross domestic product (as a control variable), historical weather-related factors [i.e., number of extreme weather events, weather-related economic impact due to property damage, and weather-related human impact (injuries and fatalities)], and state and local political affiliation. The findings of this study indicate that local political affiliation significantly influences local government climate adaptation efforts; however, state political affiliation does not. Further, local weather-related impacts do not appear to affect the likelihood of local government to engage in climate adaptation efforts, even when accounting for potential interactions with local political affiliation. These results support the hypothesis that local political affiliation is a strong and robust predictor of local climate adaptation in U.S. cities. This study contributes to literature aimed at addressing the widely acknowledged need for understanding key barriers to U.S. climate adaptation, as well as the role of politics in moderating climate action.

KEYWORDS: Adaptation; Climate change; Regional effects; Societal impacts

1. Introduction and background

This study examines the influences of state and local political affiliation and local exposure to weather-related impacts on local government climate adaptation efforts, and it contributes to literature aimed at addressing the widely acknowledged need for understanding key barriers to U.S. climate adaptation adaptation. Cities in the United States have played an increasingly important role in combating climate change by taking up ambitious plans and policies in the absence of consistent federal climate leadership (Hale et al. 2020; Watts 2017). A number of transnational, national, and regional climate action agreements and networks have gained popularity among America's subnational actors and local authorities. These agreements and networks [e.g., the International Council of Local Environmental Initiatives (ICLEI)] have been shown to positively influence the facilitation of climate action regardless of obstacles (e.g., limited financial resources) (Broto 2017; Eisenack et al. 2014; Reams et al. 2012). Initiatives supporting climate adaptation efforts in cities are particularly crucial because most adaptation planning in the United States takes place on the local level (Bierbaum et al. 2013; Fiack et al. 2021; Romero-Lankao and Dodman 2011).

Climate change adaptation is broadly defined by the Intergovernmental Panel on Climate Change as "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC 2014, p. 118). High-density urban areas (HDUAs) are particularly vulnerable to climate impacts such as exposure to extreme weather events of increasing frequency and severity (IPCC 2012; Reidmiller et al. 2018). The involvement of local authorities in climate adaptation planning can help protect people, infrastructure, and ecosystems, as well as provide financial benefits to cities through improved risk management.

Climate adaptation is emerging as a key planning and policy focus among U.S. cities and is increasingly occurring where critical infrastructure is damaged and must be replaced. Nonetheless, U.S. cities are lagging in their involvement in climate adaptation planning (Aylett 2014, 2015; Egerer et al. 2021; Hansen et al. 2013). Where adaptation plans exist, the majority are in the early stages of development (Carmin et al. 2012; Goh 2020). Such findings point to the need to better understand constraints on U.S. subnational climate adaptation—a topic of increasing interest among scholars, practitioners, and advocates (Cruce 2009; Cutter et al. 2014; Egerer et al. 2021; Shi et al. 2016).

Damage to critical infrastructure is also an important factor that can lead to climate adaptation. When critical infrastructure is damaged or destroyed by an extreme weather event, climate adaptation is more likely—either because of awareness that existing infrastructure is inadequate in the face of natural hazards (formally or informally prompting a reevaluation of existing design standards; Byun and Hamlet 2020) or because federal, state, or local policies require climate change information to inform the design of replacement infrastructure. For example, in the case of coastal infrastructure, the U.S. Army Corps of Engineers (USACE) is required by

Corresponding author: Rachel M. Gurney, rgurney@wisc.edu

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federal law to include future sea level rise (SLR) and storm-surge projections in the design of coastal infrastructure (U.S. Army Corps of Engineers 2013). This requirement implies that when coastal infrastructure is rebuilt after a natural disaster, climate adaptation to SLR automatically occurs if the USACE is involved in the design process. Thus, at least in some contexts, climate adaptation in response to weather-related impacts has become an established element of professional engineering practice, which can lead to significant adaptation efforts in states that might otherwise not be likely to engage in climate action for political reasons. Florida, for example, has a primarily Republican political base; however, decisions about how to strengthen or rebuild existing infrastructure in response to storm damage have led to widespread acknowledgment of increasing storm intensity as an important planning issue. These decisions are occurring despite some Florida politicians choosing not to acknowledge that increasing risks are related to climate change.

In a broader sense, however, a growing body of evidence supports the argument that political factors inform infrastructure-related outcomes and other forms of climate adaptation (Gurney et al. 2021; Holland 2017; Rasmussen et al. 2021). Policy action and legislation can lead to important gains in climate action. North Carolina's Executive Order 80, for example, established long-term commitments to address greenhouse gas emissions and support a green energy economy. This policy is ostensibly related to climate change mitigation but also led to North Carolina's first climate action plan (released in June of 2020). This example illustrates how climate change mitigation and adaptation efforts can coincide.

