

# Numerous strategies but limited implementation guidance in US local adaptation plans

In our article, we address two questions: 1) How do existing climate adaptation plans align with emerging principles of plan quality? 2) What community attributes are associated with high quality plans? This supplementary material provides additional background and discussion. In addition, Table A includes all the variables and data sources for our multivariate analysis, and Table B is the protocol we used to analyze the plans in our sample.

## Plan Quality

Across the United States, governments and nongovernmental organizations invest millions of dollars and countless hours in planning.<sup>1</sup> Due to this large investment, there is a growing interest in evaluating the quality of plans—documenting their content and evaluating their overall strengths and weaknesses in order to better inform practice.<sup>2</sup> Behind the call for plan quality evaluation is the idea that high-quality plans better advance community goals than lower-quality plans.<sup>3</sup> For example, high-quality plans have been found to decrease the cost of disasters more than lower-quality plans<sup>4</sup>, and Preston et al.<sup>5</sup> argue that “the best method to ensuring robust adaptation is to ensure rigorous adaptation planning processes” (p. 426).

Over the last two decades, researchers have used plan evaluation methodologies to evaluate plans from multiple domains, including hazard mitigation<sup>6</sup>, affordable housing<sup>7</sup>, and sustainability planning.<sup>8</sup> As the plan evaluation literature has grown, scholars have built a general consensus on the key principles of plan quality. In meta-analyses of plan evaluation studies, Berke and Godschalk<sup>2</sup> and Lyles and Stevens<sup>1</sup> identified six principles commonly used in plan

evaluation: 1) goals, 2) fact base, 3) policies, 4) public participation in plan creation, 5) inter-organizational coordination, and 6) details regarding implementation and monitoring. These six principles are increasingly viewed as “standard” principles for plan evaluation<sup>9</sup> and are considered to be applicable across planning domains and scales (e.g., local, regional, state).<sup>1</sup>

Goals are defined as future desired conditions that establish the breadth of a plan. Fact base identifies and prioritizes community issues, providing the empirical foundation on which strategies are based. Strategies provide a guide to decision making to ensure that plan goals are achieved. These first three plan quality principles are frequently referred to as direction-setting principles because, while every plan should include these principles, they will look different across planning domains.<sup>10</sup> For example, the strategies identified in a transportation plan will not be the same as those identified in an adaptation plan. Consequently, the evaluation criteria for these principles are tailored to the specific domain being assessed. In contrast, the last three principles – public participation, coordination, and implementation and monitoring – do not differ significantly between planning domains. Whether a transportation or adaptation plan is being evaluated, the plan should provide a description of how the public was engaged in the planning process (public participation), how other organizations and government agencies contributed to the planning process (coordination), and how the plan will be implemented and monitored in the future (implementation and monitoring).

The six standard plan principles correspond to the rational model of the planning process whereby planners are thought to review existing and future conditions, formulate goals, identify potential strategies to achieve goals, and select the optimal set of strategies for implementation.<sup>1</sup> To a large extent, the adaptation planning process proposed in guidance produced by federal, state, and non-governmental organizations follows the rational planning model. For example,

California's Adaptation Planning Guide<sup>11</sup> proposes nine steps in the adaptation planning process: identifying 1) exposure, 2) sensitivity, 3) potential impacts, 4) adaptive capacity, 5) risk and time of onset, and 6) prioritizing adaptation needs, 7) identifying strategies, 8) evaluating and prioritizing potential strategies, and 9) determining the implementation for selected strategies. The first five steps correspond to the rational model steps of reviewing existing and future conditions as well as to the fact base plan principle. The last four steps align with the rational model steps of identification and strategy selection.

The steps in California's adaptation planning process that fall under the fact base principle demonstrate how adaptation planning differs from other planning domains. Adaptation guidance literature emphasizes detailed, science-based analysis of projected changes in climate (exposure), as well as the consequences for the community, through the completion of a vulnerability or risk assessment. Because climate change is projected to have broad impacts that affect many government sectors, existing adaptation guidance proposes many different types of strategies. For example, California's Adaptation Guide<sup>11</sup> recommends strategies ranging from "Develop a water recycling program" (p. 7) to "Promote economic diversity" (p. 8). While most adaptation strategies are not new actions, the breadth of strategies that should be included in an adaptation plan is unique among planning domains, with the possible exception of sustainability planning.

In addition to the six plan principles commonly used in plan evaluation studies, efforts to prepare for climate change impacts must address uncertainty.<sup>12, 13, 14</sup> Multiple sources of uncertainty, from modeling global climate to estimating the cost of local adaptation options, create a "cascade" of uncertainty<sup>15</sup> that can be a challenge for local adaptation planning.<sup>16, 17</sup> Planning researchers argue that adaptation planning requires a break from the traditional "predict

and plan” paradigm and should embrace new approaches that enable discovering, assessing, and addressing uncertainty.<sup>12,18</sup> For example, Quay<sup>19</sup> promotes anticipatory governance, a “model of decision making under high uncertainty based on concepts of foresight and flexibility, [that] uses a wide range of possible futures to anticipate adaptation strategies, and then monitors change and uses these strategies to guide decision making” (p. 496). Similarly, adaptation guidance emphasizes the need to consider multiple futures and emphasizes strategies that provide benefits across a number of potential scenarios.<sup>11,20</sup>

To date, plan evaluation studies have not incorporated new approaches of planning under high uncertainty.<sup>21,1</sup> In our analysis we have included the concept of uncertainty as a core plan principle, which allows us to extend the plan evaluation literature and explicitly measure the extent to which adaptation plans incorporate new planning approaches (Table B).

