

Drivers of Adaptation: Responses to weather- and climate-related hazards in 60 local governments in the Intermountain Western U.S.

Abstract

Cities are key sites of action for adaptation to climate change. However, there are a wide variety of responses to hazards at the municipal level. Why do communities take adaptive action in the face of weather- and climate-related risk? We studied what cities are doing in response to existing natural hazards, such as floods, droughts, and blizzards as an analog for understanding the drivers of adaptive behavior toward climate change risks. We conducted a survey of 60 U.S. municipalities followed by 6 in-depth case studies in the intermountain west states of Colorado, Wyoming and Utah that regularly experience weather and climate extreme events. Our analysis shows that perception of risk and external factors such as planning requirements and availability of funding stand out as important drivers. Nevertheless, political action is rarely driven by a single factor or event. Overall, our results suggest that multiple factors interact or act in combination to produce an enabling environment for action in the face of weather- and climate-related risk.

Keywords: Urban, Policy, Risk, Natural Hazards, Climate Adaptation

Introduction

While there have been important policies for adaptation at the international level such as the development of the Adaptation Fund and the promotion of National Adaptation Programmes of Action (NAPAs) by the UN Framework Convention on Climate Change, there is growing recognition of the importance of local governments as sites of action for both climate mitigation and adaptation (Bulkeley, 2010). More than half of the world's population now lives in urban areas, with population growth in cities outpacing that of the planet as a whole (Birkmann et al., 2010b). Moreover, many have argued that "adaptation is local", as many of the actions that are necessary for climate change adaptation occur at the local level. These actions could relate to preparing for sea level rise, extreme events such as heat waves, flooding or drought (McBean, 2004), or more uncertainty in water supply and consequences for subsistence farming (Measham et al., 2011).

Although many cities worldwide have made progress on adaptation (Carmin et al., 2012), the enormous variation in level of adaptation activity suggests that many barriers to climate change adaptation persist (Bulkeley, 2010; Berrang-Ford et al., 2011, Tribbia and Moser, 2008; Moser and Ekstrom, 2010; Bierbaum et al., 2013). Furthermore, while adaptation planning activities are becoming more common, the implementation of actions to support climate change adaptation is limited and uneven globally (Lesnikowski et al., 2015, Araos et al. 2016). Even where adaptation is taking place, it is often contested or constrained by limited budgets, political will, and public support (e.g., Bulkeley,

2010; Dilling et al., 2015). Porter et al. (2015) found that barriers to adaptation can change over time, noting that usable information posed a barrier in early efforts for municipalities, but later on, even with sufficient information, lack of funding and competing priorities affect a city's ability to implement adaptation. Adaptation is always negotiated alongside other local priorities through inherently political processes (Healey, 2006; Few et al., 2007). Anguelovski et al. (2014) found that a combination of leadership, support from within city government departmental units, and stakeholder buy-in was necessary to implement adaptation successfully.

While it is often stated that adaptation is primarily a local responsibility within the adaptation science literature, examples on the ground demonstrate that the ability of local governments to act is often influenced and constrained by other levels of government (Naess et al., 2005; Bulkeley, 2010, Nalau et al. 2016). While a few cities globally have been notably proactive in climate adaptation (Araos et al. 2016), with competing priorities for funding it can be challenging for cities to act on climate adaptation in the absence of a mandate or assistance from other levels of government (Porter et al. 2015, Amundsen et al. 2010, Hardoy and Romero Lankao 2011). Climate adaptation may not be that different from other areas where cities might be expected to lead with local policy: in waste management, for example, plans and objectives have been found to be less effective at guiding policy implementation compared with more coercive measures such as bans and taxes (Nilsson et al. 2009). However, as more and more cities experiment with climate adaptation, it has become clear

that new ways of conceptualizing multi-level governance and understanding how authority and capacity affect urban adaptation are needed (Bulkeley and Betsill 2013).

While research has illuminated many of these barriers to adaptation, there is less research that empirically explores how municipalities navigate these politics of adaptation to take proactive steps in response to climate risk (but see Measham et al. 2011 for an analysis of the politics of climate change adaptation at the local level, and how these politics are conditioned by leadership, institutional context, and competing planning agendas). In this study we seek to understand why cities proactively undertake actions to adapt to or mitigate weather- and climate-related risks. Our theoretical perspective accepts an “actor-centric” view of risk that recognizes multiple value perspectives and objectives (Dow et al., 2013, Eisenack et al., 2014). Our framework is informed by Gupta et al. (2010) that emphasizes the multi-dimensional nature of institutions in supporting the adaptive capacity of society to respond to climate change. Critically, Biesbroek et al. (2015) have urged the adaptation science community to go beyond “barrier thinking” and instead focus on the implementation processes at work such as decision dynamics and causal processes (see also Burch et al., 2010). By focusing on actions taken, rather than barriers, we illuminate the processes that enable policy change across a spectrum of contexts, and perhaps demonstrate a wider range of possibilities for how adaptation might be engaged by cities. Such a perspective may be of use

beyond the scholarly literature for cities seeking information on how to move forward.

Given those starting points, we argue that it is unlikely that a single driver is going to explain why cities take action. Rather, we suggest that multiple factors, perhaps in combination, would support an *enabling environment* for cities to address weather- and climate-related risk. We therefore chose to conduct a multi-city comparative study of how municipalities respond to weather- and climate-related risk in order to understand whether some processes or elements were more important than others, or how multiple drivers might interact to support adaptive action. Our study uses qualitative and quantitative analytical approaches to detect and explain patterns of adaptation to weather- and climate-related risk in a large number of local governments.

Background

Over the past decade there have been several studies that have described why cities have been proactive in joining ICLEI's (Local Governments for Sustainability's) Cities for Climate Protection (CCP) campaign (Bulkeley and Betsill, 2003; Sharp et al., 2010; Anguelovski and Carmin, 2011). Like many climate policy initiatives at all levels, CCP was originally focused on actions cities could do to *mitigate* climate change, that is, to reduce greenhouse gas emissions and that several different types of factors predict the likelihood that cities will join CCP. Thus far there has been much less emphasis on *adaptation* within the climate

agendas of most CCP cities (Bulkeley, 2010). Research focused on CCP can be instructive however to a point on why cities take action regarding climate change.