Research over the past 25 years has sought to identify and quantify factors that influence U.S. subnational environmental and climate action (Broto 2017; Bulkeley et al. 2011; Bulkeley 2013; Homsy and Warner 2015; Hughes 2015; Krause 2011; Lutsey and Sperling 2008; Reams et al. 2012; Romero-Lankao and Dodman 2011). One important aspect of this research has examined climate adaptation frameworks to identify barriers to adaptation (Amundsen et al. 2010; Betsill and Bulkeley 2006, 2003; Eisenack et al. 2014; Eriksen et al. 2011; Füssel 2007; Moser and Ekstrom 2010). While extant research has identified broad patterns of climate policy adoption across U.S. cities, a nuanced understanding about the ways political factors influence climate adaptation decision-making (e.g., prioritizing goals and making trade-offs) is lacking. This aim requires greater emphasis on interdisciplinary approaches to understanding political dimensions of climate change, including the politics of U.S. urban climate adaptation.

a. *Political ideology and affiliation*

Literature on *motivated reasoning* explains that ideology is the lens through which individuals come to understand the world around them (Fischle 2000; Hartman and Newmark 2012; Lebo and Cassino 2007; Taber et al. 2009). Numerous studies have shown that ideology influences risk perception and issue importance (Bishop 2013; Egan and Mullin 2017; Leiserowitz 2006; Wildavsky and Dake 1990). Further, research reported in political science literature shows that attention to policy issues often varies based on an issue's alignment with existing ideological beliefs (Tesler 2015; Zaller 1992). Political engagement increases with partisanship (Hetherington 2008), which means individuals on each end of the political spectrum tend to be more politically engaged and hold stronger political attitudes. Political polarization intensifies partisanship for a growing number of politically stigmatized issues such as climate change.

Decades of research examining U.S. climate change public opinion has identified *political orientation* (i.e., political ideology and party affiliation, combined) as the strongest predictor of individuals' climate change views. Political orientation has been shown to influence perceptions about the existence, timing, causes, and risks associated with climate change as well as support for government climate action (Bennett 1975; Dunlap et al. 2016; Hamilton et al. 2010; Jones and Dunlap 1992; Konisky 2008; Konisky et al. 2008; McCright and Dunlap 2011a,b; 2013; McCright et al. 2014b). Political affiliation has also been shown to moderate the influences of weather-related impacts on climate change views (Eschliman et al. 2020; Marquart-Pyatt et al. 2014; McCright et al. 2014a; Ripberger et al. 2017). Similarly, existing climate change views have been shown to influence subjective experiences of weather-related impacts (e.g., above-normal temperatures) (Howe and Leiserowitz 2013). Egan and Mullin (2012) found that weather can have a significant effect on climate change views, particularly when experienced over longer periods of time; however, this effect does not necessarily induce long-term attitude change. Research focusing on the relationship between self-interest and political attitudes indicates little to no evidence that personal experiences affect political attitudes (Lau and Heldman 2009; Sears and Funk 1991; Sears et al. 1980).

Research on barriers to U.S. subnational climate adaptation has been diffuse—focused on particular cities, regions, or weather-related impacts; yet this research has generally found that climate adaptation planning is driven in large part by decision-makers' perceptions of climate-related hazards and risks (e.g., increasingly frequent/severe weather-related impacts). This thesis implies that increasingly frequent/severe weather-related impacts may motivate local involvement in climate adaptation efforts (e.g., planning, laws, policies, and/or agreements). However, because of the political stigma associated with climate change, perceptions about climate-related risks tend to be strongly influenced by existing political views. In general, literature on U.S. subnational climate adaptation has lacked focus on understanding the extent to which politics influences the likelihood of local government involvement in climate adaptation.

b. *Political context*

Political context is an important factor influencing the propensity for U.S. climate action across levels of governance. The effects of political affiliation on support for U.S. climate *mitigation* policies (i.e., policies aimed at reducing greenhouse gas concentrations) are well established in the literature.

Decades of social science research has documented the U.S. conservative movement's success in thwarting such policies on the federal level (Brulle 2020; Jacques et al. 2008; McCright and Dunlap 2003, 2000). On the local level, Dietz et al. (2015) found that politics plays a key role in explaining a city's level of greenhouse gas emissions.

Similarly, several recent studies have concluded that political affiliation significantly influences the likelihood of a city's government to engage in climate adaptation efforts (Gurney et al. 2021; Zahran et al. 2008). A recent review of research examining the knowledge–action gap associated with climate adaptation (Flagg and Kirchhoff 2018) identified climate change skepticism, politicization of climate change, and suppression of climate information by state/local elected officials as key barriers to the use of climate information in water resources planning and management. Such findings raise concern about the efficacy of adaptive measures uninformed by climate information and underline the need to better understand political context as a force facilitating or hindering climate adaptation.

Research about the influences of weather-related impacts (e.g., as a result of increasingly frequent/severe extreme weather events) on local climate action remains inconclusive (Krause 2011; Kundzewicz et al. 2020; Zahran et al. 2006) and the role of politics in moderating this effect is not well understood. Nonetheless, evidence indicates that political stigmatization of climate change and increasing political polarization in the United States create conditions under which weather-related impacts are less likely to catalyze climate action within politically conservative contexts. Though most large U.S. cities lean toward liberalism (even within conservative states), some cities (e.g., Mesa, Arizona; Oklahoma City, Oklahoma; Virginia Beach, Virginia; Colorado Springs, Colorado; and Jacksonville, Florida) are conservative (DeSilver 2020). At the outset of this study, we hypothesized that key government decision-makers in conservative cities may be less likely to link weather-related impacts to climate change, may fail to perceive these impacts as motivations for climate adaptation planning, and/or may oppose climate adaptation based on political ideology. Conversely, more liberal cities may be more inclined to link weather-related impacts to climate change and use this information to inform adaptation opportunities.

c. *Government action*

As general long-standing practice, legislators attempt to anticipate public sentiments based on objective conditions or highly apparent costs (Arnold 1990). Further, legislative representatives are more likely to respond to constituent concerns about salient issues (Kingdon 1989; Page and Shapiro 1983; Wlezien 2004). This tendency toward responsiveness is most pronounced on local levels where government officials have a relatively large number of response strategies available to them, high visibility, and few barriers to public participation.

