Explaining Progress in Climate Adaptation Planning Across 156 U.S. Municipalities

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Explaining Progress in Climate Adaptation Planning across 156 U.S. Municipalities

Abstract

Problem: Cities are increasingly experiencing the effects of climate change and taking steps to adapt to current and future natural hazard risks. Research on these efforts has identified numerous barriers to climate adaptation planning, but has not yet systematically evaluated the relative importance of different constraints for a large number of diverse cities.

Research Strategy: We draw on responses from 156 U.S. cities that participated in a 2011 global survey on local adaptation planning, 60% of which are planning for climate change. We use logistic regression analysis to assess the significance of 13 indicators measuring political leadership, fiscal and administrative resources, ability to obtain and communicate climate information, and state policies in predicting the status of adaptation planning.

Findings: In keeping with the literature, we find that greater local elected officials' commitment, higher municipal expenditures per capita, and an awareness that the climate is already changing are associated with cities engaging in adaptation planning. The presence of state policies on climate adaptation is surprisingly not a statistically significant predictor, suggesting that current policies are not yet strong enough to increase local adaptation planning. However, the model's sampling bias towards larger and more environmentally progressive cities may mask the predictive power of state policies and other indicators.

Takeaway for Practice: State governments have an opportunity to increase local political commitment by integrating requirements for climate-risk evaluations into existing funding streams and investment plans. Regional planning entities also can help overcome the lack of local fiscal capacity and political support by facilitating the exchange of information, pooling and channeling resources, and providing technical assistance to local planners.

Keywords: climate change, adaptation, urban planning, adaptive capacity

Introduction

Local governments around the country are beginning to adapt to the negative impacts of climate change, such as increasingly erratic and extreme natural hazards. Climate adaptation overlaps with initiatives for environmental sustainability, mitigating (or reducing) carbon emissions, and disaster risk reduction, but focuses especially on adjusting to future climate conditions (IPCC, 2014). To adapt, cities must identify and assess their risks and vulnerabilities; develop adaptation options and plans; implement these plans; and monitor, evaluate, and learn from the impact of these actions (IPCC, 2014; Moser & Ekstrom, 2010). Cities have developed diverse adaptation strategies, including integrating climate considerations into local land use and development plans, infrastructure design and construction regulations, ecosystems protection policies, and emergency preparedness mechanisms.

Many local governments, however, find it difficult to understand climate science or to alter historic development and planning practices in response to projected impacts (Bassett & Shandas, 2010; Cutter et al., 2014; While & Whitehead, 2013). The conditions that prevent or enable cities to adapt to climate change are collectively known as their "adaptive capacity" (IPCC, 2014). Studies find that cities with high adaptive capacity can overcome barriers to adaptation planning because they possess administrative and financial resources, strong local leadership, ability to obtain and communicate climate information to others, cultural values that support institutional responses, and strong state policies (Aylett, 2014; Carmin, Nadkarni, & Rhie, 2012; Hamin, Gurran, & Emlinger, 2014; Moser & Ekstrom, 2012). However, no study has systematically analyzed the importance of different determinants of adaptive capacity across a

large number of cities, as has been done for climate mitigation and sustainability policy (Bedsworth & Hanak, 2013; Krause, 2010, 2012; Lubell, Feiock, & Handy, 2009).

In this paper, we build on the literature on urban adaptive capacity by using logistic regression to assess the importance of different indicators of adaptive capacity. We draw on the responses from 156 U.S. cities that participated in a 2011 global survey of climate adaptation planning, 60% of which have begun adaptation planning. We model the effect of 13 measures of cities' resources, local leadership, information for climate adaptation, and state policies in predicting whether or not a city has begun to engage in adaptation planning.

We find that greater commitment by local elected officials, higher municipal expenditures per capita, and perceptions that the climate is already changing are statistically significantly associated (at the $p = 0.05$ level) with cities engaging in adaptation planning. Surprisingly, state policies, income per capita, public and business awareness, and challenges obtaining staff time, funding, and scientific data are not statistically significant predictors of planning for our sample. Larger cities are more likely to engage in adaptation planning, but this finding is of borderline statistical significance and may be due to an oversampling of larger and more progressive cities in our study.