Local politics and political context matter. There is strong evidence that political orientation and environmental values influenced cities to initially sign up for CCP. Cities in the US that were likely to commit to CCP were more likely to vote Democratic, more likely to house an environmental organization, and more likely to recycle (Zahran et al., 2008). There is also evidence in the literature that political will and leadership (Bassett and Shandas, 2010) and policy entrepreneurs or “champions” are important drivers of a city signing on for CCP (Kousky and Schneider, 2011; Krause, 2011). Many CCP cities saw climate change as an issue that would have cost saving or other co-benefits (Bulkeley and Betsill, 2003), and Sharp et al. (2010) also found that fiscally-strapped cities were more likely to sign on to CCP. In addition, coastal communities or those perceiving a risk from sea level rise as well as those experiencing extreme weather events were more associated with signing up (Zahran et al., 2008). In sum, it appears that at least in the US, action by cities on climate change *mitigation* is inextricably tied to political ideologies and interests, environmental values and perceptions of risk.

Climate adaptation, however, may be quite a different story. Climate adaptation is more appropriately framed as a risk management strategy, rather than as an environmental protection or sustainability strategy (Travis and Bates 2014). There may therefore be very different reasons why cities would undertake climate adaptation measures as compared with climate mitigation actions. The

evidence suggests that the limited climate change adaptation that is already occurring is being motivated by other factors than climate change itself (Smit and Wandel, 2006; Bulkeley, 2010; Amundsen et al., 2010, Berrang-Ford et al., 2011).

Which brings us to our main question for this research: **Why do communities take action in the face of weather- and climate-related risks?**

We chose this approach of understanding the drivers and incentives that motivate local communities to take action to current risks in order to shed light on why communities might implement climate change adaptation actions in the future. Given the fact that climate change adaptation actions are uneven or limited at best and in some places climate change or even the word climate is politically charged (e.g. Dow et al., 2013), we could not assume that most cities would even have considered acting on climate adaptation. Therefore, instead of studying climate change adaptation actions, we chose to focus on actions taken to mitigate the risk from natural hazards as an analog for possible adaptation to climate risks in the future. This approach also enables us to observe a much broader suite of policy behaviors than by only focusing on 'early adopters' of climate policies at the municipal level.

"Forecasting by analogy" has been discussed as a way of estimating uncertain future climate change impacts from existing variability in the past, and has been suggested to be a useful tool for aiding "scientific inquiry into societies' capabilities to cope with environmental change" (Glantz 1991, pg. 32). While reasoning by analogy is not a perfect parallel, it can provide useful insight into

drivers and mechanisms of problems and their potential solutions. Naess et al. (2005) have used this approach with the case of flood response and protection to explore institutional barriers and interactions for future climate adaptation. Here we employ this logic to suggest that by understanding the behavior of municipalities toward natural hazard risk, such as floods, drought, winter storms, and so on we can reasonably infer at least some of the drivers for adaptive action to climate change. We further reason that by examining adaptation to existing climate variability and extremes, we can gain insight into how policy processes at the local level might confront climate risk in the future. The past five decades of literature on natural hazards provide several hypotheses for what drives policy change in the face of risks such as floods, droughts, hurricanes, and so on. While not definitive or exhaustive, the list of potential drivers includes: experience with disastrous events (Birkmann et al., 2010a; Godschalk, 2003; Penning-Rowsell et al., 2006; Pearce, 2003), financial opportunities and incentives, advocacy from local (or higher level) champions (Birkland, 2006), awareness and access to information (White et al., 2001), community pressure, an adjacent community suffers a disaster, supportive institutional arrangements (Burch, 2010; Tompkins and Amundsen, 2008), and socio-cognitive factors (Grothmann and Patt, 2005).

Our approach is to develop and test an argument about the multiple factors that constitute an “enabling environment” for proactive decision making related to weather- and climate-related risk in local governments. In this paper we use a mixed methods approach to identify factors that may be causally

associated with action on natural hazards and how they might interact. We combine analysis of data collected from a representative sample of 60 medium and large cities with qualitative analysis of six comparative case studies. We then discuss the implications for both adaptation to weather- and climate-related hazards and how our results may or may not shed light on actions to adapt to climate change.

Methods

Overall Design and Study Region Background

In our study design, we do not focus only on local communities that were particularly proactive toward weather-and climate-related hazards. Rather, we designed our study to examine a representative sample of localities in our region, to more fully capture the wide range of possibilities for why communities might act in anticipation of weather-and climate-related hazards.

Our study area consists of three states in the Intermountain West – Colorado, Wyoming and Utah – that are a part of the Western Water Assessment (WWA) program under which this study was conducted. WWA is a Regional Integrated Sciences and Assessment (RISA) program sponsored by the US National Oceanic and Atmospheric Administration (NOAA). Utah, Colorado, and Wyoming are characterized by relatively dry climates with variable topography from elevated plains to high mountain peaks. These states are instructive as to broader issues facing municipal adaptation because (1) they reflect a diverse profile of risk exposure from hazards, with multiple climate-driven risks, and (2)

have diverse local politics, reflecting a great deal of the United States' political variation. Municipalities in the region are concerned about a variety of weather- and climate-related hazards ranging from droughts to floods and tornados to blizzards. Each state has experienced numerous multi-million dollar losses with respect to various natural hazards, such as hail, tornados, winter weather, wildfire, floods, severe storms and landslides¹ (HRVI 2012). As tracked from 1960-2012, Colorado has experienced the most million-dollar plus events with 205 events, while Utah has experienced 81 events and Wyoming only 49 events (it should be noted that Wyoming has less population overall and fewer population centers exposed compared to the other two states). Of these events, severe storms were the most common in Colorado and Wyoming (namely hail, wind, and lightning), while floods (including landslides) and severe storms occurred at similar rates in Utah.