Problem severity is an important factor influencing government decision-making. The *conditional theory of specialized governance* (Mullin 2008) posits that the severity or salience of a public problem conditions the effect of government policy outcomes. In cases of high problem severity, the electoral incentive for local government authorities to address a public problem increases, and in cases of low problem severity, the likelihood of a policy response decreases. Mullin (2008) argues that this shift in policy outcomes has the potential to occur through two different pathways: 1) increased problem severity can increase legislator attention and the likelihood that limited resources will be allocated to address a particular problem, and 2) increased problem severity can provide electoral incentives facing government officials. Focusing policy efforts where the public's attention is drawn has been shown to play out in a number of ways. For example, local government social policy is more geared toward social inclusion in cities with higher poverty rates (Hughes et al. 2018), and cities with high immigrant populations are more likely to implement immigration policies (Walker and Leitner 2011).

Historically, literature on climate impacts and policy responsiveness of local governments have developed in isolation without much attention to the interplay between these two realms (Hughes et al. 2018; Krause 2012; Mullin 2008; Teodoro 2010). Recent research on urban politics, however, has focused on the potential of problem severity to influence local policy response. For example, studies have examined whether observed temperature change, recent exposure to weather-related impacts, and greenhouse gas emissions influence local government support for climate change policy (Hughes et al. 2018; Krause 2012; Zahran et al. 2008). As noted previously, such research is generally inconclusive about the effects of weather-related impacts on local climate policy, with some studies finding a strong influence (Brody et al. 2008; McGuire and Silvia 2010; Zahran et al. 2008) and others finding little or no evidence that weather-related impacts increase local climate policy adoption (Hughes et al. 2018; Krause 2012).

2. Research design and hypotheses

This study's primary unit of observation is the city, and these observations are drawn from 88 U.S. cities across 32 states with varying sociopolitical, economic, and geographic characteristics. This study tests three interrelated hypotheses (H1–H3) aimed at examining the effects of exposure to weather-related impacts on local government climate adaptation and the influence of political affiliation in moderating these effects while controlling for local gross domestic product (GDP).

H1: *Political affiliation is a robust predictor of local climate adaptation*—Building upon the findings of Gurney et al. (2021), which found politics to be a robust predictor of U.S. local climate action (adaptation and mitigation), this study focuses specifically on the effects of local and state political affiliation on local climate adaptation while controlling for local GDP. (State and local political affiliation values were calculated using political affiliation indices.)

H2: *Local exposure to weather-related impacts is a predictor of local climate adaptation*—Gurney et al. (2021) found that indices based on generalized climate change risk

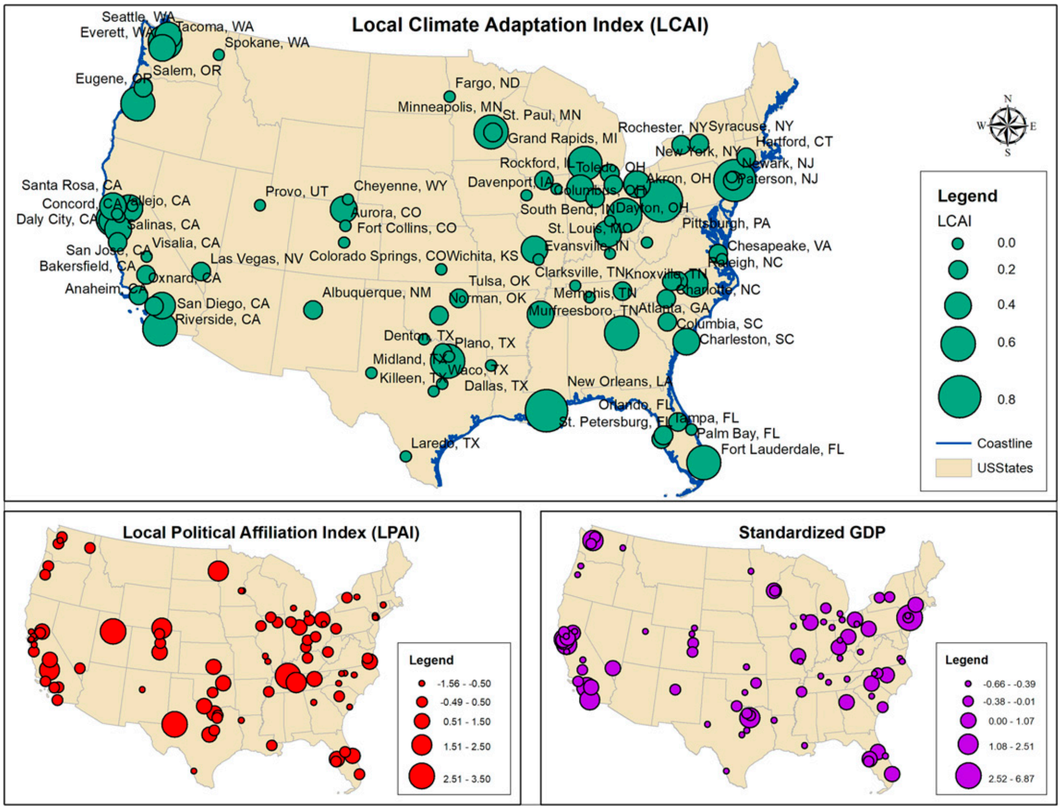

FIG. 1. Standardized index scores and GDP for all 88 cities in the sample.