The following section reviews existing knowledge on the barriers to adaptation planning and highlights the lack of consistent measures of municipal adaptive capacity. The second section introduces the survey on which we basis our analyses, and the third section presents our methodology and variables. In the fourth section, we discuss our findings and their limits, which include non-representative sampling, questionnaire design constraints, and the fact that our model explains only 26% of the variation in cities' planning status. The final section identifies a need for state and regional governments to help promote awareness among local politicians and

to support local planners in adaptation planning.

Progress and Barriers to Local Government Adaptation

Climate adaptation planning helps cities identify specific climate impacts, develop options for responding to these impacts, and mobilize the resources to implement these options. Figure 1 shows the iterative process of adaptation planning, from scoping the problem, to analyzing the options and alternative adaptation strategies, to implementing adaptation plans. Strategies that cities have developed include investments in ecological and engineering infrastructure; institutional reforms to existing plans, codes, insurance policies, and development approval processes; as well as programs to alter cultural and behavioral practices (Carmin et al., 2015; Ebi & Burton, 2008; Hamin & Gurran, 2009; Lemieux & Scott, 2011; Solecki, Leichenko, & O'Brien, 2011).

[Figure 1 here]

Adaptation planning processes require substantial technical capacity, financial resources, and political support (National Research Council, 2010). Adaptation plans task local governments with translating scientific projections of future climate conditions into tangible impacts on local operations through risk and vulnerability assessments, and selecting from potentially costly and controversial adaptation options in the face of uncertain climate impacts over long planning horizons (Berrang-Ford, Ford, & Paterson, 2011; Carmin, Dodman, & Chu, 2013; Füssel, 2007; Moser & Ekstrom, 2010; Preston, Westaway, & Yuen, 2011). As of 2012,

only around 150 of over 14,000 urban areas and clusters[1] nationwide have overcome these hurdles to initiate adaptation planning (Aylett, 2014; Bierbaum et al., 2013; Carmin et al., 2012).

Scholars have tried to catalyze more widespread adaptation planning by identifying the conditions that prevented or enabled cities such as Keene (NH), Baltimore, Boston, and Chicago to start planning at an early stage. Qualitative research on local adaptation planning has found that the lack of policy mandates from state governments as well as the lack of resources, leadership, ability to access and communicate climate information, and supportive cultural values among local governments all constrain adaptation planning at the local level (Aylett, 2014; Carmin et al., 2012; Hamin et al., 2014; Moser & Ekstrom, 2010, 2012). However, while researchers generally agree on the importance of these broad categories of adaptive capacity, there is less agreement on specific metrics that predict cities' likelihood of actually engaging in adaptation planning (Moser, 2009, 2015). In the following review, we discuss the first four types of barriers to adaptation planning listed above as well as potential measures of these barriers.

Resources

The lack of resources is one of the most cited barriers to adaptation (Anguelovski, Chu, & Carmin, 2014; Carmin et al., 2012; Hunt & Watkiss, 2010; Moser & Ekstrom, 2012). Studies report that smaller cities have a particularly difficult time raising the fiscal and staffing resources for adaptation planning (Hamin et al., 2014). As a result, relatively few small cities have undertaken adaptation planning without the support of regional planning agencies and foundation grants such as the Kresge and Barr Foundations (Bryan, 2015; Hamin et al., 2014; Moser & Ekstrom, 2012; Shi, Chu, & Carmin, 2015). Larger cities tend to have more stable tax bases and technically trained staff, greater regulatory and political autonomy, more access to environmental and municipal networks, such as ICLEI and the Urban Sustainability Directors Network, that

provide additional resources for adaptation planning (Homsy & Warner, 2015; Westerhoff, Keskitalo, & Juhola, 2011). Nevertheless, even large cities report challenges dedicating staff and funding given competing priorities, particularly after the 2008 recession (Carmin et al., 2012).

Scholars have used a variety of resource indicators to predict local capacity to plan for both climate mitigation and adaptation. Studies have used household income (Krause, 2010, 2012) or municipal revenue per capita (Lubell et al., 2009) to predict whether or not cities develop plans for climate mitigation. Others have used debt-to-revenue (Cutter, Boruff, & Shirley, 2003) or debt-to-expenditure ratios (Borden et al., 2007) to predict local vulnerability to climate impacts. Administrative capacity for adaptation planning can also be difficult to gauge. While some cities have established climate change offices and funded dedicated climate staff (Carmin et al., 2013), others have integrated climate considerations into ongoing planning processes by reallocating the time of existing staff (Halsnæs & Trærup, 2009; Klein, 2010).