Hypotheses

We began our study with several hypotheses in mind that emerged from the literature on drivers of policy change, focusing on literature related to natural hazards policy as described above. We decided to focus our analysis on four of the hypotheses that seemed particularly common across the literature:

H1. *The "Champion" hypothesis: Cities where there is an internal champion advocating for planning will see more preparation and prevention measures.*

The effects of champions or policy entrepreneurs are well-studied in general

¹ Spatial Hazard Events and Losses Database for the United States. <http://hvri.geog.sc.edu/SHELDUS/>

(Mintrom and Norman 2009), and have been found to be important to the adoption of climate mitigation policies at the local level (Bulkeley and Betsill 2003).

H2. *The “External Incentives” hypothesis. Cities perceiving a requirement to plan or opportunity to obtain funding for planning will see more preparation and prevention measures.* Both incentives (such as funding) and coercive measures such as legal requirements make a difference to hazard policy adoption (Birkland 2006) as well as to the implementation of other local government responsibilities (Nilsson et al. 2009).

H3. *The “Previous (Extreme) Event” hypothesis: Cities that have direct experience with more types of weather- and climate- related hazards will see more preparation and prevention measures.* This hypothesis builds from the idea that experiencing an extreme event will open a “window of opportunity” that both raises awareness of the exposure to a hazard, and allows for new policies to be implemented in the aftermath of an extreme event (Birkland 2006, Pennings-Rowell 2006).

H4. *The “Perceived Risk” hypothesis: Cities where officials perceive the risk of weather- and climate-related hazards to be higher will see more preparation and prevention measures.* Perception of risk has been shown to be quite important for individual decision making (Grothmann and Patt 2005) as well as for managers making decisions for the community at large (Krause 2013).

To test these hypotheses, we combined qualitative and quantitative methods using a survey and a set of 6 in-depth case studies.

60-City Survey

To obtain a final sample of 60 cities total in the study area, we follow a two-stage sampling strategy, developed by the United States Census Bureau's Census of Governments (US Census of Governments, 2007). In the first stage, we identified all cities and towns with at least 75,000 inhabitants. That produced a list of 19 cities and towns distributed across the three states. In the second stage, we randomly selected 41 cities and towns that according to the US 2007 Census of Governments had a population between 10,000 and 70,000 people. Our sample covers about 72% of the population living in towns with more than 10,000 people in the three states, meaning that the findings from our study are relatively generalizable for medium and large-sized cities and towns across the three states.

In all sampled cities, we conducted face-to-face or phone semi-structured interviews (Schensul et al., 1999) with three categories of key informants: (1) the emergency manager or city official charged with responding to hazards; (2) the city manager or top *appointed* city official (if available); and (3) the mayor or other top-level *elected* city official (if available). In total, 136 interviews in 60 cities were completed (26 cities in Colorado, 25 in Utah, and nine in Wyoming).² We

² The number of municipalities we selected in each state was proportional to the state's population. Thus, fewer municipalities were selected in Wyoming because Wyoming has a much smaller population compared with Utah and Colorado.

conducted these interviews between July of 2011 and November of 2012 using a team of 6 different interviewers.

We asked a total of 12 core questions in the interviews. Topics included: priority areas for each municipality, perception of risk, allocation of resources to address hazards, experience with hazard planning, experience with previous events, access to information, collaboration with other organizations and citizen groups, and perceptions of climate change. Interviews were recorded and transcribed for further use in the coding process.

Our process for coding responses to our open-ended questions was informed by prior reading of the literature as well as from the characteristics of the data itself. There is no generally agreed upon method for categorizing hazard responses, and actions can range across varying degrees of “increasingly active and complex adjustments” (Burton et al. 1993, page 57). We chose to separate actions into general categories based on how they were used to address risks. After initial reading of the interview transcripts, we grouped interview responses into three broad classes of activities for coding and analysis: (a) prevention activities, e.g. widening and clearing culverts, (b) preparedness activities, e.g. making sure emergency communication procedures are clear, and (c) other activities. Our "prevention" category included all adjustments that were designed to *reduce or mitigate the exposure* of the community in the long term to a future hazard in advance of the hazard occurring. The "preparedness" category included all adjustments that were designed to *improve responses to a natural hazard event* during the event itself. The "other" category included all

actions mentioned by interviewees that could not be clearly coded as either prevention or preparedness. For all data collected, the unit of analysis was the municipality. Thus, particular prevention or preparedness activities taken by municipalities were counted as 'present' if they were mentioned by at least one respondent from the municipality, irrespective of the number of times the activity was mentioned. Coding was conducted using NVivo software. Almost all of the coding was completed by a single person. The codebook was developed by comparing independent coding of a subset of interviews by 4 of the researchers involved, and early intercoder reliability testing indicated that scoring was reliable across coders.

Quantitative Analysis

The 60-City survey data set was then used for quantitative analysis to test the four hypotheses identified above.

Independent Variables: Our key independent variables were taken from the answers given for why a municipality chose to create an all-hazard plan and other select measures of experience with previous events and risk perception.

H1: Champion: *Plan Champion* is a dummy variable coded 1 if a policy champion was reported as a driver of the all-hazards plan and 0 otherwise (tested with model 1).

H2: External Incentives: Three types of responses were used to examine how that external incentive affects municipal hazard mitigation rates. Responses that reported either a) the Department of Homeland

Security or b) the Federal Emergency Management Administration (both Federal government entities) provided incentives, including financial support or c) that plans were designed to comply with regulations that originated outside of the city we combined into the measure, *Plan External*. *Plan External* is coded 1 for municipalities where external support was reported and 0 otherwise (tested with model 2).

H3: Previous Extreme Event: *Plan Event* is a dummy variable coded 1 if respondents reported plans were made because of experience with a natural hazard. As an alternative measure of the municipal experience, we also test whether experience with more different types of events affects planning. *# of Event Types* is a combined score between 0 and 5 of the total number of different types of hazards (e.g. flood, drought, etc) that a municipality has experienced. Model 3 contains both the number of different types of previous events experienced by the city (*# of Event Types*) and the statement by the municipal officials that previous events drove the development of the all-hazards plan (*Plan Event*). Model 4 tests the effect of this perceived driver without controlling for actual experience with different types of previous events.