factors (e.g., proximity to the coast, exposure to hurricanes) are not meaningful predictors of local climate action. This study uses records of actual (rather than expected or estimated) exposure to weather-related impacts with the understanding that actual exposure to weather-related impacts could reveal a stronger relationship between weather-related impacts and climate adaptation—particularly because storm damage to critical infrastructure has led to de facto adaptation in some cities (e.g., New Orleans, Louisiana; New York, New York; and Houston, Texas).

H3: *Political affiliation moderates the effect of exposure to weather-related impacts on local climate adaptation*—This hypothesis examines the effects of potential interactions between politics and weather-related impacts on local climate adaptation.

Building upon the methods developed by Gurney et al. (2021), these hypotheses were tested using multiple linear regression models, including variables derived from three indices [the local climate adaptation index (LCAI) (as the dependent variable), the local political affiliation index (LPAI), and the state political affiliation index (SPAI)], data measuring local exposure to weather-related impacts over time, and local GDP (as the control variable). Due to data limitations and the scope of this research, this study does not consider the effects of individual-level characteristics outside of political affiliation (e.g., scientific literacy; Drummond and Fischhoff 2017; Kahan et al. 2012), nor does this study consider climate adaptation efforts made by individuals concerning their private homes and property.

3. Methods

This study's sample of 88 cities was selected based on data availability and research design from a larger sample of 136 cities examined by Gurney et al. (2021). Gurney et al. (2021) selected these cities from the sample of U.S. urban cities (populations > 100 000) included in the University of Notre Dame's Urban Adaptation Assessment (UAA) (Notre Dame Global Adaptation Initiative 2018). Pairing county-level data with each city, redundancies in counties across cities (i.e., multiple cities associated with the same county) were addressed by keeping only the highest population city associated with each county in this study's original sample of 136 cities. We chose the largest city in each case because it represents the largest fraction of a county's population. This process of refining the data resulted in a final sample of 88 cities for this study. Figure 1 shows city locations and other key variables.

This study measures local exposure to weather-related impacts over 10 years (2009–18) using data from the National Oceanic and Atmospheric Administration's Storm Events Database (NOAA 2019). These data are documented on the county level and include the number of weather-related impacts [number of events (NE)], weather-related economic impact due to property

TABLE 1. Description of variables and coding for the local climate adaptation index.

Variable	Description	Coding
Water Utility Climate Alliance[a]	The Water Utility Climate Alliance (WUCA) is committed to better understanding the impacts of climate change on water-related infrastructure and water resource supplies; WUCA facilitates leadership and collaboration on climate change issues affecting U.S. water agencies	1 = presence; 0 = absence
100 Resilient Cities[b]	The 100 Resilient Cities is a global network of cities committed to becoming more resilient to the physical, social, and economic challenges associated with addressing environmental problems	1 = presence; 0 = absence
Climate Mayors[c]	Climate Mayors is a bipartisan, peer-to-peer network of U.S. mayors working together to demonstrate leadership on climate change through meaningful actions in their communities and to express and build political will for effective federal and global policy change	1 = presence; 0 = absence
ICLEI local government for sustainability[d]	ICLEI member cities, towns, and counties compose the largest network of local governments working to create more sustainable, resilient communities; along with ICLEI's regional and higher-education affiliates, these communities lead action toward creating low-carbon, equitable, and resilient communities that utilize nature-based and circular solutions	1 = presence; 0 = absence
Local climate adaptation plans[e]	City (or associated county) climate adaptation plan	1 = presence; 0 = absence

[a] Water Utility Climate Alliance (2018).
[b] https://resilientcitiesnetwork.org/.
[c] https://climatemayors.org/member-cities/.
[d] ICLEI (2018).
[e] Georgetown Climate Center (2018).

damage [economic impact (EI), in increments of $1000], and weather-related injuries and fatalities [human impact (HI)]. Capturing weather data over a 10-yr period accounts for variations in impacts, including any weather-related anomalies that may have impacted a county but left a city unaffected.

For this study, *local government climate adaptation* is defined as the existence of local climate adaptation plans and/or local government involvement in transnational, national, and/or regional climate adaptation commitments. The LCAI (Table 1) is based on five binary variables representing participation/nonparticipation in local government climate adaptation efforts such as plans, initiatives, memberships, and commitments. Although some climate actions in this index relate to both climate mitigation and adaptation, actions aimed at reducing vulnerability to climate-related impacts are categorized as adaptation efforts. LCAI values for regression were calculated by averaging across five binary variables, resulting in a categorical variable ranging between zero and one (0, 0.2, 0.4, 0.6, 0.8, and 1.0). Apart from the presence or absence of local climate adaptation plans, some of the commitments and memberships represented in the LCAI are nonbinding. Nonetheless, they represent important signals of (intended) climate action. The inclusion of these variables provides a more robust indicator of local governments' propensity toward climate adaptation measures than using climate adaptation plans as a dependent variable alone.