Typically, researchers use content analysis, which involves “a systematic reading of a body of texts, images, and symbolic matter,”<sup>22</sup> to score plans on the degree to which they adhere to criteria associated with the various plan quality principles. Using this method, researchers develop a coding protocol that includes metrics corresponding to each planning principle. For example, in a recent evaluation of official community plans in British Columbia, Canada, Stevens<sup>9</sup> includes the metric “Are organizations and individuals that were involved in plan preparation identified?” in the public participation principle. If the plan does identify who was involved in plan preparation, it receives a score of 1; otherwise it receives a score of 0. Assessing the presence/absence of criteria allows the conversion of text to a quantitative measurement of plan quality, which eases comparisons between plans and allows for statistical analyses. The aim of this coding procedure is to draw inferences from plans that are both replicable and valid.<sup>3</sup>

### **Climate Adaptation Planning**

To date, few studies have used content analysis to evaluate local climate adaptation plans. Preston, Westaway, and Yuen<sup>5</sup> evaluated 57 adaptation plans from a range of geopolitical scales in Australia, the United Kingdom, and the United States against 19 process-based evaluation criteria based on a Logic Framework approach and adaptation guidance materials. Their results indicate that adaptation plan quality is highly variable: plans scored between 16% and 61% of possible points. Overall, however, adaptation plans were relatively weak, scoring on average 37%.<sup>5</sup> Baker et al.<sup>23</sup> analyzed seven local adaptation plans in Southeast Queensland, Australia, with similar results. The plans included in these samples exhibited high awareness of climate issues and had strong scores on assessment of climate drivers and impacts.<sup>5, 23</sup> They did not, however, include a complete analysis of local conditions such as non-climatic drivers, key financial and natural capital, or existing adaptive capacities that will help the communities prepare for future climatic impacts.<sup>5, 23</sup> In addition, few plans provided objectives or success criteria to measure progress, and most failed to include details about implementation.<sup>5, 23</sup>

While these studies provide a foundational understanding of adaptation plan content and quality, they fail to integrate the methodologies and lessons learned from the long history of plan evaluation. Preston, Westaway, and Yuen<sup>5</sup> use a Logic Framework Analysis (LFA) approach in their assessment, which evaluates the relationship of program goals to the activities identified to achieve those goals, the inputs required to undertake those activities, and the outputs that emerge. Using this framework, Preston, Westaway, and Yuen<sup>5</sup> define four stages of adaptation planning: (1) goal setting, (2) stock-taking, (3) decision-making, and (4) implementation and evaluation. While these four stages overlap with the principles of plan quality, it is extremely challenging to place the results of Preston and colleagues within the larger plan evaluation

landscape due to the lack of comparability between their evaluation criteria and those used in other plan evaluation approaches.

Moreover, the evaluation criteria used by Preston, Westaway, and Yuen<sup>5</sup> are skewed towards fact base, with little attention given to other important planning principles; eight of the 19 criteria measure how well plans assess capital, climate drivers, and impacts. Only one criterion is dedicated to public participation and goals. As a result, these important principles, which are typically given equal weight to the other principles in plan evaluation studies, represent only approximately 5% of the plan quality measured by Preston, Westaway, and Yuen.<sup>5</sup> Because the authors do not use plan principles to organize their evaluation metrics, their results cannot be used to examine how well adaptation plans follow established planning practices such as goal setting, public participation, and inter-organizational coordination. This omission also means that we are unable to compare the quality of adaptation plans to the quality of other planning domains such as hazard mitigation.

Baker et al.<sup>23</sup> also use distinct evaluation criteria that inhibit comparison of their findings to those of other plan evaluation studies. For their analysis, Baker and colleagues<sup>23</sup> created a set of desirable outcome goals and scored plans 0-4 on how well they aligned with these outcome goals. For example, one criterion used by the authors is “the impacts of flooding are minimized or avoided.” Plans were also rated on a scale of 0-4 (low to high) representing how well they performed on five plan principle concepts, including the inclusion of 1) an information base; 2) vision, goals and objectives; 3) options and priorities; 4) actions; and 5) implementation and monitoring. Because Baker et al. do not specify the metrics they used to assign scores for each of the principles, it is unclear exactly what these scores represent and is challenging to compare their results to those of other studies.

Additionally, both of these previous studies used broad evaluation criteria that lack sufficient detail to identify specific strengths and weaknesses of plans. For example, Preston, Westaway, and Yuen<sup>5</sup> include a single code for “articulation of objectives, goals and priorities.” This approach groups together four distinct concepts: a vision statement, goals, objectives, and prioritization. Separating these concepts into different codes is necessary to gain the specific knowledge required to understand and improve local adaptation plans and planning processes.

A number of researchers have called for more detailed analyses of local climate adaptation planning processes and associated planning documents.<sup>24, 25, 5</sup> No existing studies provide a complete analysis of the local stand-alone climate adaptation plan landscape in the U.S. Preston, Westaway, and Yuen<sup>5</sup> analyze only nine local adaptation plans from the U.S., all written before 2009, and Baker et al.<sup>23</sup> include no plans from the U.S. With the recent growth of local adaptation plans in the U.S. and a need to understand how U.S. local planning compares to planning emerging in other developed as well as developing countries, a new evaluation that integrates methods from the plan evaluation literature is necessary to place adaptation plans within the larger planning landscape, to compare adaptation planning to planning in other domains, and to identify how the current adaptation planning process could be improved.

### **Explaining Variation in Plan Quality**

In addition to measuring plan quality, many plan evaluation studies explore why some plans are of higher quality than others.<sup>1, 21, 26</sup> In the adaptation field, a substantial academic literature has developed describing adaptation processes and barriers.<sup>27, 28, 29</sup> This research, however, has predominately focused on providing rich descriptions of adaptation pathways of an individual city or small sets of cities.<sup>30, 31</sup> Few studies have attempted to use quantitative methods

to test theories related to why plan quality varies on a larger scale.<sup>32</sup> Drawing on past plan quality and local climate adaptation research, we created four conceptual models that may affect the quality of local adaptation plans: capacity, commitment, policy diffusion, and internal drivers.

### *Capacity*

Theoretically, communities that have more capacity, defined as resources available to dedicate to planning, would produce better plans.<sup>33</sup> Capacity, however, represents only the potential to create a high-quality plan. High capacity does not guarantee the development of a strong plan, nor do deficiencies in resources necessarily preclude it.<sup>34, 23, 30</sup>

Capacity has garnered significant attention as a precursor for adaptation.<sup>30, 29, 35</sup> Pursuing adaptation requires financial resources to support staff time, acquire technical expertise, build networks, and promote outreach.<sup>36</sup> Inadequate resources are the barrier to adaptation most commonly cited by practitioners.<sup>29, 36</sup> In a survey of ICLEI-member cities in the U.S., approximately 90% of participants indicated that securing funding was a major challenge to their adaptation-related efforts.<sup>36</sup>

Variables to operationalize capacity such as the presence of funding to create a plan, access to data, provision of technical assistance, and community wealth are commonly included in plan quality studies.<sup>26, 8</sup> These studies also consistently find that state mandates, which build capacity by requiring localities to go through the planning process, are associated with higher plan quality.<sup>37, 38, 39</sup> By participating in comprehensive planning, a wide range of local officials can gain knowledge of the planning process and can exchange information, recognize shared goals, and build trust.<sup>6</sup> These benefits have been found to translate to stronger hazard mitigation plans and flood control efforts<sup>6, 33</sup> and, we theorize, will also positively influence adaptation plan quality. Given this theoretical grounding, we include the presence of funding, the local municipal



operating budget, per capita household income, the presence of state planning mandates, and the presence of state hazard mitigation planning mandates in our capacity model.