H4: Perceived Risk. We measure perceived risk in two different ways. The first measure relied on responses of managers who stated specifically that the development of the all-hazard plan was driven by a sense of vulnerability. *Plan Vulnerability* is coded as 1 if vulnerability was reported and 0 otherwise (model 5). Our second measure of perceived

risk comes from a separate question where we asked respondents to rate their degree of concern for various hazards in their town in general (model 6). We then aggregated those scores for each of these types of severe weather events into a single measure (excluding earthquakes, which were brought up in interviews in Utah). The result, *Total Risk*, is a perceived risk score for each city ranging from 6 to 29³. A table of risk assessment by type and state is in Table 1.

In Model 7, we simply test the four key hypotheses without exploring interactions. Model 8 combines all hypotheses and includes interaction effects.

Dependent Variable: The dependent variable is a count of the number of preparation and prevention activities each city reported undertaking.⁴

Control Variables. We include control variables of income per capita and total population to control for the size of the loss a potential disaster might cause (more population and economic activity to lose) and to control for the ability of the city to afford prevention and preparation activities. Level of income in a city is not a significant driver of action on natural hazards. We also control for experience of any previous event at any point in the municipality's history. 97% of municipalities reported experience with some type of natural hazard (dummy variable *Event Reported*). It seems unlikely that any municipality in these three states has not

³ This variable was calculated by adding up the reported rankings (0-5) of degree of concern for each natural hazard event type asked about in the interview (see table 1).

⁴ We acknowledge that the reasons for putting in place an all-hazard plan (many of our independent variables) might not be expected to directly correlate with the actions taken to mitigate hazards in a city, but we did not collect data on why all of the different actions themselves were taken, so the closest proxy we had was to look at the reasons taken for one specific action, i.e. putting in place the plan, and comparing that to the actions taken across the city for natural hazards.

experienced at least a severe storm, so this is included partly to control for recall bias – how well does the city official being interviewed recall previous events.

Because there may be systematic differences between the policy, social, or environmental systems across states, we also include state dummy variables to control for this state-by-state variation. Overall levels of hazard mitigation actions reported do not vary significantly by state, but these controls do change the significance of a few relationships, as discussed below.

Cities report between 0 and 11 preparation activities, between 0 and 7 prevention activities, and between 2 and 15 hazard mitigation activities in total. Because the dependent variable is a count of activities undertaken, we use Poisson-regression techniques.⁵ Table 2 displays the summary statistics for the dependent variable *Total Hazard-Related Activities*, the two component measures of prevention and preparation activities, and other key variables for the quantitative analysis.

In-depth Case Studies

In addition to the quantitative analyses conducted on the 60-City survey data set, we conducted qualitative analyses of six case studies with municipalities in Utah and Colorado to gather more detailed and multi-perspective data on the reasons why municipalities implement actions to mitigate weather and climate hazards. Case study municipalities were chosen out of our larger set of cities based on similar socioeconomic demographics and weather-

⁵ Count data often have non-normal distributions, requiring the use of a Poisson model. We compare the goodness of fit for each Poisson model and find that the use of this transformation is appropriate.

and climate-related hazard vulnerability. Semi-structured interviews were conducted with four to seven municipal employees for each case study city, for a total of 30 interviews (note that some interviews included multiple employees). Each interview lasted between 30-60 minutes. Municipal employees from a variety of departments were interviewed, including emergency management, city management, fire, parks and recreation, public utilities, sustainability, city council, and planning. Respondents were asked to discuss specific activities, planning efforts, and/or responses they were involved in that relate to weather and climate hazards. Each individual case study transcript was coded using the qualitative analytical software NVivo. All case study interviews and coding were conducted by the same person.

Results

i. Characterizing Risk Perception and Natural Hazard Responses

The study region faces a variety of weather- and climate-related hazards, with some differences across the three states. Blizzards, floods, and severe storms were perceived to be of highest concern across the three states, followed by wildfires, droughts, and earthquakes (Figure 1). Earthquakes were by far the hazard of highest concern in Utah, while floods and blizzards were top in Wyoming, and all weather and climate related hazards were of high concern in Colorado (excluding pests and earthquakes). Earthquakes were excluded from all further analysis as we do not consider them directly weather or climate related.

While municipalities within each state undertook both preparedness and prevention-related activities, frequencies of each type of response to natural hazards varied among the three states and within each of the activities themselves. For example, some of the most common preparedness activities were putting in place various types of infrastructure, planning, and communication (Table 3). As Table 4 shows, roughly half of all preparedness activities were blizzard related. Prevention planning ranged from water conservation, to wildfire planning, to floodplain management. While almost twenty percent of preparedness activities were linked to floods, flooding accounted for half of the prevention-related activities (Table 5). Roughly 80% of the municipalities in each of the three states reported engaging in prevention infrastructure projects, such as physically altering floodplains, increasing water storage capacity, or changes to the municipality's electrical infrastructure (Table 6).

Despite these general similarities, municipalities did show some large differences in responses even to the same type of hazard. For example, although some municipalities reporting a similar risk for flooding, there was quite a range of responses to that risk. When asked about risks related to flooding along the Front Range of Colorado (the most populated area of the state on the eastern side of the Rocky Mountains), some of our interviewees noted extensive infrastructure and mitigation work, along with active monitoring, planning, zoning, and collaboration with other government agencies, while others suggested they engage in more basic mitigation and monitoring. As one interviewee noted, “I

think we have one of the best flood mitigation programs west of the Mississippi; if you look at our flood rating⁶, it's one of the highest. [We've] done a lot in the area of educating people, putting warning systems in place, monitoring rivers and streams, and rainfall. As well as making sure we minimize construction and life safety issues in 25, 50, and 100-year flood plains. We're actually pretty aggressive in that area." Conversely, in another municipality where the city manager interviewed reported the same high risk for flooding, they explained how the municipality removes debris and sand bars to prevent obstructions in the river, but also that "[i]f it does hit you just have to deal with it. The city has a huge stock pile of sandbags." A comparable range was seen in Utah where interviewees also reported a high flood risk. For example, some interviewees reported extensive monitoring of reservoirs and runoff, while others reported investing millions of dollars in infrastructure projects such as detention basins and retention ponds.