Total SPAI and LPAI scores for each city were calculated by averaging across a set of standardized variables (which implies relatively equal weights) (Table 2). To normalize binary variables, 0.5 was subtracted from the raw binary values (0, 1) to produce a mean value near zero across all cities, with unchanged variance. Continuous variables were standardized in the normal manner (mean = 0, standard deviation = 1).

The resulting SPAI and LPAI capture each city's political affiliation prominence across multiple sectors at state and local levels. These index values were restandardized (mean = 0, standard deviation = 1) before including them in the regression models in order to avoid biasing the outcomes toward any one variable due to different magnitude or units. For the standardized indices, negative values represent prominence of Democrats, positive values represent prominence of Republicans, and values near zero indicate bipartisan affiliation.

This study uses local GDP (U.S. Bureau of Economic Analysis 2018) as a control variable to account for variations in government financial resources. As previously discussed, financial limitations are a known constraint on climate adaptation efforts. Further, government budgetary constraints on the repair or replacement of faulty infrastructure may account for greater weather-related impacts in some cases. Preliminary analyses for this study involved testing a range of local demographic variables (e.g., population, median income, area, and education) from the University of Notre Dame's UAA (Notre Dame Global Adaptation Initiative 2018), none of which were shown to be stronger predictors of LCAI than local GDP.

TABLE 2. Description of variables and coding for the political affiliation indices.

Variable	Coding/calculation
SPAI	
Governor political party affiliation[a]	0.5 = Republican; −0.5 = all else[f]
State senate political party majority[a]	0.5 = Republican; −0.5 = all else[f]
State house political party majority[a]	0.5 = Republican; −0.5 = all else[f]
Political party advantage[b]	Standardized: (Republican population − Democrat population)/Democrat population
Percent Trump voters[c]	Standardized: (votes for Trump/total votes) × 100
LPAI	
Mayor political party affiliation[d]	0.5 = Republican; −0.5 = all else[f]
Political party advantage[e]	Standardized: (Republican population − Democrat population)/Democrat population
Percent Trump voters[c]	Standardized: (votes for Trump/total votes) × 100

[a] Henry J. Kaiser Family Foundation (2019).
[b] Gallup (2018).
[c] 2016 election (Bloch et al. 2018)
[d] Data collected for each mayor from various sources.
[e] 2018 Yale partisan climate change public opinion data (Howe et al. 2015).
[f] "All else" = Democrat (and people who are registered as independent, when present in the data).

This study utilizes 11 multiple linear regression models to test the three aforementioned hypotheses examining the influences of state and local political affiliation and local weather-related impacts on local climate adaptation while controlling for GDP (μ is the error term explaining all unobserved factors that influence the local climate adaptation):

$$\text{LCAI} = \alpha + \beta 1 \times \text{LPAI} + \beta 2 \times \text{SPAI} + \beta 3 \times \text{Weather Impacts} + \beta 4 \times \text{GDP} + \mu. \quad (1)$$

All independent variables were standardized (mean = 0; standard deviation = 1) prior to analysis. In addition to evaluating the statistical significance of regression coefficients across models, this study reports adjusted R^2 to compare model fit.

The first hypothesis (H1) aims to examine the influence of state and local political affiliation on local climate adaptation:

$$\text{H}_0\text{: } \beta 1 = 0 \quad \text{and/or} \quad \beta 2 = 0. \quad (2)$$

The null hypothesis (equation above) is rejected if regression coefficients for state and/or local political affiliation are shown to be statistically significant. The second hypothesis (H2) aims to examine the influences of local exposure to weather-related impacts (number of severe weather events, economic impact, and human impact) on local climate adaptation:

$$\text{H}_0\text{: } \beta 3 = 0. \quad (3)$$

This null hypothesis (equation above) is rejected if any combination of weather-related impact variables has a statistically significant regression coefficient.

This study utilizes three interaction terms to test the third hypothesis (H3). These interaction terms test whether political affiliation moderates the influence of weather-related impacts on climate adaptation:

$$\text{Interaction 1} = (\text{NE} + 10)/(\text{LPAI} + 10), \quad (4)$$

$$\text{Interaction 2} = (\text{EI} + 10)/(\text{LPAI} + 10), \quad \text{and} \quad (5)$$

$$\text{Interaction 3} = (\text{HI} + 10)/(\text{LPAI} + 10). \quad (6)$$

An arbitrary integer constant (10) was added to the numerator and denominator to make both positive definite. Resulting values from the equations above were then standardized to create the final interaction term values. Each interaction term *increases* in magnitude as the weather-related impact *increases* and/or LPAI *decreases*. That is, the highest values of the interaction terms represent cities that have historically had heavy exposure to weather-related impacts and have strong prominence of Democrats, and cities with the lowest interaction values have low weather-related impacts and a high prominence of Republicans.