### *Commitment*

Commitment describes a local government's dedication to an issue, and lack of commitment is often noted as a major impediment to risk reduction<sup>4</sup> and climate adaptation efforts.<sup>28</sup> Hazard mitigation, for example, tends to receive little commitment even when local governments would benefit and have the capacity to implement risk reduction measures – a situation Burby<sup>4</sup> terms “the local government paradox.” Similarly, local governments often find that they are unable to gain widespread public interest and engagement in climate-related issues.<sup>40</sup> Public awareness of climate change and perception of the risk generally influence public support for climate change policy<sup>41</sup> and may be important variables in understanding local government commitment to adaptation.<sup>26</sup>

Disasters are often framed as "focusing events" that can be used to increase public awareness and government support for preparedness action, at least temporarily. Even though the science of attributing specific extreme events to climate change is still emerging, disaster experience frequently sparks climate adaptation planning efforts.<sup>40,42</sup> Firsthand experience with disasters can transform perceptions of climate change from a temporally and spatially remote risk to one that is immediate and personal.<sup>41</sup> For example, in Durban, South Africa, climate adaptation efforts gained wide support only after flooding and tornadoes increased awareness and created a sense of urgency.<sup>31</sup> Plan quality studies have consistently found that disaster experience is significantly and positively correlated with hazard mitigation plan quality.<sup>16,21</sup>

Previous climate change and hazard mitigation activities may also indicate local government support for adaptation. In an evaluation of climate change planning in British

Columbia, Canada, researchers found that governments with stronger climate change adaptation plans had demonstrated previous commitment to climate mitigation action.<sup>42</sup> Adaptation frequently grows from similar institutional and political roots as mitigation<sup>30,43</sup>; thus previous mitigation activities and involvement in climate networks may indicate commitment to climate adaptation. Similarly, hazard mitigation activities may indicate a community's commitment to addressing long-term risk and indicate support for climate adaptation. We include in our commitment model county-level data on the public's concern about climate change, the presence of a climate mitigation plan, whether a community is a signatory of the U.S. Mayors Climate Protection Agreement, whether the community is a signatory of the Resilient Communities for America pledge, whether the community participates in the Community Rating System, whether the plan has been formally adopted by a local elected body, and previous presidentially declared disasters.

### *Policy Diffusion*

Policy diffusion refers to the movement of ideas or actions across jurisdictional lines, often through friendly competition or community networks. Diffusion of information and ideas through professional associations is believed to have helped shape climate mitigation initiatives<sup>44,45</sup> and may similarly influence adaptation efforts.<sup>32</sup> In particular, membership organizations such as ICLEI-Local Governments for Sustainability (ICLEI) and the Urban Sustainability Directors Network (USDN) provide opportunities for municipalities to share lessons learned and promising practices with their peers, which may stimulate more innovation and overall climate action. In addition, the year of plan publication has also been found to influence the quality of local plans, presumably because plans published later build on and benefit from lessons learned from earlier planning efforts.<sup>6,8</sup> Given these factors, we included the year of plan publication, the

presence of a state adaptation plan, and membership in ICLEI and USDN in our policy diffusion model.

### *Internal Operations*

The fourth model we test is an internal operations model, which includes plan author (taskforce, environmental department/organization, or planning department/organization) and source of funding (federal, state, or nongovernmental). Authorship, and the involvement of planners specifically, is known to influence hazard mitigation and adaptation plan quality.<sup>6,23</sup> While previous studies have not included funding source, we theorize that different funders have different priorities and requirements for the planning process, which leads to plans of varying quality.

Most of these conceptual models have been tested in hazard, comprehensive, and climate mitigation (also known as climate action) plan quality studies, but they have yet to be evaluated in the context of climate adaptation plans. Given these omissions, a more detailed look at U.S. local climate adaptation planning is needed in order to understand what variables, if any, help explain why some communities create stronger plans than others.<sup>24,25</sup>

## **Discussion of Results**

We use content analysis to evaluate 44 local adaptation plans in the United States and multivariate regression to examine the association between plan quality and local capacity, commitment, internal operations, and policy diffusion. We find that existing plans have strong fact bases, drawing upon multiple data sources to project future climate exposure and analyze impacts, as well as strong policy frameworks that include a breadth of strategies. Plans, however, fail to prioritize impacts and strategies and generally have weak implementation and monitoring

components. In addition, most plans fail to use planning approaches to manage uncertainty. These omissions raise concerns about whether adaptation plans will translate into on-the-ground projects that increase a community's resilience. Our analysis also indicates that communities where the planning department led the plan creation process or the plan was formally adopted by an elected body had higher scoring plans. We additionally find that communities that received state funding produced lower quality plans.

Below we discuss these results in more detail. First, we expand on adaptation plan quality providing additional examples and comparing our results to the literature; in particular, we focus on plans' treatment of uncertainty. We then compare the quality of adaptation plans in our sample to plans in other domains (e.g. hazard mitigation, comprehensive planning). Finally, we summarize the results of the multivariate regression and explore potential explanations of the negative relationships between plan quality principles and state funding, USDN membership, and household income.

### *Adaptation Plan Quality*

Plans in our sample scored highest in the strategies and fact base principles mostly due to their inclusion of a wide diversity of strategy types. This finding starkly contrasts Baker and colleagues (2012) conclusion that local governments have not developed specific adaptation actions. The high score on the strategies principle in our study suggests that U.S. local communities may be 'hedging their bets' against future climate impacts by including a variety of adaptation options in their plans. Other than one plan that did not include any strategies, all plans proposed at least five of the fifteen types of strategies coded in our analysis. Conversely, these plans rarely include details about co-benefits and the costs associated with implementing identified adaptation strategies. For example, Austin, TX's plan (*Toward a Climate Resilient*

*Austin*) includes 11 of the 15 different types of strategies included in our analysis, but it includes none of the metrics related to *co-benefits*, *costs*, and *priorities*.