ii. Motivations for Undertaking Natural Hazards Actions: Testing Hypotheses

Hypothesis 1: Policy champion

A consistent theme seen across the case study interviews was the notion that a particular individual was pivotal in some aspect of weather- and climate-related hazard planning and response. Departments may have mandates, but it

⁶ By flood rating, the interviewee is referring to the National Flood Insurance Program Community Rating System that recognizes efforts to improve floodplain management. High in this case means the municipality has been ranked with FEMA as having higher levels of effort toward mitigating flood risk.

often took individual effort for the activity or policy to succeed. For example, one respondent described the Emergency Manager of the municipality as "...just one of these unusual guys that just is willing to give a lot of his own time to try to make the world a better place." It was often expressed that without this individual's effort, the planning or response efforts would not have been as successful.

Additionally, trust and authority were seen as important characteristics for a champion to be effective (see also: Andersson, 2004). In our cases, some interviewees described why champions were effective, and they often cited the individual's passion, expertise, personality, and organizing ability. It seems that somewhat unique personal characteristics are important for an individual to be effective in implementing actions or natural hazards plans.

In the survey data, using our quantitative model (1) testing the impact of a policy champion alone, we found the relationship between the presence of a champion and the number of actions is positive and weakly significant ($p < 0.10$), indicating that municipalities with a policy champion are more likely to implement these actions (Table 7). This is consistent with our first hypothesis. However, in the full models that tests all four hypotheses simultaneously, (Models 7 and 8, Table 8), the presence of a policy champion remains weakly significant ($p < 0.10$), and only when the interaction of *Total Risk* (our second Perceived Risk independent variable) and *Plan External* are included. Without the interaction (Model 7), the policy champion does not have a significant effect on the number of actions. This suggests that in our survey data set, the presence of policy

champions is not a very robust driver of local adaptation by itself. The lack of statistical significance of champions and events as drivers may indeed reflect their lesser importance, or may indicate our measure is not adequate for capturing the role of champions across a wide number of actions, or may be an artifact of the limitations of binary, quantitative coding to represent complex, contextual information and relationships. Champions tend to press for and bring about specific actions, and we can thus speculate that because their efforts are focused in only one or two areas of interest, reports of a champion in a particular context may not be correlated with a greater number of overall actions in a town.

Hypothesis 2: External Incentives

In the case studies, several respondents discussed how funding may restrict the municipality's ability to respond to hazards. For example, some respondents noted how some particular programs (e.g., Community Emergency Response Teams) could only be implemented once outside grants were acquired. Further, some funding required the municipality to be compliant with regulations prior to grants being approved.

Municipalities, and departments within those municipalities, often do not act alone when it comes to weather- and climate-related hazards. The municipalities have working relationships, both financially and logistically, with other municipalities as well as county, state, and federal entities. We found that these relationships can create incentives through regulatory requirements,

financial incentives, information sharing, and logistical and physical support for emergency services.

In our survey data, the quantitative relationship between external drivers such as funding and requirements is positive and statistically significant ($p < 0.01$). Where there is external pressure or funding opportunities to develop an all-hazard plan, municipalities are significantly more likely to implement actions to mitigate weather and climate-related risks. This relationship remains significant in the full model where we test all four hypotheses (model 8).

Hypothesis 3: Previous Extreme events

In our case studies, large-scale damaging or extreme events were often cited as reasons for new responses or activities to reduce vulnerability. Many of the interviewees discussed how a previous event is necessary to help educate both city leaders and the general public about the importance of a policy change. The engagement and support for change was only effectively achieved once an event demonstrated vulnerabilities within the municipality. An Emergency Manager from one of the municipalities discussed this specifically in reference to a recent wildfire the municipality had experienced, and noted that often people don't think about a municipality's vulnerability until an event actually occurs. Building 'social capital' within the community to help in emergency preparedness for natural hazards has been discussed as an essential part of municipal emergency management (Murphy, 2007). Neither experiencing a previous event nor engaging the public was by itself sufficient for the change, but 'taking advantage' – as one interviewee put it – of one was essential in engaging the

other. Events also often served as an opening for managers to increase engagement with the public on an ongoing basis.

A large-scale event was also seen as necessary for emphasizing the salience of a particular issue, or convincing higher authorities some change or action was needed. Birkmann et al. (2010a) also found that larger disasters, rather than smaller ones, seemed more relevant as focusing events driving policy change with respect to hazards. It is interesting to note that the previous event did not necessarily need to be a local event, especially for engaging the general public. For example, several interviewees discussed how Hurricane Katrina in 2005 and the Boston Marathon bombings in 2013 changed what citizens expect from their governments and their general level of preparedness.

Additionally, experiencing an event may expose unknown or unintended vulnerabilities in existing institutional and decision-making processes. Without the event occurring, those vulnerabilities may not be known, and therefore cannot be addressed. An Emergency Manager from one of the case studies discussed this process in regards to a tornado event that exposed how deficient the municipality's emergency communication was during an event, and how that specific event changed how communication occurred during future events. This included not only physical communication equipment, but also communication and leadership protocols between the various levels of government. Following the original event, and subsequent learning, the Emergency Manager noted their response to events is "night and day better."

When analyzing the survey data in the regression model, the number of types of hazard events experienced by a municipality is positive but only weakly significant ($p < 0.10$) in its relation to the number of hazard mitigation activities reported (Model 3). However, in the full model (Models 7 and 8), *# of Event Types* is significant ($p < .01$), meaning that experience with multiple types of events explains variation in action when other factors of external incentives, the presence of champions, and risk are already taken into account. This is consistent with our expectations, as many types of hazard mitigation actions are specific to the hazard, e.g. snow plows for blizzards are not much use in a flood. So with more types of hazards experienced, more actions might be logically be expected as some will be unique to each hazard.