H3 indicates a positive correlation between interaction variables and LCAI while controlling for GDP:

$$\text{LCAI} = \alpha + \gamma \times \text{Interaction} + \beta 4 \times \text{GDP} + \mu \quad \text{and} \quad (7)$$

$$\text{H}_0\text{: } \gamma = 0. \quad (8)$$

For the interaction term to be meaningful, the regression coefficient has to be larger for the interaction term than for its individual components in alternate models. So, for an interaction term based on party affiliation and weather impacts, the interaction term should have a larger coefficient than party affiliation and weather impacts alone in alternate models. If not, the interaction is not considered important.

Model validation was carried out using leave-one-out and split-samples approaches, with different fractions of the data used in the training datasets for split samples. Both tests showed robust error characteristics for the models (see Tables 4 and 5, described in more detail below).

TABLE 3. Results of linear regression models of the local climate adaptation index. Here, $N = 88$, * indicates $p \leq 0.10$, ** indicates $p \leq 0.05$, *** indicates $p \leq 0.01$, and standard errors are given in parentheses.

	1	2	3	4	5	6	7	8	9	10	11
LPAI	−0.062***		−0.058***	−0.057***	−0.058***		−0.061***				
	(0.023)		(0.021)	(0.020)	(0.020)		(0.022)				
SPAI	0.011					−0.014	0.010				
	(0.026)					(0.022)	(0.022)				
NE	−0.003	−0.007	0.000								
	(0.023)	(0.022)	(0.021)								
EI	−0.026	−0.022	−0.025								
	(0.021)	(0.022)	(0.021)								
HI	0.026	0.031	0.027	0.020							
	(0.022)	(0.023)	(0.022)	(0.020)							
Interaction 1[a]									0.038*		
									(0.020)		
Interaction 2[b]										0.023	
										(0.021)	
Interaction 3[c]											0.052**
											(0.021)
GDP	0.108***	0.120***	0.106***	0.107***	0.110***	0.121***	0.111***	0.126***	0.122***	0.121***	0.112***
	(0.022)	(0.021)	(0.021)	(0.021)	(0.020)	(0.022)	(0.021)	(0.020)	(0.020)	(0.021)	(0.021)
Constant	0.227***	0.227***	0.227***	0.227***	0.227***	0.227***	0.227***	0.227***	0.227***	0.227***	0.227***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
R^2	0.384	0.324	0.382	0.372	0.365	0.308	0.366	0.305	0.332	0.315	0.353
Adjusted R^2	0.338	0.291	0.345	0.349	0.350	0.292	0.343	0.297	0.316	0.299	0.338

[a] Interaction 1 = (NE +10)/(LPAI + 10).
[b] Interaction 2 = (EI + 10)/(LPAI + 10).
[c] Interaction 3 = (HI +10)/(LPAI + 10).

4. Results

Table 3 summarizes results from this study's 11 regression models to examine the influences of state and local political affiliation (SPAI and LPAI) and local exposure to weather-related impacts on local climate adaptation. All 11 models control for local GDP. Model 8 shows local GDP alone is highly significant ($p \leq 0.01$) and positively correlated with local climate adaptation (regression coefficient 0.126) with an adjusted R^2 of 0.297. GDP is the best single predictor of local climate adaptation.

Model 2 shows the effects of local exposure to weather-related impacts [number of events, weather-related economic impact from property damage, and weather-related human impact (injuries and deaths)] with an adjusted R^2 of 0.291 and no statistically significant effects of weather-related impact variables. Model 6 shows the influence of state political affiliation on local climate adaptation. Model 6 has an adjusted R^2 of 0.292 and shows no statistical significance for state political affiliation. Model 2 and model 6 have the lowest predictive skill (adjusted R^2) compared to all other models in this study. Model 8 (GDP alone) has stronger predictive skill than model 2 and model 6, which indicates that the predictive skill of model 2 and model 6 is due primarily to the inclusion of GDP and that exposure to weather-related impacts has no significant effect on local climate adaptation as defined in this study.

State political affiliation and weather-related impact variables are not significant predictors of local climate adaptation in any of the models in which they appear as additive variables (models 1, 2, 3, 4, 6, and 7). The weather-related impact variables for number of events and human impact only show significance when combined with local political affiliation for the variables Interaction 1 (NE divided by LPAI) and Interaction 3 (HI divided by LPAI) (model 11 and model 9). Interaction 2 (EI divided by LPAI) (model 10) shows no statistical significance. Interaction 1 (model 9) shows weak statistical significance ($p \leq 0.10$) with an adjusted R^2 of 0.316. Model 11, testing the predictive skill of Interaction 3, shows the highest R^2 (0.338) among all three interaction models. Model 11 shows statistical significance ($p \leq 0.05$) for interaction 3 as a predictor of local climate adaption. Both HI and Interaction 3 are positively correlated with LCAI, and model 11 indicates that cities with historically higher weather-related injuries and deaths, as well as higher prominence of Democrats, are more likely to be involved in local government climate adaptation efforts compared to the inverse. However, comparing model 11 to model 4, which tests the predictive skill of LPAI and HI as separate additive variables, shows that model 4 has a higher adjusted R^2 (0.349) than model 11 and local political affiliation is highly significant ($p \leq 0.01$) while weather-related human impact is not. These findings indicate that interactions between local political affiliation and weather-related impacts are not significant predictors of local climate adaptation and local political affiliation does not appear to be moderating the effects of weather-related impacts on local climate adaptation. This is consistent with the fact that exposure to weather-related impacts has a weak and/or nonsignificant effect on local climate adaption (as shown in models 1, 2, 3, and 4) and suggests that any predictive skill associated with the interaction terms is primarily due to the effects of LPAI in the denominator of the interaction terms.