The lack of implementation details suggests that the actions proposed in adaptation plans may not easily be translated into on-the-ground projects. This may in part reflect differing plan purposes as suggested by Preston, Westaway, and Yuen (2010), since several of the plans in our sample appear to be preliminary strategy documents or consultation papers that provide an initial review of a community's vulnerability with little discussion of appropriate adaptation strategies.<sup>46</sup>

Plans also draw on multiple data sources and have strong analysis of future climate exposure and potential impacts to community infrastructure, the economy, natural systems, public health, and cultural assets. Few plans, however, provide details about where impacts to these systems will occur. For example, only one plan in the sample included maps or detailed identification of the location of potential health impacts associated with climate change (the Confederated Salish and Kootenai Tribes' *Climate Change Strategic Plan*). Similar to Preston, Westaway, and Yuen's (2010) analysis, plans in our sample did a poor job of prioritizing impacts, providing detailed analysis about where impacts will occur, and discussing how non-climatic drivers, existing social, economic, and financial capacities, and underlying causes of vulnerability will impact future vulnerability. In contrast to Preston, Westaway, and Yuen (2010), however, many plans in our sample provided detailed and rigorous climate analyses, often through considering multiple climate scenarios. This suggests that the delivery of useable climate information to local stakeholders may have improved over time.

Another troubling finding from our analysis that was shared in work by Baker et al., (2012) and Preston, Westaway, and Yuen (2010) is a lack of prioritized impacts and adaptation

strategies, combined with weak implementation and monitoring components. These omissions raise serious concerns about whether adaptation plans will translate into on-the-ground projects. This concern is further compounded by the dearth of evaluation metrics included in plans: plans in our sample consistently failed to provide tangible objectives or evaluation metrics by which to measure progress. Only half of the plans in our sample include goals and only 17% include objectives. No plans include quantifiable objectives for each goal. Similarly, only 15% of the plans provide metrics by which to measure strategy implementation.

The concept of uncertainty has been widely recognized as a major barrier to adaptation planning and significant attention has been dedicated to developing new and refining existing planning approaches to address uncertainty such as scenario planning, robust and flexible strategies, and adaptive management. While most plans in our sample recognize uncertainty as a challenge for adaptation planning (75%) and many demonstrate awareness of planning approaches that account for uncertainty, very few actually employ these approaches. The failure to address uncertainty in the plan may make implementation more difficult and limit the effectiveness of proposed strategies.

One of the most commonly touted approaches to addressing uncertainty is the use of scenario planning. Unfortunately, no plan in our sample undertook structured scenario planning exercises. Only one plan developed local scenarios to consider the opportunities, constraints, and trade-offs of different growth patterns (Lafourche Parish, LA's *The Lafourche Parish Comprehensive Resiliency Plan*). Several plans used different disaster and climate scenarios to solicit input about vulnerabilities and priorities from stakeholders (Baltimore, MD's *Disaster Preparedness and Planning Project*), but, most commonly, only one greenhouse gas emission scenario was used as a basis for strategy selection. This finding seems to suggest that plans in our

sample are not using techniques to address uncertainty in their planning processes. Focusing on a single scenario when selecting strategies, suggests that the flexibility and performance of strategies across multiple scenarios is not considered in the planning process. Indeed, plans rarely discuss the potential of flexible and robust strategies as a tool to manage uncertainty. Whether or not this equates to the selection of strategies that are inadequate for uncertain future conditions, however, remains unclear. More research is needed to specifically understand if the lack of techniques to manage uncertainty in the planning process is leading to the selection of insufficient or maladaptive adaptation strategies.

The adaptation literature also emphasizes learning by continuously monitoring indicators and scientific evidence in order to update plans and policies in real time.<sup>47</sup> While 43% of plans mention adaptive management, only 18% establish a process to incorporate new information from experience, monitoring, and science into decision-making. Plans that mention adaptive management typically reference the need for an iterative process to incorporate new knowledge. The lack of evaluation metrics and methods, as well as the absence of objectives, however, raises questions about how communities will identify successful strategies or learn from their experiences. Several communities in our sample are in the process of updating their adaptation plans, so tracking the change in communities plans overtime could illuminate if communities are learning from implementation experience and incorporating new scientific evidence.

#### *Comparison to Other Planning Domains*

Although it is difficult to compare scores across plan evaluation studies because of differing coding protocols and methodologies, our results show a unique pattern on plan principle scores. In a meta-analysis of 16 plan evaluation studies published between 1997 and 2007, Berke and Godschalk found that plans scored relatively low in goals, fact base, and

strategies, as compared to organizational coordination, implementation, and monitoring. In contrast, the adaptation plans in our sample scored well in the fact base and strategies principles but were much weaker in implementation and monitoring. Our plan principle scores, ranging from 28 to 62% of possible points, are comparable to studies included in Berke and Godschalk's (2009) meta-analysis, which produced scores ranging from 3 to 91%.

### ***Multivariate Regression***

Using multivariate regression we explored the relationship between community capacity, commitment, policy diffusion, and internal operations and plan quality. Three variables are significantly correlated with plan quality: 1) formal adoption of the adaptation plan; 2) whether the plan was written by the planning department; and 3) whether a plan received state funding. State funding decreased plan quality, while the other two variables had a positive relationship with plan quality.

Regression analyses with the seven plan principles as the dependent variable demonstrate that community variables do not uniformly influence plan principles and also highlights additional community variables that may influence the planning process and the quality of plans. Specifically, counter to our hypotheses, median household income has a significant negative relationship with inter-organizational coordination ( $b = -0.000007$ ,  $t = -3.81$ ,  $p < 0.001$ ), and communities that were members of the Urban Sustainability Directors Network (USDN) were found to have significantly lower scores on the strategies principle ( $b = -0.13$ ,  $t = -2.21$ ,  $p < 0.05$ ) than non-members. Below we explore potential explanations of these relationships.



