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Identifying and overcoming barriers in urban adaptation efforts to climate change: Case study findings from the San Francisco Bay Area, California, USA

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Abstract

The persistent gap, termed the "adaptation deficit," between the assumed ability of communities to adapt to climate change and the on-the-ground evidence of their progress to adapt is well-documented. To at least partially explain this adaptation deficit, a growing number of researchers have focused on the existence and nature of barriers to adaptation and about society's ability to overcome them. This paper presents a study that systematically identifies barriers to adaptation processes in the San Francisco Bay Area, California, USA. A three–step, theory-driven framework, previously developed by the authors from a meta-analysis of the existing literature, is used here to identify, organize, and diagnose barriers in four cities and one largely urbanized region. Taken together, the most frequent type of barrier encountered in these cases is related to institutional and governance issues followed by the attitudes, values and motivations of the actors involved. Resource and funding constraints also matter, but scientific and technical issues are far less prominent than often presumed.' The theoretical framework was found to usefully support the identification and organization of barriers and to provide a "road map" for designing strategies to circumvent, remove, or lower the barriers and thus come closer to closing the adaptation deficit.

Keywords

Climate change; adaptation; governance; barriers; institutions; San Francisco

Highlights

- Institutional and governance barriers were the most frequently appearing type of constraint on climate adaptation found in this study

- The three-step, theory driven framework was useful for identifying, organizing and diagnosing barriers to adaptation in an urban context
- Many of the strategies in early climate adaptation efforts are efforts to overcome or reduce barriers, setting the stage for future endeavors

1. INTRODUCTION

Adaptation to climate change has risen sharply on the scientific and policy agendas in recent years [[1-3]. A growing number of researchers has attempted to explain a widely observed "adaptation deficit" [4], i.e., a gap between what might be considered a well-adapted society to the existing climate and the actual and inadequate adaptation achievements of that society. This deficit is not only common in poorer nations and communities of the developing world, but also evident in developed nations like the US as inadequate preparedness for disasters, continued development in high-hazard areas, and growing losses from weather-related extreme events indicate [5]. To at least partially explain this adaptation deficit, some researchers have focused on the existence and nature of barriers to adaptation and about society's ability to overcome them (e.g., [4, 6-16]).

Much of the existing literature on adaptation barriers has been empirically driven, conducted sporadically on individual projects or locations, and unsystematic in its approach. This has fostered both greater understanding of the impacts and importance of barriers, and greater awareness of the fact that much adaptation is hampered by barriers, even in well-resourced entities with well-functioning institutions. A meta-analysis of the existing body of research has led to a theory-driven framework for systematically diagnosing adaptation barriers [17, 18]. Subsequently and independently, a Dutch research group reviewed some of the same and additional literature and produced almost identical results [19]. This suggests that the diagnostic framework is robust and well supported by existing theory and scientific literature. The present study empirically tests the framework's robustness and practical usefulness in the context of a regional focus of California's Third Climate Impacts Assessment [20]. The study uses the framework to reveal the full range of barriers to adaptation for this region and how actors are overcoming them.

Below, we briefly summarize the theoretical framing (Section 2), the research methods and geographic setting of the case study (Section 3). Section 4 provides an overview of adaptation progress made to date in each of the cases, while Section 5 focuses on the main study findings regarding adaptation barriers (the nature of the barriers, aids and advantages that help avoid barriers, and strategies to overcome the barriers). Section 6 discusses implications of the findings and Section 7 concludes with thoughts on how our insights can be used and recommendations on future work.

2. THEORY: THE DIAGNOSTIC FRAMEWORK

To improve our understanding of barriers to adaptation in a real-world context, our study compared multiple cases in the San Francisco Bay Area of California, USA. To guide the study, we used a framework to identify and organize barriers to adaptation, developed on the basis of an extensive literature review on barriers to adaptation [17, 21]. This diagnostic framework first organizes barriers by relevant stages in the adaptation process (Figure 1). This simple heuristic constitutes the dynamic dimension of the framework. In a second step the framework helps identify the cause of each barrier in a given social-ecological system (Figure 2), its structural component. The three fundamental sources of the

barriers are (1) the actors involved in the adaptation process (which typically changes over time), (2) the larger context in which they act (for example, the governance system and socio-economic conditions), and (3) the object upon which they act (here called the system of concern, which is the system that is exposed to climate change impacts and needs to be managed).