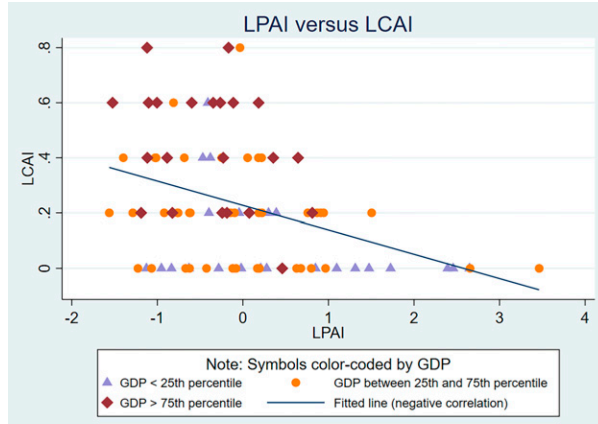

FIG. 2. Scatterplot and fitted line showing the relationship between the local political affiliation index and local climate adaptation index.

Apart from local GDP, local political affiliation (LPAI) is the strongest predictor of local climate adaptation (LCAI). Local political affiliation is highly significant ($p \leq 0.01$) across all models in which it appears (models 1, 3, 4, 5, and 7). Figure 2 shows the negative correlation between the LPAI and LCAI, wherein strong local prominence of Democrats (LPAI < 0) and bipartisan prominence increase the likelihood of local government climate adaptation efforts. This is not to say that all Democrat-leaning cities have high LCAI values—cities with strong prominence of Democrats (LCAI ≤ -1) span a wide range of LCAI values (0–0.8). By comparison, however, of the 10 cities with strong Republican prominence (LPAI ≥ 1), 9 show an LCAI value of zero. Although there are only 5 cities in the data with very strong Republican prominence (LCAI ≥ 2), these cities all have LCAI values of 0 (Fig. 2).

Model 7 includes both state (SPAI) and local (LPAI) political affiliation and has an adjusted R^2 of 0.343. As expected, SPAI is negatively correlated with LCAI, but the regression coefficient is not statistically significant for any of the models that included this variable, nor does adding SPAI increase predictive skill. Model 5 shows the predictive skill of LPAI (controlling for GDP) with an adjusted R^2 of 0.350 and high significance ($p \leq 0.01$) for LPAI with a regression coefficient of -0.058. Model 5 has the strongest predictive skill of all 11 models. When combined with weather-related impact variables alone in model 3, and SPAI plus weather-related impact variables in model 1, LPAI retains its strong statistical significance ($p \leq 0.01$) and negative regression coefficient but adjusted R^2 decreases (model 1 adjusted R^2: 0.338, model 3 adjusted R^2: 0.345), indicating that including weather-related impacts does not improve the overall predictive skill of the model. Leave-one-out cross validation (Table 4; pseudo $R^2 = 0.275$) and a subsample robustness check (Table 5) show that these findings are robust and not sensitive to the choice of training dataset.

TABLE 4. Performance metrics for model 1 based on leave-one-out cross-validation runs.

Method	Value
Root-mean-square errors	0.198
Mean absolute errors	0.154
Pseudo-R^2	0.275

Overall, these findings lead to a rejection of the first null hypothesis ($\beta 1 = 0$) across all models indicating a robust finding that local climate adaptation is significantly influenced by local political affiliation. To test whether this finding was due to the composition of this study's LCAI, logistic regressions of the same 11 models were also run using the presence/absence of a local climate adaptation plan (LCAP) as a binary dependent variable (rather than the more comprehensive LCAI). LPAI also proved to be a robust predictor of LCAP for all models in which it was included. None of the other predictors (including GDP) were statistically significant in these alternative regression models. These findings once again point to LPAI as a strong and robust predictor of climate adaptation across U.S. cities.

This study finds that exposure to weather-related impacts is not a statistically significant predictor of local climate adaptation; therefore, the second null hypothesis ($\beta 2 = 0$) cannot be rejected. However, interactions between NE and LPAI (Interaction 1), and HI and LPAI (Interaction 3) show significance ($p \leq 0.10$ and $p \leq 0.05$, respectively) as predictors of local climate adaptation. This leads to rejection of the third null hypothesis, though the effect is relatively weak for the interaction term based on NE, and neither these models are superior to their additive counterparts in overall skill [e.g., model 4 (additive model) is superior to model 11 (interaction model)].

Table 6 shows correlations between all noninteraction variables in this study. Note that GDP is not strongly correlated with any other explanatory variable, which further supports the choice of GDP as a useful control variable.