### *State Funding*

The negative relationship between state funding and plan quality may, in part, be due to states selectively funding communities that are particularly vulnerable to climate change impacts. For example, Maryland funded four local adaptation plans, all in counties extremely vulnerable to sea level rise: about 60% of Dorchester County lies in the 100-year floodplain and many properties and roads are flooded during spring high tides and in Somerset County 58% of the land area and 44% of the structures are within the 100-year floodplain. The State of New Hampshire funded two local plans in our sample: Seabrook, which has experienced nine presidential disaster declarations in the last ten years, and Durham, which has experienced seven. Extremely vulnerable communities may engage in adaptation planning but lack the capacity, even with state funding, to produce high quality plans. For example, a community extremely vulnerable to sea level rise, but with an extremely small planning department, may receive state support to create a plan but lack the technical knowledge, time, or staffing capacity needed to provide a strong and contextually relevant plan. State funded plans may focus more on identifying vulnerabilities to start the adaptation process, but fail to engage community members and organizations in the plan creation, thereby leading to lower plan quality scores. If true, this suggests that additional measures of vulnerability are needed in future analyses, since different types of vulnerability may directly affect plan quality.

State-funded plans may also be driven by state interests and, consequently, fail to develop meaningful local participation or buy-in. For example, State's may strongly encourage grantees to emphasize certain topics or use specific data in their analyses, thereby coloring the local adaptation planning process. The extent to which this is true, however, is unclear. As such, additional research is needed to explore the role of funders in the planning process. Although we

did not measure these factors directly, other forms of state support of local adaptation, such as providing technical data and planning guidance, likely enhance local adaptation efforts.

### *USDN membership*

Initially we thought USDN members might score lower on the strategies principle because they produce more focused plans that include a smaller set of well-supported strategies, but additional analysis shows that USDN members tend to include fewer types of strategies and less discussion of co-benefits, costs, and priorities in their adaptation plans (although these differences are not significant). One possible explanation is that USDN members may focus on mainstreaming or embedding climate adaptation into other community plans such as hazard mitigation and sustainability plans. If true, this may mean that adaptation plans in these communities are designed to document the community's vulnerability and adaptation priorities, as opposed to being stand-alone plans for adaptation action. Again, as Preston, Westaway, and Yuen (2010) suggest, strategy scores likely reflect the plan purpose since adaptation "plans" may act as preliminary strategy documents or consultation papers. More work is needed, however, to understand whether this hypothesis is true.

### *Household Income*

In previous studies of plan quality, household income has been used as a proxy for community capacity. In our analysis, we find that household income has a negative relationship with plan quality, suggesting that community wealth and a larger tax base does not necessarily translate into higher quality plans. One possible explanation for this negative relationship is that communities with greater wealth are those that have a higher adaptive capacity, or a higher ability to adapt to climate-related impacts. In these communities, the impetus for holistic adaptation planning might be weaker than in more resource-constrained communities where

climate-related vulnerabilities are pervasive. More research is needed, however, to see if this hypothesis holds.

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**Table A: Variables included in multivariate analysis of plan quality**

<b>VARIABLE</b>	<b>VARIABLE OPERATION</b>	<b>SOURCE</b>
<b>CAPACITY MODEL</b>		
Funding	Did the community receive outside funding to create the plan? 0 for no; 1 for yes	Each adaptation plan
Budget	Log base 10 of community operating budget for fiscal year 2014	Each local government's website
Household income	2009-2013 median household income	American Community Survey
Hazard mitigation mandate	Is the community located in a state with a hazard mitigation planning mandate? 0 for no; 1 for yes	American Planning Association ( <a href="http://www.slideshare.net/ibhs/summary-of-state-land-use-planning-laws">http://www.slideshare.net/ibhs/summary-of-state-land-use-planning-laws</a> )
Comprehensive plan mandate	Is the community located in a state with a comprehensive planning mandate? 0 for no; 1 for yes	American Planning Association ( <a href="http://www.slideshare.net/ibhs/summary-of-state-land-use-planning-laws">http://www.slideshare.net/ibhs/summary-of-state-land-use-planning-laws</a> )
<b>COMMITMENT MODEL</b>		
Adoption	Was the adaptation plan formally adopted by an elected body? 0 for no; 1 for yes	Each adaptation plan and local government's website
Public perception	Percent of county population that is worried about climate change	Yale Project on Climate Change Communication and the George Mason Center for Climate Change Communication <a href="http://environment.yale.edu/poe/v2014/">http://environment.yale.edu/poe/v2014/</a> (for details, see Howe et al. 2015)
Disaster experience	Number of presidentially declared disasters in county from 2004-2014	FEMA Disaster Declaration website
ICLEI	Is the community a member of ICLEI-Local Governments for Sustainability, USA? 0 for no; 1 for yes	ICLEI USA's membership department
Climate Protection Agreement	Is the community a signatory of the U.S. Mayors Climate Protection Agreement? 0 for no; 1 for yes	U.S. Mayors Climate Protection Agreement signatory list (website)
Resilient Communities	Is the community a signatory of the Resilient Communities for America pledge? 0 for no; 1 for yes	Resilient Communities for America signatory list (website)
CRS	Does the community participate in FEMA's Community Rating System? 0 for no; 1 for yes	FEMA's Community Rating System (CRS) Communities and Their Classes list
<b>POLICY DIFFUSION MODEL</b>		
Year	Year that the plan was published	Each adaptation plan
State adaptation plan	Is the community located in a state with an adaptation plan? 0 for no; 1 for yes	Georgetown Climate Center's State and Local Adaptation Plan Map
ICLEI	Is the community a member of ICLEI-Local Governments for Sustainability, USA? 0 for no; 1 for yes	ICLEI USA's membership department
USDN	Is the community a member of the Urban Sustainability Directors Network (USDN)? 0 for no; 1 for yes	USDN Website
<b>INTERNAL PROCESS MODEL</b>		
Plan author	Organization responsible for writing the plan. Dummy variable for external, internal taskforce, environmental department, and planning department	Each adaptation plan; emails to local government if author was uncertain
Source of funding	Source of outside funding to create the plan. Dummy variable for federal, state, or non-governmental organization funding	Each adaptation plan

\* Less confidence is placed in data collected directly from plans, since information may be omitted from the plan. When we were uncertain about data collected from plans, we reached out to the community for clarification. We also have less confidence in demographic data for tribal communities, since this information is estimated through different procedures. Finally, it is important to note that demographic and financial data is provided for the most recent year available and does not necessarily correspond to when the plan was written.