Local Leadership

Many studies cite the lack of leadership, especially among planning staff and local elected officials, as an important barrier to adaptation planning. Planning staff in cities that pursued adaptation early on pushed for climate impact assessments and plans even without state or federal policy mandates because they were motivated by their own beliefs, perceptions of climate impacts, or participation in global forums and networks where these ideas were gaining traction (Anguelovski & Carmin, 2011). These adaptation champions helped build local coalitions and political support for adaptation planning (Bulkeley, 2010; Lowe, Foster, & Winkelmand, 2009; Roberts, 2010). Still, many planners report difficulty in gaining support from their mayors and city councilors (Carmin et al., 2012) due to the pervasiveness of climate change denialism (Germain, Ellingboe, & Kroh, 2015), the uncertainty of climate projections and

impacts (Amundsen, Berglund, & Westskog, 2010; Bedsworth & Hanak, 2010; Moser, 2009), or the prioritizing of day-to-day operations (Carmin et al., 2013; Measham et al., 2011). In a vicious cycle, low political support then translates into difficulties increasing staffing capacity, allocating funding, and coordinating with other departments for adaptation planning (Aylett, 2014; Gurran, Norman, & Hamin, 2013).

Measures of local leadership on climate change issues tend to rely on survey questions on local officials' commitment or support (e.g., Hanak et al., 2008) for lack of better data at the municipal level. Support for climate policy among members of Congress is clearly divided by political party (Germain et al., 2015). However, at least for climate mitigation, past studies have found that local voter political affiliation has little statistical or practical significance in predicting whether municipalities sign pledges or adopt plans to reduce carbon emissions (Bedsworth & Hanak, 2013; Lubell et al., 2009).

Information and Communication

The difficulties associated with obtaining, interpreting, and communicating data on climate change present a third set of barriers to advancing local adaptation plans (Fünfgeld, 2010; Tribbia & Moser, 2008). Even though federal and state agencies are increasingly making climate models available to local governments, cities often still need to hire technical consultants to interpret these models into specific impacts on local infrastructure and services. Planners have found it even more challenging to build broad-based support and communicate the importance of climate adaptation to their elected officials, the public, and the business community (Brulle, Carmichael, & Jenkins, 2012; Carmin et al., 2012; Howe, Mildenberger, Marlon, & Leiserowitz, 2015; McCright & Dunlap, 2011). Although natural disasters often trigger greater public

awareness and political impetus for local adaptation planning, adaptation champions often find it difficult to sustain this "window of opportunity" (Birkmann et al., 2010).

In general, the extent to which planners are able to access climate information and communicate the need for adaptation to their constituents has been difficult to assess. This is due to the fact that variables such as mayor's political party, voter party registration, and polling data on political or public opinions of climate change are not collected nationwide or are only available down to the county level (Howe et al., 2015). Similarly, data on the cost of natural hazard losses, such as the University of South Carolina's SHELDUS dataset, are reported by storm, state, or county, but not by city, making it difficult to systematically assess how the experience of climate impacts affect adaptation planning.

State Policy Framework

A final barrier is the lack of federal and state policies on urban climate adaptation, which means there is little pressure on, resources for, or guidance to local governments on adaptation planning (Amundsen et al., 2010; Measham et al., 2011). Since 2013, the Obama Administration has issued several executive orders mandating federal agencies to plan for adaptation, but these new policies have yet to trickle down to the state and local levels.[2] According to the Georgetown Climate Center, 14 states have developed adaptation plans and policies, and six others have issued plans for sectors such as transportation, water, and energy (Georgetown Climate Center, 2015). With few exceptions[3], most of these policies do not mandate local action, but instead recommend that state and local agencies consider climate impacts in their planning processes (Cruce, 2009; Schectman & Brady, 2013) or monitor ongoing adaptation activities (Herzog, Moser, & Newkirk, 2015).

Although some early adopter cities have initiated adaptation planning without state mandates, less progressive cities are unlikely to do so absent stronger regulatory carrots and sticks (Barbour & Deakin, 2012; Bedsworth & Hanak, 2010; Betsill & Rabe, 2009). Experiences enforcing past environmental policies demonstrate that strong regulatory frameworks are critical for promoting local policy adoption, especially when local actions require difficult tradeoffs in resource allocation between development and environmental priorities (Amundsen et al., 2010; Dalton & Burby, 1994; Haughton & Counsell, 2004; Measham et al., 2011).