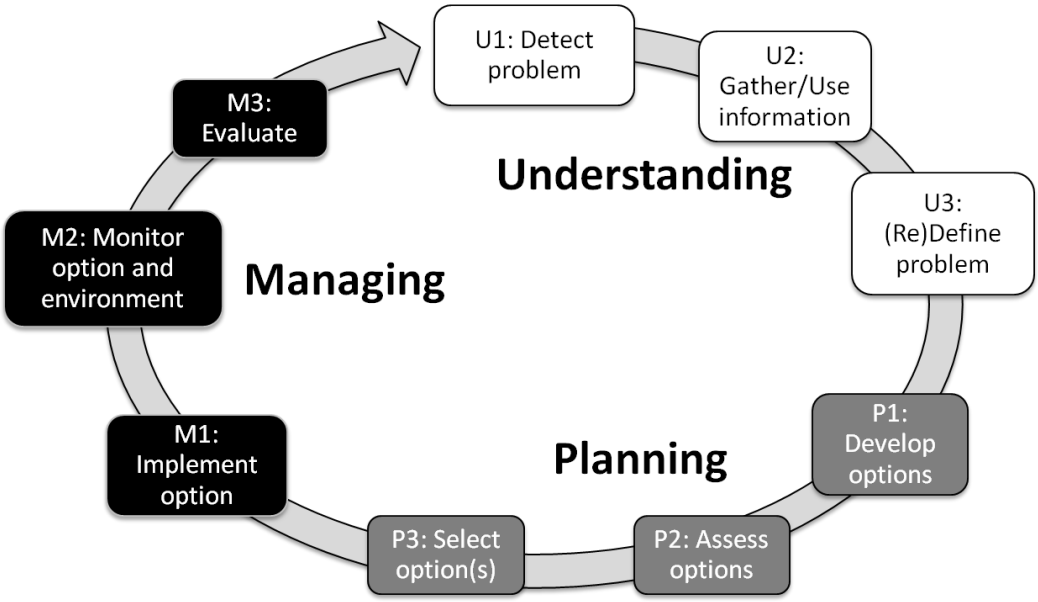

Figure 1. The diagnostic framework's dynamic component: Ideal-type stages of the adaptation decision-making process (Source: adapted from [17])

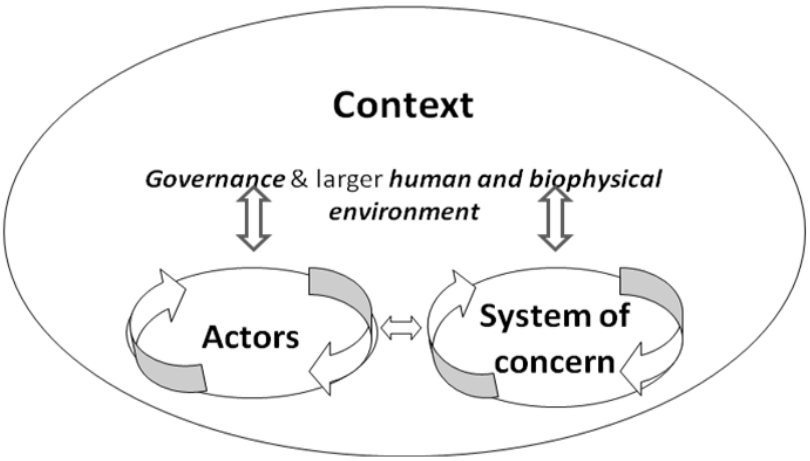

Figure 2: The diagnostic framework's structural component: Fundamental Sources for the Existence of Barriers

Source: [21] p.16)

The first two components (process and structure) of the framework help answer two fundamental questions, namely: (1) What could or does thwart the process from moving forward? And (2) how do the actor(s), context, and the system of concern contribute to the barrier?

The third component of the diagnostic framework is a simple matrix that helps map the source of the barrier relative to the actor's influence over it for a given point in time and thus can be a first step in identifying interventions to overcome identified barriers (Figure 3). The two axes of this matrix locate the sources of these barriers—and thus the locus of control over them—along a temporal and a spatial/ jurisdictional axis.