**Table B:** Criteria included in the seven plan quality principles, descriptions of the criteria, the percentage of plans that included each criterion, and the inter-coder reliability score and Krippendorff’s alpha (in parentheses) for each criterion

	Criterion	Description	% Plans	Reliability % agreement (Krippendorff alpha)
<b>A</b>	<b>ARTICULATION OF PURPOSE, GOALS, AND OBJECTIVES</b>			
A1	Plan purpose	States the purpose of the plan.	80%	70% (0.313)
A2	Vision statement	Includes a vision statement, which establishes an overall image of a desired future (Berke et al. 2006).	23%	84% (0.567)
A3	Define resilience, adaptation, or preparedness	Defines resilience, adaptation or preparedness.	68%	86% (0.709)
A4	Goals	Includes goals, which are outcomes that the community aspires towards. Goals are usually expressed in adjectives and nouns (not verbs) and are not quantified (Berke et al. 2006). Goals reflect public values and express future desired conditions (Berke and Godschalk 2009).	50%	79% (0.595)
A5	Objectives	Includes objectives, which are tangible, measurable outcomes leading to the achievement of a goal (Berke et al. 2006).	16%	72% (0.171)
A6	Objectives detailed	Includes quantifiable objectives for each goal (e.g., reduce heat-related mortality by 1,000 by 2020; must have objectives for each goal).	0%	97% (0)
<b>B</b>	<b>PUBLIC PARTICIPATION</b>			
B1	Planning process	Describes the process undertaken to create the plan.	61%	84% (0.681)
B2	Plan preparation involvement	Describes the stakeholders involved in plan preparation.	66%	79% (0.569)
B3	Plan preparation involvement detailed	Includes detailed description of organizations and individuals involved in plan preparation. Description must include number of stakeholders and the general categories of stakeholders (e.g. residents, companies, non-profits, governmental agencies).	43%	65% (.261)
B4	Representative stakeholders	Mentions how stakeholders who were involved represent all the groups affected by proposed policies or how the planning process sought to engage disadvantaged populations. Disadvantaged populations are those that may not traditionally be included in the planning process and may be adversely affected by climate change, such as the poor, elderly, or those for whom English is a second language.	11%	93% (0.629)
B5	Participation techniques	Mentions participation techniques used to create the plan, such as meetings, surveys, charettes, public comments on drafts, etc.	61%	79% (0.594)
B6	Participation techniques detailed	Describes participation techniques with details about each method including number of participants, main topics covered, and activities used to elicit input.	27%	70% (0.196)
B7	Public meetings	States that meetings were used to engage stakeholders and that these meetings were open to the public.	50%	86% (0.725)
B8	Planning or steering committee	States that a steering committee or advisory committee was used to guide plan creation.	59%	72% (0.461)
B9	Public participation maintenance	Discusses how public engagement will continue in plan maintenance/evaluation.	16%	81% (0.448)
<b>C</b>	<b>COORDINATION</b>			



C1	Local university	States that local universities were engaged in the planning process.	57%	82% (0.64)
C2	Federal agencies	States that federal agencies were engaged in the planning process.	41%	84% (0.655)
C3	State agencies	States that state agencies were engaged in the planning process.	34%	84% (0.63)
C4	Nonprofits	States that nonprofits were engaged in the planning process.	39%	84% (0.63)
C5	Businesses	States that businesses were engaged in the planning process.	30%	91% (0.76)
C6	Neighboring jurisdictions	States that neighboring jurisdictions were given the opportunity to participate in the planning process. Neighboring jurisdictions include regional planning organizations and counties as well as other cities, towns, or villages.	30%	82% (0.521)
C7	Internal support	Describes agency support and involvement from within the local government.	68%	75% (0.484)
C8	Detailed internal support	Includes detailed description of agency support and involvement. Must describe responsibilities or demonstrate agency support for the planning process.	18%	79% (0.285)
C9	Elected official engagement	Mentions involvement of elected official(s) in the planning process.	16%	84% (0.444)
<b>D</b>	<b>FACT BASE</b>			
D1	Data collection	Provides information about the type of data collected and analyzed in order to make the plan.	66%	79% (0.59)
D2	National studies	States that national studies were used to inform the plan. Studies may include climate, demographics, economic projections, etc.	66%	73% (0.451)
D3	Regional studies	States that regional studies were used to inform the plan. Studies may include climate, demographics, economic projections, etc.	89%	77% (0.31)
D4	International studies	States that international studies were used to inform the plan. Studies may include climate, demographics, economic projections, etc.	70%	82% (0.568)
D5	Local knowledge	States that local, indigenous, or traditional knowledge was used to inform the plan.	86%	63.6 (0.136)
D6	Existing impacts	Identifies ways that climate change or changing weather conditions are already affecting the community.	61%	66% (0.261)
D7	Existing conditions	Discusses existing social, economic, environmental, or built infrastructure conditions that could lead to enhanced vulnerability in the future.	86%	75% (0.27)
D8	Existing actions	Identifies actions and plans that are in progress or planned that have adaptation value. Actions do not need to be specifically designed to address climate change.	80%	79% (0.443)
D9	Historic changes weather/climate	Discusses how climate or weather trends in the area have changed to date.	82%	77% (0.401)
D10	Primary economic base(s)	Identifies the community's major economic sectors.	45%	79% (0.569)
D11	Primary cultural base(s)	Identifies the community's major cultural assets (e.g., museums, art work, recreation centers).	30%	84% (0.535)
D12	Primary natural system(s)	Identifies the major natural systems that are part of the community.	32%	75% (0.419)
D13	Presidentially declared disaster	Indicates that the community has experienced a presidentially declared disaster.	7%	98% (0.97)
D14	Previous hazardous events	Includes information on previous occurrences of hazardous events.	66%	91% (0.806)
D15	Repetitive loss properties	Discusses areas or specific properties that have been repetitively damaged by hazardous events.	14%	91% (0.618)
D16	Projected changes	Identifies climate change exposure, which is the climate change effects a community expects to feel, e.g., warmer temperature, increased precipitation, rising sea level (CA APG 2012).	100%	91% (-0.036)
D17	Prioritized exposure	Prioritizes climate change effects or hazards.	36%	75% (0.458)