In summary, existing research has found that cities' ability to plan for climate adaptation depends on state policies, local government staff and fiscal resources, leadership from local elected officials, the availability of climate data, and levels of public support. However, these studies do not consistently use the same metrics to evaluate barriers to adaptation planning, partly because nationwide, climate-related, city-level data are scarce. Scholars of climate adaptation have also found it challenging to identify quantitative measures of successful adaptation (Adger, Arnell, & Tompkins, 2005; Kates, Travis, & Wilbanks, 2012; Quay, 2010). As a result, no study has systematically evaluated whether the indicators identified by the literature are significant across large samples of cities, and if so, how important they are relative to each other.

Survey of Adaptation Planning Progress

This paper contributes to the literature on adaptive capacity by quantitatively comparing the responses of climate and sustainability staff from 156 cities to a survey on climate adaptation (Carmin et al., 2012). The survey defined adaptation as "any activity you are pursuing to address the impacts of climate change could have on your community." This definition emphasizes the

consideration of *future* climate conditions, not just present climate risks. The survey instrument[4] asked respondents 40 closed-ended questions on whether their cities had initiated adaptation planning, their strategies and motivations, and the barriers and support they faced along the way. These responses, along with supplementary census and municipal fiscal data, allow us to statistically evaluate the relative importance of different adaptive capacity measures in predicting the status of adaptation planning. We model three of the crosscutting barriers that Moser and Ekstrom (2010) identify—leadership, resources, and information and communication—as well as additional indicators for population size and the presence of state adaptation policies.[5]

The survey, of which the research reported here is a part, used the ICLEI-Local Governments for Sustainability's network of 1,200 municipalities in 86 countries as a sampling frame to describe global urban adaptation trends. ICLEI members commit to addressing climate change and sustainability and are likely to include many early adopters of adaptation planning. The researchers tested the survey instrument with ICLEI staff, who then sent local government representatives an introductory email providing the option to complete the questionnaire online or to receive a paper copy. ICLEI staff reminded non-respondents at one and two-week intervals, and 72 and 24 hours before the online portal closed.

Nearly 300 U.S. local governments completed at least part of the survey (a 52% national response rate). We exclude county governments and those cities that did not fully respond to the six survey questions on which we base our analyses. Those questions sought information on whether or not cities have experienced climate impacts, the status of adaptation planning in their city, the commitment of local elected officials and departments to adaptation planning, the challenges staff face in adaptation planning, and whether or not cities have climate offices and dedicated staff. This created a sample of 156 diverse U.S. cities, whose socio-demographic

characteristics and survey responses are shown in Table 1. Figure 2 maps the cities that constitute the sample for the analyses presented here.

[Table 1 and Figure 2 here]

We rely on the U.S. component of the global survey because it was the first to study urban adaptation planning across the country and presents an opportunity to evaluate important measures of adaptive capacity. However, the survey has a number of limitations that can introduce sampling bias and affect the reliability of the responses. For one, the ICLEI network attracts comparatively larger, wealthier, and more environmentally progressive cities in the United States.[6] When compared to the rest of the country, cities in the sample that have begun adaptation planning are by definition early adopters of adaptation planning. In addition, the survey's questions were purposefully general and some response options were also vaguely defined in order to apply to diverse cities around the world. Each of these challenges reduces the reliability of the survey responses, which may affect the statistical relationships between the variables in our model.

Constructing the Model

We use logistic regression to assess the relative importance of different indicators of adaptive capacity in predicting whether or not a city engages in adaptation planning. Cities' planning status is based on the survey question: "Have you completed or are you working on some form of climate adaptation planning? Answer 'yes' even if you are in the earliest phases of planning or action, such as having informal discussions and meetings." We include cities in the early planning stages because getting climate adaptation onto the local agenda may already be an

initial indicator of a city's adaptive capacity. We then use additional survey questions and census data to develop a list of 13 explanatory variables representing leadership, resources, information and communication, and state climate adaptation policies that may be associated with adaptation planning. Table 1 presents the explanatory variables. Below, we describe these variables and their sources of data. The Technical Appendix explains the model building and testing process.

Leadership. We measure leadership as the level of commitment to adaptation planning among local elected officials. This variable is based on the survey question that asks respondents to rate officials' commitment as *very low*, *low*, *moderate, high,* or *very high*.