Hypothesis 4: Perceived risk

In our case studies, in addition to experiencing previous events, many of the interviewees discussed how the perceived risk for hazards impacted their risk mitigation and planning. Municipal officials often have a sense of the risks their communities face and respond not just to previous events or public awareness but to their assessment of the level of risk and vulnerability faced by their city.

Unsurprisingly, interviewees stated that their perceptions of risk were related to past exposure. For example, it was discussed in one municipality how experiencing a wildfire out of the “normal” summer season has now changed the way they perceive the risk of wildfires. Because of their wildfire history, the

municipality now perceives the wildfire risk as being both increased generally and throughout the entire year.

In the survey data, only 10% of officials reported that vulnerability drives the development of all-hazard plans, and in our statistical tests, the relationship to action is only weakly significant (Model 5: $p < 0.10$). However, *Total Risk*, the combined weather- and climate-related perceived risk, has a significant effect on the number of actions taken (Model 6: $p < 0.05$). It may be then that perceived risk can drive policy adoption although officials do not consistently report that perceived vulnerability has affected their development of an all-hazards plan.

Combining Hypotheses

All six case studies reflected the fact that multiple factors in a complex setting over time can combine to produce actions that cities had taken on natural hazards. Using our survey data in our final two models (7 and 8), we tested the four hypotheses simultaneously, along with the standard controls. Of the four hypotheses we tested for development of the hazards plan, only the relationship of external support for planning and prevention activities remains statistically significant ($p < 0.01$). Across municipalities, places where officials report they developed an all-hazard plan because of policy champions or events do not have higher rates of adoption of hazard policy action. Similarly, municipalities where officials credit vulnerability with driving all-hazard plans do not take more actions to respond to hazards. However, the more different types of events experienced in the municipality and the higher the perceived risk across all hazards, the higher the number of actions taken to respond to hazards ($p < 0.05$). This

suggests that perceived risk does matter for the development of all-hazard plans, even though officials do not always cite these as the key driver.

Model 8 extends this finding to see whether the effect of external support is consistent across cities with different levels of risk. The results show that external support matters less in cities where officials perceive the risk of natural- and climate-related events to be higher. Put differently, cities with perceived high risk are likely to undertake similar numbers of activities regardless of external support while cities with low risk will undertake more activities when they have external support than when they do not (Figure 2).

Other drivers of policy action on hazards at the municipal scale were mentioned by both the respondents to the survey and the case study participants. These are likely important as well but none appeared to us to be driving factors across all three states, were not analyzed in great detail, and thus could deserve further study. They include a sense of moral obligations (i.e. “it’s the right thing to do”), the presence of the Church of Latter Day Saints (LDS) and its emphasis on preparedness from a religious perspective, being part of a network of municipal and other actors, and responding to information on hazards from monitoring networks and agencies.

Discussion

We found that a combination of factors and the interactions between them are important to creating an enabling environment for proactive action on

weather- and climate-related hazards across municipalities in the US Intermountain West. Cities demonstrate a wide variety of responses to hazard risk along a spectrum from basic preparedness measures to extensive infrastructure projects designed to reduce risk. The case studies told a broadly similar story of interwoven conditions that enabled cities to put in place policies to mitigate weather- and climate-hazards. However, when four different factors were tested quantitatively, one factor appeared to be significantly related to actions across all conditions and alone—the presence of external requirements or the availability of external funding. And it appears that a strong perception of hazard risk can promote action even in the absence of these external motivators; indeed, consistent with our findings, others have found perception of risk to drive climate adaptation planning in cities across the globe (Lee and Hughes 2016). Finally, previous extreme events, while not significant on their own, do show an interactive effect that combines with other factors to be associated with greater action on natural hazards. We found that municipal champions and previous events are important for moving forward on actions to mitigate natural hazards, but are not by themselves sufficient to motivate action, a finding which supports Bulkeley's (2010) finding that policy champions may be a "necessary but not sufficient" element of policy action for climate adaptation (pg. 234). This suggests that some drivers may be more powerful than others, but multiple factors are likely important to increasing adaptive actions. As a set of case studies of adaptation across the global South points out, it may be more effective to

consider cities as systems, rather than having only one or two entry points that might drive policy (Anguelovski et al. 2014).

Our finding that external factors such as requirements or funding opportunities influence adaptation decisions is consistent with a growing number of studies that suggest that expecting cities to “go it alone” in implementing adaptation is not realistic nor will it be effective (Nalau et al. 2015). Studies across multiple municipalities in the UK (Porter et al. 2015), Norway (Amundsen 2010), Latin America and the Caribbean (Hardoy and Romero Lankao 2011) similarly found that a strong mandate, support and funding from higher levels of government was needed to support local action on climate adaptation, although this is not always the case (Roberts and O’Donoghue 2013). It also may explain why comprehensive assessments of climate adaptation have remarked on the prevalence of adaptation planning but the lack of adaptation implementation on the ground (e.g. Bierbaum et al. 2012, Araos et al. 2016), although studies may be failing to capture much of the adaptation that is occurring outside of government reporting structures and by non-traditional actors (Araos et al. 2016).

The gap between planning and implementation is not unique to climate adaptation of course. Relying on goals and objectives, in the absence of legal mandates and/or funding, results in much less effective policy implementation in other common local responsibility areas such as waste management (Nilsson et al. 2009) and sustainable development (Blake 2007). As Bulkeley and Betsill (2013) point out, it is necessary both for researchers to “engage critically with where the authority and responsibility for addressing climate change as an urban

problem lie” (p. 145) and ultimately perhaps for cities to discuss and renegotiate responsibilities for policy outcomes (Blake 2007).

Our 60-city survey was limited by the fact we only had data on reasons why managers implemented one action, all-hazards planning, to inform our independent variables (along with measures of risk perception and types of events). While we had data on reasons for implementing a broader suite of actions from our six in-depth case studies, ideally we would have liked to have had specific data on reasons for implementing all types of hazard-related actions across all 60 cities, but given the scope of questions and the breadth of hazards discussed this was simply not feasible for this initial study. Future work could focus on one type of hazard, either within a region or examine a category of hazard response across a wider region. Further analysis on this data set could examine more carefully the substantive differences in types of actions taken, to tease apart whether municipalities are more preferentially choosing actions that change their underlying exposure, as adaptation would do, or merely putting in place coping strategies that will enable cities to respond in the thick of a disaster.