D18	Non-climatic drivers	Mentions other factors that may impact future vulnerability or resilience. Non-climatic factors include a shifting economy, growing or depleting population, or changing land use patterns.	50%	70% (0.413)
D19	Non-climatic drivers detailed	Explicitly discusses projections for non-climatic factors over time and how this could affect vulnerability or resilience. Non-climatic factors include a shifting economy, growing or depleting population, or changing land use patterns.	11%	77% (0.046)
D20	Vulnerability assessment	Clearly indicates that a vulnerability assessment was undertaken as part of the planning process. A vulnerability assessment includes an analysis of exposure, sensitivity, and adaptive capacity.	73%	75% (0.458)
D21	Adaptive capacity	Clearly indicates that an assessment of adaptive capacity was undertaken. Adaptive capacity is the community's current and future ability to address projected impacts (CA APG 2012).	34%	79% (0.503)
D22	Adaptive capacity detailed	Provides a detailed description of adaptive capacity, including a clear description of what factors were considered in assessing adaptive capacity.	14%	86% (0.184)
D23	Risk assessment	Clearly indicates that a risk assessment was undertaken as part of the planning process. A risk assessment includes an assessment of the likelihood and consequence of an event.	30%	93% (0.842)
D24	Water supply	Discusses impacts of changing climate conditions on the community's water supply.	82%	73% (0.232)
D25	Water supply detailed	Provides a detailed description of the vulnerability of water supplies to changing climate conditions. Must include a map of areas at risk or a detailed text description of vulnerable areas that identifies specific locations.	14%	89% (0.468)
D26	Water quality	Discusses impacts of changing climate conditions on the community's water quality.	73%	86% (0.676)
D27	Water quality detailed	Provides a detailed description of the vulnerability of water quality to changing climate conditions. Must include a map of areas at risk of low water quality or a detailed text description of at-risk areas that includes the location of specific vulnerable areas.	5%	98% (0.79)
D28	Natural systems	Discusses impacts of changing climate conditions on natural systems.	95%	93% (0.54)
D29	Natural systems detailed	Provides a detailed description of the vulnerability of natural systems to changing climate conditions. Vulnerable natural systems must be mapped, or a detailed text description including the specific location of vulnerable natural systems must be provided.	36%	68% (0.3)
D30	Vulnerable populations	Identifies populations that will be disproportionately impacted by changing climate conditions. Must identify specific populations, not just mention that some groups will be adversely affected.	68%	82% (0.612)
D31	Vulnerable populations detailed	Provides a detailed description of populations vulnerable to changing climate condition. Vulnerable populations must be mapped, or a detailed description of vulnerable populations and their specific location must be provided.	14%	95% (0.832)
D32	Human/public health	Identifies public health issues that will be impacted by changing climate conditions.	86%	91% (0.698)
D33	Human/public health detailed	Provides a detailed description of public health vulnerabilities to changing climate conditions. Public health issues must be mapped, or a detailed description of where public health impacts are expected to be severe must be provided.	2%	93% (-0.024)
D34	Cultural assets	Identifies cultural assets that will be impacted by changing climate conditions. Includes things such as archeologically significant sites, recreational opportunities, events such as sports tournaments, museums, public art, and other culturally relevant places.	73%	79% (0.525)
D35	Cultural assets detailed	Provides a detailed description of cultural assets that are vulnerable to changing climate conditions. The location of vulnerable cultural assets must be mapped, or a detailed description of the cultural assets and their location must be provided.	30%	86% (0.64)
D36	Built environments / infrastructure	Identifies infrastructure that will be impacted by changing climate conditions.	100%	91% (-0.036)

D37	Built environments / infrastructure detailed	Provides a detailed description of infrastructure vulnerable to changing climate conditions. Vulnerable locations are mapped, or a detailed description of the vulnerable built environments and their location is provided.	61%	86% (0.728)
D38	Public services	Identifies sensitive public services, including emergency services, that will be impacted by climate change.	77%	89% (0.691)
D39	Public services detailed	Provides a detailed description of public services vulnerable to changing climate conditions. Vulnerable public services must be mapped, or a detailed description, including a list of vulnerable services, must be included.	30%	91% (-0.036)
D40	Economic systems	Identifies economic impacts of changing climate conditions. This may be a general discussion of impacts to entire economic sectors such as agriculture, forestry, tourism, OR a more specific discussion of impacts such as reduced patronage during extreme heat, or business closure and damage during extreme events.	91%	93% (0.54)
D41	Economic systems detailed	Provides a detailed description of the economies vulnerable to changing climate conditions. Vulnerable economies must be mapped, or a detailed description, including a list of the vulnerable economic sectors, must be provided.	25%	89% (0.691)
D42	Prioritization of vulnerabilities or risks	Includes the results of a prioritization of identified vulnerabilities.	36%	73% (0.442)
D43	Prioritization of vulnerabilities or risks detailed	Prioritizes risks and clearly describes how risks were ranked.	25%	77% (0.46)
D44	Underlying Causes / Transformation	Mentions the need to address fundamental drivers of human vulnerability or "transformational" adaptation/change. "Fundamental drivers of vulnerability" refers to underlying causes of social vulnerability reinforced by existing institutions and social systems; "transformational" adaptation or change reassesses the way a system operates and may take the form of new rights claims and changes in political systems (PROVIA 2013). Transformational change affects how individuals and society make decisions and allocate resources to cope with climate change; it may alternatively include changes in institutional arrangements, priorities, and norms (Kates et al. 2012)	9%	77% (0.046)
<b>E</b>	<b>UNCERTAINTY</b>			
E1	Acknowledgement of uncertainties	The plan acknowledges uncertainties involved in projection of climate change or estimation of vulnerabilities.	75%	77% (0.46)
E2	Acknowledgement of uncertainty detailed	Describes sources of uncertainty.	32%	77% (0.46)
E3	Multiple scenarios	Mentions that different climate scenarios were considered.	70%	84% (0.63)
E4	Multiple scenarios detailed	Provides a detailed description of scenarios. Description must include how scenarios were developed and how scenarios differ in terms of assumptions and impacts.	43%	82% (0.621)
E5	Adaptive management	Mentions adaptive management. Adaptive management is the process of incorporating new information from monitoring and science into decision-making with an emphasis on learning.	43%	66% (0.308)
E6	Adaptive management detailed	Emphasizes adaptive management and learning throughout the plan and establishes a process for incorporating new information from monitoring and science into decision-making.	18%	84% (0.375)
E7	Multiple time frames	Includes both short-term (next 5 years) and long-term (5+ years) strategies.	23%	84% (0.535)
E8	Flexible strategies	Explicitly recognizes the need for flexible adaptation strategies.	23%	86% (0.64)
E9	Flexible strategies detailed	Includes flexible strategies and explicitly identifies strategies as being flexible.	5%	93% (-0.024)
E10	Robust strategies	Discusses robust strategies as an option to address uncertainty. Robust strategies are those that produce positive outcomes across a range of different scenarios or future conditions.	30%	93% (0.54)