Resources. We test seven potential measures of staffing and financial capacity: presence of dedicated climate staff; challenges reallocating staff time, reallocating resources, and obtaining funding for adaptation; log of income and municipal expenditures per capita; and log of city population size. The presence of staff is based on the survey question, "Does your local government have one or more full-time staff members who work solely on climate issues (adaptation, mitigation, or both)?" The survey also asks respondents to rate the level of challenge they experienced in securing funding, reallocating staff time, and reallocating existing resources to work on adaptation. Ratings followed a five-point scale, from "no challenge" to "major challenge." The data on city population, income, and municipal expenditures are based on the 2010 U.S. Census, supplemented by local and state budget records.

Information and Communication. We examine four potential measures of cities' ability to collect and communicate information: awareness of climate impacts, challenges obtaining climate data, and challenges generating interest among public and business communities. The first indicator is based on the survey question asking respondents if they "have noted or experienced any of the following changes in [their] community in the past five years, as

compared to general trends and historical conditions (check all that apply)." We use a dummy variable to indicate experience of any of the listed changes, ranging from increased frequency of natural disasters, to increased damage and deaths from such disasters, to changes in precipitation, temperature, sea level, and local flora and fauna. We base three additional potential variables on survey questions that ask respondents to use a five-point scale to rate the level of challenge they experienced while obtaining sufficient scientific data on climate change, communicating the need for climate adaptation to the public, and generating interest in adaptation among business.

State Climate Planning. We use a dummy variable to represent whether a city is located in one of the 20 states that had adopted adaptation policies by 2011, as indicated by the Georgetown Climate Center. Policies include comprehensive adaptation plans or explicit proposals for city-relevant sectors, such as transportation, water, and energy.

Discussion of Modeling Results

Overall, 60% of cities are engaged in adaptation planning, with 24% in the early scoping stages, 27% in the planning and analysis stage, and 9% in the implementation stage. Figure 1 shows the number of cities in our sample at each stage of the adaptation planning process. The average city in our sample has a population of 116,000, income per capita of $33,700, and municipal expenditure rate of $2,900 per capita. Twenty-four percent of cities report that their elected officials are extremely or highly committed to climate adaptation, 20% have dedicated climate staff, 78% have experienced one or more climate impacts, and 73% are located in a state with a climate adaptation policy. On average, respondents found reallocating staff time, reallocating resources, and securing funding much more challenging than obtaining scientific data, communicating with the public, and generating interest among business.

Table 2 in the Technical Appendix presents the regression model. We find that only three out of the 13 variables are statistically significant (at the $p = .05$ level) in predicting adaptation planning status: municipal expenditures per capita, experience of climate impacts, and commitment by local officials. The final model explains 26% of the variation in cities' adaptation planning status. These findings corroborate past research on the importance of leadership, resources, and information and communication to adaptation planning (Carmin et al., 2013; Hamin et al., 2014; Moser & Ekstrom, 2012). They also highlight the relative importance of local leadership in predicting adaptation planning, identify fiscal capacity and communication variables that are more effective in predicting adaptation planning, and suggest that state policies at this time are not associated with adaptation planning, at least for our sample.

First, the model highlights the strong predictive power of local leadership. The model predicts that the odds of a city engaging in adaptation planning triple exponentially with each one-unit increase in the commitment of local officials to climate adaptation planning. For instance, holding all else equal, a city that has very high political commitment is 81 times more likely to plan for climate adaptation as a city with very low political commitment. The importance of leadership persists even when controlling for expenditure rates and population size, indicating that strong leadership helps overcome resource constraints (Carmin et al., 2013).

The importance of leadership in predicting adaptation planning underscores the need for better measures on the conditions that promote political leadership. Past research has found that political commitment to adaptation builds on the efforts of local adaptation champions, who are often staff in planning and environment departments, to compile climate data and build interest across departments (Bulkeley, 2010; Lowe et al., 2009; Roberts, 2010). Political and organizational cultures—such as local governments' flexibility, openness to new ideas and

experimentation, and incentives for departmental staff to go beyond existing policy mandates—create the conditions for local adaptation champions and political commitment to emerge (Leck & Roberts, 2015; Moser & Ekstrom, 2012). However, the survey on which we base our analyses does not include questions on organizational values and beliefs. More recent surveys of climate mitigation and adaptation have included measures of these aspects (see Aylett, 2014) and provide an avenue for future research.