Conclusion

Cities may increasingly face a familiar paradox—being seen as the leaders for implementing policies that provide solutions and benefits to residents while at the same time operating within a changing network of governance, public-private partnerships, and civic organizations that may not yet support the new functions that are required. However, new evidence from our work on

adaptation to weather- and climate-related hazards suggests that there are many ways that conditions come together to create an enabling environment for implementing policy action, and that there are a myriad of options that cities already pursue to become more weather- and climate-resilient. That in itself should give reason for cautious optimism.

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Table 1: This table presents statistics on the perception of risk by type and state for managers averaged across municipalities within each state. Managers were asked to rank concern about each hazard on a scale from 1-5, with 5 being most concerned.

Event Type	Colorado (N=26)		Utah (N=25)		Wyoming (N=9)	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std. Dev.
Blizzard	3.73	(1.06)	3.10	1.08	3.17	1.32
Flood	3.44	(1.22)	3.18	1.16	3.78	1.56
Drought	2.98	(1.37)	1.98	1.43	1.83	2.03
Fire	2.81	1.66	2.28	1.67	2.50	2.09
Tornado	2.88	1.38	1.16	1.28	1.00	1.50
Severe Storm	3.50	0.98	2.78	1.37	1.78	1.39

Table 2: This table displays the summary statistics for the dependent variable *Total Hazard-Related Activities*, the two component measures of prevention and preparation activities, and other key variables for the analysis.

Dependent Variable	Mean	Std. Deviation	Min	Max
Total Hazard-related Activities ⁷	7.90	2.83	2	15
<i>Dependent Variable Components</i>				
Preparation Activities	5.02	2.00	0	11
Prevention Activities	2.88	1.61	0	7
Independent Variables				
Plan Champion	0.42	0.50	0	1
Plan External	0.20	0.40	0	1
Plan Event	0.20	0.40	0	1
# of Event Types	2.03	1.07	0	5
Total Risk	16.43	5.56	6	29
Plan Vulnerability	0.10	0.30	0	1
Control Variables				
Log population	10.68	0.95	9.16	13.30
Population	72403.88	99579.96	9520	600158
Event Reported	0.97	0.18	0	1
Income per capita ⁸	27349.47	6980.16	16631	46238

⁷ Weather- and climate-related hazards specifically

⁸ For ease of interpretation, we present income per capita here, but scale to income in millions of dollars per capita for the analysis presented in tables 7 and 8.

Table 3: Percentages and counts of respondents from 60-city data set reporting activities undertaken in these **preparedness** categories (with preparedness meaning a focus on actions to reduce the severity of events when occurring or immediately after). Rows are separated into categories that showed up regularly in responses from city key informants in all three states, those with variable occurrence in some items, and those with consistently low occurrence across all three states. Counts are in parentheses.

	CO (26)	UT (25)	WY (9)
Consistently High Across States:			
Infrastructure	73% (19)	92%(23)	78% (7)
Planning	88% (23)	60% (15)	56% (5)
Communication	50% (13)	56% (14)	67% (6)
Variable Across States:			
CERT	12% (3)	88% (22)	44% (4)
Working with other groups	23% (6)	48% (12)	11% (1)
Training	65% (17)	56% (14)	33% (3)
Financial	23% (6)	4% (1)	44% (4)
LDS Church ¹	0% (0)	80% (20)	22% (2)
Citizen Education	54%(14)	16% (4)	22% (2)
Monitoring used	42% (11)	28% (7)	22%(2)
Low Occurrence Across States:			
Forecasting	8% (2)	0% (0)	0% (0)
Emergency Personnel	31%(8)	16%(4)	11%(1)
Business as usual	19%(5)	0%(0)	10%(1)

¹ The Church of Jesus Christ of Latter-Day Saints (LDS) is prominent in Utah and has a strong belief that members must be prepared for religious reasons. They therefore often have stores of food and water and other survival equipment at hand and thus achieve a high degree of preparedness for natural hazards.

Table 4: The percentage of preparedness activities (with preparedness meaning a focus on actions to reduce the severity of events when occurring or immediately after) taken in response to each type of hazard as reported by key informants across the 60 municipalities.

	Blizzard	Drought	Flood	Severe Storm	Tornado	Wildfire	Total
Colorado	46	8	16	11	22	5	108
Utah	48	4	19	5	2	10	88
Wyoming	23	1	9	3	7	3	46
Total	117	13	44	19	31	18	242
Percentage	48.3%	5.4%	18.1%	7.9%	12.8%	7.4%	100%

Table 5. The percentage of prevention activities (with prevention meaning a focus on actions designed to reduce the exposure to a possible event that might occur in the future) taken in response to each type of hazard as reported by key informants across the 60 municipalities.

	Blizzard	Drought	Flood	Severe Storm	Tornado	Wildfire	Total
Colorado	1	28	45	5	2	12	93
Utah	1	25	52	8	0	23	109
Wyoming	1	6	14	2	0	1	24
Total	3	59	111	15	2	36	226
Percentage	1.3%	26.1%	49.1%	6.6%	0.88%	15.9%	100%

Table 6: Percentages and counts of 60-city data set reporting activities undertaken in these **prevention** categories (with prevention meaning a focus on actions designed to reduce the exposure to a possible event that might occur in the future). Rows are separated into categories that showed up regularly in responses from city key informants in all three states, those with variable occurrence in some items, and those with consistently low occurrence across all three states. Counts are included in parentheses.