E11	Robust strategies detailed	Includes robust strategies. Robust strategies produce positive outcomes across a range of different scenarios or future conditions. Must identify the strategies as robust.	20%	100% (1.00)
E12	No- or low-regrets strategies	Discusses no- or low-regrets strategies as an option to address uncertainty. No-regrets strategies are those that can be justified under current climate conditions but also make even more sense with climate change (CCS 2011); these may also be called win-win strategies. Low-regret strategies are low-cost strategies with relatively large benefits, although those benefits are realized mainly under projected future climate change. Must explicitly discuss no- or low- regrets strategies.	30%	95% (0.887)
E13	No- or low-regrets strategies detailed	Includes no- or low- regret strategies. No-regrets strategies are those that can be justified under current climate conditions but also make even more sense with climate change (CCS 2011); these may also be called win-win strategies. Low-regret strategies are low-cost strategies with relatively large benefits, although those benefits are realized mainly under projected future climate change. Must explicitly identify strategies as no- or low- regrets.	2%	97% (0)
<b>F</b>	<b>STRATEGY IDENTIFICATION</b>			
F1	Prioritized actions	Prioritizes adaptation strategies.	34%	75%(0.392)
F2	Prioritized strategies detailed	Prioritizes adaptation strategies and describes how strategies were ranked.	20%	89% (0.603)
F3	Specific adaptation strategies	Includes strategies that are linked to specific impacts.	55%	68% (0.337)
F4	Capacity building	Includes capacity-building strategies. Capacity building is developing human resources, institutions, and communities, equipping them with the capability to adapt.	84%	95% (0.809)
F5	Advocacy	Includes advocacy strategies. Advocacy includes encouraging regional and state agencies to have adaptation-appropriate strategies.	25%	82% (0.568)
F6	General strategies	Includes generic adaptation strategies, which are strategies not specific enough to be classified in another category.	91%	77% (0.16)
F7	Information and awareness	Includes information and awareness strategies, which focus on increasing public knowledge.	84%	93% (0.732)
F8	Research and monitoring	Includes research or monitoring strategies, which focus on gathering information and creating reports, maps, or models. Monitoring includes observation or repeated measurements over time.	95%	91% (0.293)
F9	Planning	Includes planning-related strategies, including strategies that incorporate understanding of climate science, impacts, vulnerability and risk into government and institutional planning processes, efforts, or existing initiatives.	91%	91% (0.554)
F10	Practice and behavior	Includes strategies to change practice and behavior. Practice and behavior strategies revise or expand practices and on-the-ground behavior that affect resilience.	95%	89% (0.603)
F11	Policy and legislation	Includes policy and legislative strategies aimed at preparing for climate change.	80%	77% (0.31)
F12	Physical infrastructure	Includes physical infrastructure strategies to prepare for climate change.	82%	86% (0.736)
F13	Building codes and engineering design standards	Includes strategies to improve physical infrastructure's response to changing climate through improved standards or engineering.	70%	68% (0.275)
F14	Green infrastructure	Includes green infrastructure strategies aimed at providing protection from climate hazards.	64%	73% (0.417)
F15	Land use	Includes land use strategies focused on preparing for climate change.	82%	89% (0.64)
F16	Conservation	Includes conservation strategies to preserve biodiversity and protect open space under a changing climate.	66%	82% (0.628)
F17	Financing	Includes financing or insurance strategies to prepare for future climate changes.	55%	79% (0.594)

F18	Technology	Includes technology strategies.	66%	75% (0.499)
F19	Cost	Estimates the cost of implementing specific adaptation actions.	30%	89% (0.736)
F20	Cost detailed	Identifies the cost of implementing each adaptation strategy.	16%	91% (0.698)
F21	Cost of inaction	States that taking action to adapt to climate change costs less than not acting.	43%	82% (0.634)
F22	Cost of inaction detailed	Provides specific dollar figures on the cost of inaction versus adaptation-related action.	30%	77% (0.46)
F23	Co-benefits	Identifies co-benefits associated with taking adaptation action.	50%	66% (0.296)
<b>G</b>	<b>IMPLEMENTATION AND MONITORING</b>			
G1	Timetable for implementation	Provides a timetable for when each action will be implemented.	32%	93% (0.834)
G2	Implementation responsibilities	Assigns responsibility for policies broadly to organizations or agencies.	39%	91% (0.800)
G3	Implementation responsibilities detailed	Assigns responsibility for the implementation of each strategy.	34%	89% (0.724)
G4	Funding (need for)	Describes the <i>need</i> for funding sources to implement the plan.	36%	75% (0.441)
G5	Potential funding sources detailed	Clearly describes potential funding sources and associates them with particular strategies.	23%	86% (0.568)
G6	Reporting requirements	Includes requirements for the regular reporting of implementation progress.	16%	89% (0.486)
G7	Monitoring responsibility	Mentions assignment of responsibility for monitoring.	20%	82% (0.448)
G8	Evaluation method	Establishes a process to evaluate the plan.	7%	95% (0.646)
G9	Evaluation method detailed	Describes when analyses of progress toward objectives will take place and how results will be used.	5%	93% (-0.024)
G10	Evaluation metrics	Mentions how to measure progress towards implementing strategies.	16%	98% (0.921)
G11	Evaluation metrics detailed	Mentions how to measure progress towards implementing each strategy identified in the plan.	14%	98% (0.897)
G12	Mainstreaming	Discusses mainstreaming climate change adaptation. Mainstreaming refers to the integration of climate adaptation into other sector policies or plans (Rauken et al. 2014).	84%	73% (0.232)
G13	Mainstreaming detailed	Identifies specific plans and programs as opportunities for mainstreaming. Mainstreaming refers to the integration of climate adaptation into other sector policies or plans (Rauken et al. 2014).	61%	61% (0.232)
G14	Plan updates	Mentions need for updates.	27%	81% (0.568)
G15	Plan updates detailed	Includes timetable for updating plan.	16%	93% (0.784)
G16	Barriers	Mentions barriers to climate adaptation.	23%	84% (0.593)