Second, the model shows that municipal expenditures per capita is a more effective predictor of adaptation planning than income per capita, dedicated climate staff, and challenges securing funding for adaptation. The model predicts that the odds of a city engaging in adaptation planning will increase by nearly five-fold with a ten-fold increase in expenditures per capita. Like past studies (e.g. Krause, 2010, 2012), we find that income per capita is not a statistically significant predictor of adaptation planning, likely because personal wealth does not necessarily translate into higher local government spending capacity. More surprising is the lack of significance of dedicated climate staff and challenges securing funding for adaptation. These findings may reflect the fact that many cities in our sample are in the early stages of adaptation planning, when dedicated climate staff and access to specific adaptation funds are not as critical. During these early stage, staff from many different agencies are participating in informal discussion and data gathering, thereby reducing the demand for time from any one staff member.

Third, the experience of changing climatic conditions is the only significant predictor related to obtaining information on and communicating the need for climate adaptation. The model predicts that the odds of a city planning for adaptation will triple when respondents say that their city has witnessed changes in precipitation, temperature, and coastal conditions. Better data on climate impacts, such as the economic damages of disasters or the number of federally

declared disasters in a city, would help clarify the predictive power of experiences of climate change. Worryingly, this finding suggests that many cities are reactively responding to past impacts rather than proactively anticipating future change. In addition, obtaining climate data, interest among citizens, and interest among businesses are not significant predictors of adaptation planning. These findings indicate that these challenges may not pose as much of an obstacle to adaptation planning as previous research suggests.

Fourth, contrary to existing literature, we do not find the presence of state adaptation policies to be a significant predictor of local adaptation planning for our sample. This is not evidence that state policies are irrelevant so much as an indication that most state adaptation policies are still advisory rather than mandatory, and do not link their recommendations to new sources of funding. In addition, more time may be needed to allow these new state policies to trickle down and catalyze local planning before we can evaluate their impact. More nuanced variables may find that specific kinds of state policies are associated with higher rates of local adaptation planning. For instance, variables might distinguish between policies that require versus recommend actions, encourage climate adaptation versus prohibit agencies from addressing climate change, or those that attach additional funding for adaptation planning versus those that are unfunded mandates.

Finally, the importance of city size is not clear. The model predicts that cities are twice as likely to plan for adaptation with every ten-fold increase in population size. For example, holding all else constant, a city of one million is predicted to be twice as likely to plan for adaptation than a city of 100,000. However, this relationship falls just short of statistical significance ($p = 0.055$), suggesting that city size is only a proxy for resources and leadership and that size itself does not effectively explain planning once other factors are taken into account.

Our sample of larger and more environmentally progressive cities, however, likely understates the degree to which state policies, climate staff, and funding resources could be associated with adaptation planning in most U.S. cities. Cities in our sample are more likely to engage in adaptation planning regardless of state policies on climate adaptation, which is not representative of environmental planning in most cities (Barbour & Deakin, 2012; Betsill & Rabe, 2009). In addition, dedicated staff and funding resources may become more important in later planning stages involving assessments, plan development, and implementation.

Implications for Policymakers and Planners

Above all, our findings point to the importance of generating political support in order to advance adaptation planning. The question for planners is how they can better leverage existing resources to build political leadership, short of waiting for a major climate disaster or budgetary reforms. Early adopter cities, which our sample represents, have successfully put adaptation on the local political agenda, initiated adaptation planning by tapping into foundation grants and environmental networks, and embedded climate considerations into existing planning processes, such as those for hazard mitigation and coastal zone management. Planners in other cities can learn from their experiences, draw on the data generated from earlier climate risk and vulnerability assessments, and use existing plans, policies, assessments, and models as templates.

However, catalyzing adaptation planning across U.S. cities, which tend to have fewer resources than those in our sample, will require other levels of governments to develop regulatory and fiscal mandates and incentives for climate adaptation planning. States can facilitate local adaptation planning by requiring local governments to account for climate impacts in environmental permitting requests for new developments, as done in Maine, or to account for

them in local comprehensive plans, as done in Rhode Island. These policy changes can help elected officials politicians overcome local opposition and climate denialism, and empower planners to initiate adaptation planning. States can also require projects that they fund to consider climate impacts, which would facilitate the integration of adaptation objectives into local expenditure plans. These approaches build on the emerging national policies for federal investments and requirements on local planning processes.