	CO (26)	UT(25)	WY(9)
Consistently High Across States:			
Infrastructure	85% (22)	84% (21)	78% (7)
Medium Frequency Across States:			
Risk Reduction	50%(13)	32%(8)	33%(3)
Monitoring	35%(9)	20%(5)	22%(2)
Variable Across States:			
Planning	81% (21)	48%(12)	33%(3)
Business as usual	23%(6)	12%(3)	0%(0)
Citizen education	35%(9)	32%(8)	11%(1)
Financial	23%(6)	4%(1)	33%(3)
Securing Rights and Resources	19%(5)	8%(2)	11%(1)
Low Occurrence Across States:			
Communication	8%(2)	0%(0)	0%(0)

Table 7: Results from Models 1-4. Model 1 tests the hypothesis that champions alone were responsible for promoting action on creating the all-hazard plan. Model 2 tests the role of external factors such as requirements from federal agencies and funding opportunities. Model 3 tests the role of previous events and varieties of types of events combined. Model 4 tests the role of previous events by themselves.

	Model 1	Model 2	Model 3	Model 4
<i>Independent Variable</i>				
Plan Champ	0.155* (0.093)			
Plan External		0.293*** (0.090)		
Plan Event			0.072 (0.105)	0.042 (0.106)
# of Event Types			0.083* (0.046)	
<i>Control Variables</i>				
Event Reported	0.758*** (0.089)	0.834*** (0.168)	0.571*** (0.141)	0.737*** (0.105)
Colorado	0.218 (0.162)	0.157 (0.138)	0.142 (0.158)	0.195 (0.176)
Utah	0.063 (0.150)	0.154 (0.128)	0.096 (0.134)	0.127 (0.156)
Log Population	0.011 (0.056)	0.024 (0.047)	0.022 (0.054)	0.016 (0.055)
Income per Capita	-3.528 (0.537)	-0.858 (7.677)	-3.112 (8.494)	-2.201 (8.926)
Constant	1.120 (0.654)	0.816 (0.532)	1.066 (0.650)	1.082 (0.634)
Wald Chi2 =	405.290	49.160	175.730	188.680
Probability > Chi2 =	0.000	0.000	0.000	0.000
Standard Errors in Parentheses				
*** p<.01, **p<.05, *p<.1				

Table 8: Regression results from models 5-8. Model 5 tests the role of the perception of vulnerability to natural hazards of the manager interviewed on driving forward planning. Model 6 tests the perception of risk more generally across several hazards. Model 7 looks at all four hypotheses together. Finally, Model 8 looks at the interactions between external funding and perceived risks.

	Model 5	Model 6	Model 7	Model 8
<i>Independent Variable</i>				
Plan Champ			0.134 (0.881)	0.149* (0.082)
Plan External			0.315*** (0.081)	0.796*** (0.219)
Plan Event			0.0622 (0.087)	0.092 (0.088)
# of Event Types			0.080** (0.038)	0.077** (0.037)
Plan vulnerability	0.234* (0.141)		0.175 (0.126)	0.182 (0.123)
Total Risk		0.017** (0.007)	0.0132** (0.006)	0.019*** (0.007)
Plan External * Total Risk			.	-0.028** (0.015)
<i>Control Variables</i>				
Event Reported	0.700*** (0.097)	0.699*** (0.131)	0.597*** (0.196)	0.597*** (0.228)
Colorado	0.186 (0.164)	0.119 (0.167)	0.038 (0.109)	0.059 (0.109)
Utah	0.142 (0.148)	0.133 (0.142)	0.076 (0.108)	0.035 (0.115)
Log Population	0.037 (0.051)	0.015 (0.056)	0.050 (0.040)	0.046 (0.039)
Income per Capita	-1.724 (8.066)	-1.982 (8.500)	0.037 (6.513)	-1.577 (6.607)
Constant	0.866 (0.586)	0.889 (0.638)	0.348 (0.505)	0.340 (0.510)
Wald Chi2 =	240.670	75.55	90.67	98.97
Probability > Chi2 =	0.000	0.000	0.000	0.000
Standard Errors in Parentheses				
*** p<.01, **p<.05, *p<.1				

Figure 1. Hazard Risk Perceptions in Utah, Wyoming and Colorado combined. Shows the perceived risk of each hazard by the municipality's Emergency Manager or equivalent position for the respondents. Interviewees were asked to quantify the risk of each hazard on a 0-5 scale. Note that the error bars are the standard deviations, to help demonstrate the spread of the responses.

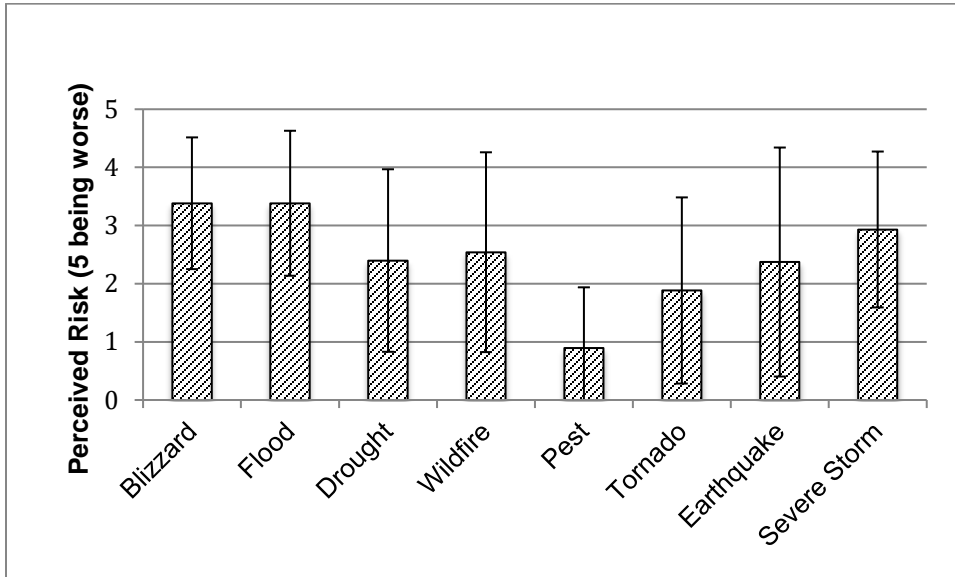


Figure 2. The observed number of activities vs. the total risk for each municipality. The lines show the estimated relationship between risk and activities for municipalities with and without external support. Lighter dashed lines indicate 95% confidence intervals.