5. Discussion and conclusions

This study examines the influences of state and local political affiliation and local exposure to weather-related impacts on local government climate adaptation efforts within 88 U.S. cities across 32 states. Findings indicate that exposure to weather-related impacts is not strongly associated with local climate adaptation efforts (defined as membership in transnational, national, and/or regional climate adaptation agreements/networks) nor city climate adaptation plans alone. Rather (when controlling for local GDP), local political affiliation is the strongest predictor of local climate adaptation efforts, regardless of local exposure to weather-related impacts. Further, this study shows that the local prominence of Democrats increases the likelihood of local government climate adaptation. State political affiliation in all cases showed no significant effect on local climate adaptation efforts, which highlights the importance of unique political characteristics of cities.

Despite the weak relationship between weather-related impacts and local adaptation shown in additive regression models, this study tested whether local political affiliation functions as a conditioning variable for weather-related impacts by investigating the relative performance of regression models using three interaction variables. In all cases, simple additive models outperformed the interaction models, which supports the conclusion that political affiliation is the dominant factor in determining a city's adaptation responses; and weather-related impacts (either included as stand-alone variables or as elements of interaction terms) do not appear to be an important factor in these decisions. While a detailed focus on particular cities is outside the scope of this study, future research might compare local government responses to similar storm events (e.g., recent hurricanes impacting New York

TABLE 5. Results of a subsample robustness check. Here, * indicates $p \leq 0.10$, ** indicates $p \leq 0.05$, *** indicates $p \leq 0.01$, and standard errors are given in parentheses.

	1	2	3	4	5	6
LPAI	−0.062***	−0.069***	−0.070***	−0.046*	−0.085***	−0.082***
	(0.018)	(0.019)	(0.021)	(0.023)	(0.030)	(0.025)
SPAI	0.011	0.009	0.018	−0.009	−0.002	0.037
	(0.025)	(0.025)	(0.027)	(0.036)	(0.032)	(0.032)
NE	−0.003	−0.007	0.000	0.012	0.016	0.022
	(0.032)	(0.033)	(0.038)	(0.044)	(0.040)	(0.042)
EI	−0.026	−0.027	−0.050***	−0.036*	−0.039**	−0.005
	(0.018)	(0.019)	(0.012)	(0.020)	(0.019)	(0.031)
HI	0.026*	0.027*	0.024	0.031**	0.010	0.002
	(0.013)	(0.014)	(0.015)	(0.014)	(0.014)	(0.013)
GDP	0.108***	0.099***	0.134***	0.098***	0.096***	0.162***
	(0.025)	(0.023)	(0.036)	(0.020)	(0.028)	(0.052)
Constant	0.227***	0.232***	0.215***	0.229***	0.249***	0.218***
	(0.020)	(0.021)	(0.022)	(0.024)	(0.024)	(0.030)
R^2	0.384	0.396	0.358	0.397	0.510	0.381
Adjusted R^2	0.338	0.346	0.297	0.331	0.446	0.280
N	88	79	70	62	53	44

TABLE 6. Variable cross correlations.

	LCAI	LPAI	SPAI	NE	EI	HI
LPAI	−0.388					
SPAI	−0.227	0.434				
NE	−0.081	0.143	0.470			
EI	−0.071	−0.035	0.248	0.175		
HI	0.162	−0.070	0.223	0.284	0.310	
GDP	0.552	−0.277	−0.311	−0.134	−0.019	0.123

City, New Jersey cities, Houston, and New Orleans). Such research could provide useful insight for better understanding the influences of political context on local climate adaptation efforts.

Political science literature largely supports the assumption that issue severity positively correlates with government action. The findings of this study, however, challenge this assumption by showing how the relationship between issue severity and government action becomes essentially null when applied to local exposure to weather-related impacts and climate adaptation efforts. This relationship expresses itself as a robust and statistically significant relationship between LPAI and LCAI, and weak relationships between weather-related impacts and LCAI. These findings can perhaps best be explained by the literature on motivated reasoning and policy fit, which describe the influence of political ideology on government decision-making and the cognitive dissonance that can result within the sphere of climate action. This study's findings raise important questions about how political barriers to climate action might be overcome if not by the increasing frequency/severity of weather-related impacts.

This situation suggests that one way forward is to increase the number of legal mandates (and impact pathways included within them) affecting long-term planning, professional engineering practice, and management to ensure that adaptation takes place when replacement infrastructure is designed following an extreme event. Although this approach may appear straightforward, and in some ways it is, significant obstacles exist to revising federal infrastructure design guidelines. In the federal highway administration, for example, "replace in kind" strategies for culverts and bridges, originally designed to streamline replacements and reduce short-term costs, may be an obstacle to implementing more proactive (and therefore more expensive) approaches that include climate adaptation in the design process. Lacking also are well-established, risk-based approaches for creating design standards in response to a nonstationary environment (Byun and Hamlet 2020).

In response to increasingly frequent and severe extreme weather events, local governments will likely be required to develop new partnerships (Bidwell Dietz and Scavia 2013; Birkmann et al. 2010) and build political will for new projects and policies. This study's findings support the argument that city governments may be more or less likely to build such support based on political affiliation. In recent years, however, signs of change have become apparent. Specifically, a growing call for climate action has sounded from young Republicans (Brady 2020; Cohen 2020; Smith-Schoenwalder 2019). This trend, if persistent, has the potential to reduce the polarizing influence of political affiliation on U.S. climate action over time.

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Data availability statement. All primary data utilized in this study are free and available to the public via the references cited. Postprocessed datasets used in the regression analysis are available by contacting the authors.

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