Regional planning entities—such as councils of government, planning councils, metropolitan planning organizations, county governments, and water and conservation districts—can also help local governments overcome barriers to adaptation planning. Regional entities can foster local leadership by facilitating the exchange of information between cities, and communicating why and how some cities have translated their awareness of climate impacts into actual adaptation plans and projects. Many regional entities are already taking on these roles. For example, the Metropolitan Area Planning Council helped 14 mayors in the metro Boston area commit to working together to share information, coordinate planning, and address regional priorities for climate adaptation. In Southeast Florida, the secretariat of the four-county Regional Climate Compact has helped over 30 out of 110 mayors in the region pledge to implement the Regional Climate Action Plan for both climate adaptation and mitigation. In California, five metropolitan areas have formed regional collaboratives that engage local and regional governments and private and nonprofit groups to work on adaptation planning.

In this study, we have demonstrated the degree to which strong political leadership, high municipal expenditures, and perceptions that the climate is already changing are associated with adaptation planning among environmentally progressive cities. As more cities begin to plan and as they progress along the adaptation planning process, there is an opportunity for future research

to focus on the factors that help planners implement adaptation plans, and the conditions under which implementation results in actual reductions in damages from climate change. Future models of adaptation planning, drawing on representative samples of U.S. cities, can help policymakers assess and benchmark municipalities with each other and evaluate how governments at different levels can better support local adaptation planning and implementation.

Notes

[1] The U.S. census defines urban areas as those with a population of 50,000 and urban clusters with a population between 2,500 and 50,000.

[2] In 2013, President Obama established the Task Force on Climate Preparedness and Resilience and issued an executive order (#13653) to update federal programs to support climate-resilient investments, and develop adaptation plans for federally owned facilities, lands and waters. The Task Force also recommended that federal agencies require their investments to withstand climate risks. However, these emerging federal rules and regulations have yet to trickle down to local governments. For instance, the Federal Emergency Management Agency began requiring state-level hazard mitigation plans (HMPs) to include future climate scenarios and projections in early 2015, but has not extended this rule to the over 20,000 municipalities that have their own HMPs.

[3] Notable exceptions include Massachusetts and Maine's mandate that new construction projects over a certain size account for sea level rise, and Rhode Island's mandate that local comprehensive plans integrate climate hazards (Schectman & Brady, 2013).

[4] The full survey instrument is available online at http://dspace.mit.edu/handle/1721.1/89521.

[5] We do not evaluate the fourth barrier, cultural values, because the survey did not ask questions on this topic.

[6] ICLEI membership dues for U.S. cities range from $600 to $8,000 per year, depending on city population size.

Technical Appendix

Our approach to building the regression model consists of two steps. We first test each potential predictor by assessing its bivariate association with adaptation planning. Only those predictors found to be significant in the bivariate models are included in the subsequent multivariate model. These are population, commitment by elected officials, expenditure per capita, funding availability, experience of climate impacts, data availability, and business interest. We log-transform both population size and expenditure per capita to compensate for their positively skewed distributions. We use log-base ten for ease of interpretation, allowing us to interpret the regression coefficients in terms of the increase in the odds of adaptation planning associated with a ten-fold increase in population or expenditure per capita.

We find that presence of climate staff, state climate policies, income per capita, and challenges in reallocating staff, reallocating resources, and communicating the need for adaptation to the public are not statistically significant predictors in bivariate regression. The final model, which explains 26% of the variation in cities' adaptation planning, includes the remaining seven explanatory variables: municipal expenditures per capita, experience of climate impacts, commitment by local officials, population, and the challenges of securing funding, obtaining data, and gaining business interest in adaptation. While each of these variables is a significant predictor of adaptation when we regress them individually, only municipal expenditures per capita, experience of climate impacts, and commitment by local officials are statistically significant (at the $p = .05$ level) in the final, multivariate model.

Table 2 presents the results of the final multivariate logistic regression model. Each explanatory variable is listed along with its beta coefficient (β), which we exponentiate to find the odds ratio that results from a one-unit increase in that variable. For example, the coefficient on commitment of elected officials is approximately 2. Raising the base of the natural logarithm (e) to the power of 2 gives us an odds ratio equal to 2.7. This result indicates that the odds of a city engaging in adaptation planning increase by 2.7 times for each one-unit increase in the commitment of elected officials (which we assess on a five-point scale).

[Table 2 here]

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