		Temporal	
		Contemporary	Legacy
Spatial/Jurisdictional	Proximate	**A**	**C**
	Remote	**B**	**D**

Figure 3: Locus of Control over Adaptation Barriers along Temporal and Spatial/ Jurisdictional Scales

Source: Adapted from [21], (p.54)

Together, the nature of the barrier, its source, and the location of influence over the barrier provide a "road map" to design strategies to circumvent, remove, or lower the barriers. Leadership, strategic thinking, resourcefulness, creativity, collaboration and effective communication emerged from the literature as key resources for overcoming them.

The study has three basic goals:

(1) Systematically identify the adaptation barriers encountered by local communities (local government entities, i.e., municipalities and counties) in San Francisco Bay.
(2) Empirically test the robustness and practical usefulness of the diagnostic framework so as to modify or refine its components.
(3) Draw larger lessons about the adaptation process and the importance of adaptation barriers—even in highly developed nations—for the scientific community in terms of future research priorities and for policy-makers.

3. METHODS

3.1 **Setting, Context and Case Study Selection**

Our study focused on the San Francisco Bay Area, located on the north central coast of California, USA. With over 7.1 million residents in 101 cities and 9 counties, it is the fifth most populous metropolitan area in the United States and a tourist attraction for millions of visitors annually (Figure 4). Projections of climate change in the region include increasing temperatures, earlier spring, warmer winters, uncertain changes in precipitation, and rising sea level (for a review of potential impacts, see [22]). Sea-level rise and its associated flood and inundation risks has received the greatest attention in the region to date.

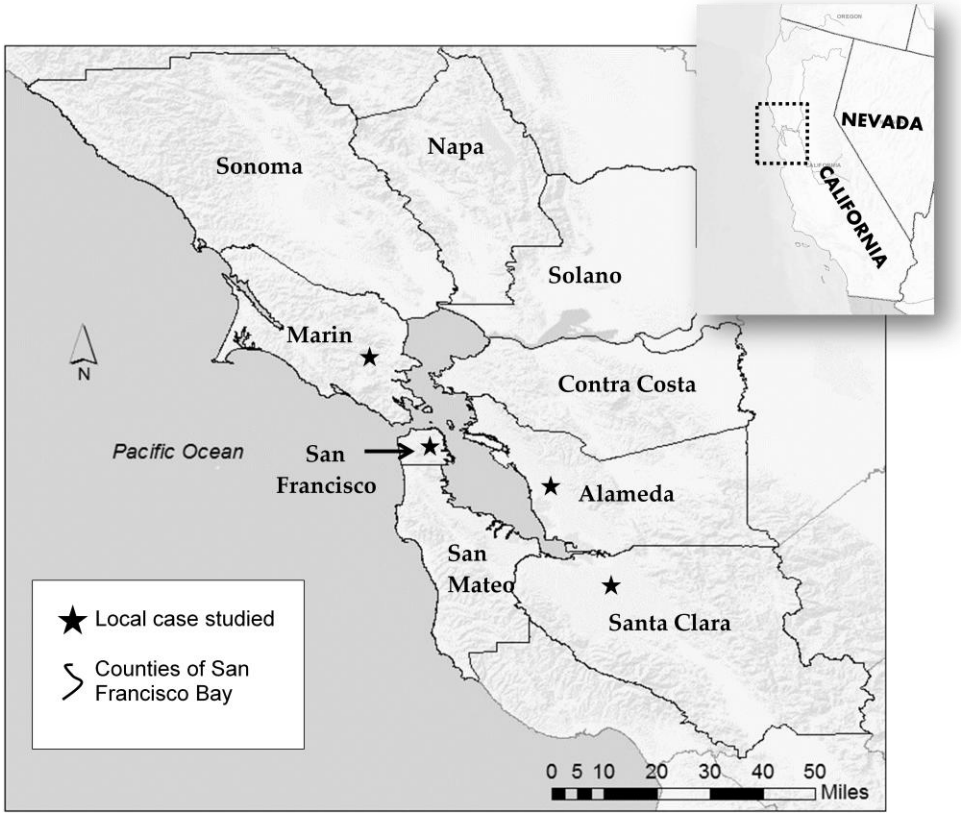

Figure 4: Map of San Francisco Bay Showing the Location of Case Studies

A total of five cases were selected for this study based on two variables – exposure to the physical risk of sea-level rise, and differences in social vulnerability – and three additional criteria - an adaptation process had been initiated within the governance entity, both local (cities and counties) and a regional governance entity was included, and the entity was willing to participate in study (for further details on the pre-selection work, see [18]). The following five cases were selected:

- City of Hayward (particularly the activities of its Hayward Area Shoreline Planning Agency, HASPA)
- City and County of San Francisco
- County of Marin
- County of Santa Clara
- Regional adaptation process through the Bay Conservation and Development Commission and Joint Policy Committee

3.2 Methods

We collected a variety of data using a mixed-methods approach. We interviewed 43 key informants, observed public meetings related to climate change adaptation, and analyzed relevant documents (e.g., climate action plans, general plans, climate-related risk assessments) between October 2010 and May 2011. From these sources we sought information on where the local governments were in the adaptation process, what they were doing, how they defined climate adaptation, and what barriers they encountered. The interview protocol is available from Moser and Ekstrom [18]. For the data analysis we each independently identified barriers, aids and advantages to avoid barriers, and strategies to overcome them (in each case whether they were mentioned by informants or deduced by us), and then developed a classification for each. Our typologies were compared and reconciled where necessary before fully coding the interview transcripts, and tallying codes. The choice for both researchers to identify and classify barriers, aids/advantages, and strategies first independently, and then to reconcile them where necessary, was made to add rigor to the study. The careful discussions of the details of each case significantly deepened the researchers' understanding of each locale's adaptation process, and aided the critical analysis and evaluation of the diagnostic framework.

The resulting "frequency" measure of barriers represents a count of unique, i.e., clearly distinguishable barriers regardless of how often a barrier was mentioned.[1] Thus, frequency should not be interpreted as a direct indication of "importance" and cannot reveal how difficult it is to overcome a particular barrier.[2] Barriers, aids/advantages, and strategies were summarized by case and by stage in the adaptation process.

4. STATUS OF ADAPTATION IN THE CASES TO DATE

Here we introduce each case studied with a very brief synopsis of its adaptation endeavors up to September 2013 (for detailed discussion see [18]).

[1] When coding the interviews, several possible ways of "counting" the barriers emerged: Counting every single mention of a barrier, counting how often the same barrier was mentioned, and counting all unique barriers. The first option would represent an absolute frequency without distinguishing whether the same barrier appeared, say, ten times or ten different barriers were mentioned just once. The second would give an indication of how often a particular barrier was repeated in the course of the conversation (a fact difficult to interpret, and a number difficult to normalize in key informant interviews of varying lengths). And the third would be a count of clearly distinguishable barriers without an indication of how frequently each is mentioned. In the Section 5, the latter of these three options is shown, a choice partly driven by the primary methodology chosen for this study (key informant interviews) and partly by an inability to unambiguously interpret the other frequency measures. The goal here was not to measure personality differences (e.g., an informant's passion, politics, or singular interest) or any possible "barrier de jour" phenomena, but the number of unique barriers that seem to occur in actors' experience.

[2] Take, for example, science-related barriers. Some scientific issues are easy to resolve by making existing information more accessible, whereas others require 10 years of a national research program. Similarly, some institutional barriers may pose daunting challenges while others are more easily resolved. This kind of information cannot be obtained from a frequency measure as reported here. Moreover, the subjective judgments of key informants may not easily map onto objective reality.

San Francisco Bay Area

On a regional level the San Francisco Bay Area has progressed in its awareness and efforts to adapt to climate change by focusing on the increasing risks from sea-level rise. The Bay Conservation and Development Commission (BCDC) is the regional agency with permitting authority over shoreline development. BCDC has a longstanding interest in sea-level rise (since 1988), but has dramatically increased public and political awareness about climate change through several regional initiatives since 2008, including publishing sea-level rise vulnerability maps, establishing a local government adaptation assistance program, and incorporating sea-level rise adaptation requirements into its guiding strategic plan (the Bay Plan) and related permitting process in September 2011. Amending its permitting process, however, was met by strong opposition from developers and many local governments, all fearing further regulation of land use and possible devaluation of their bay front property. Now a larger process through the Bay Area Joint Policy Committee (JPC) is underway to plan for advancing adaptation on a regional level to deal with sea-level rise and other impacts of climate change.

City of Hayward (HASPA)

The Hayward Shoreline is the only case studied here that focuses on a single climate issue – sea-level rise driven flooding of the shoreline. HASPA was established in 1970 to better coordinate shoreline planning activities and includes the City of Hayward and two park districts. It has been the lead on the sea-level rise related work in this case [23].

After years of unsuccessful attempts to raise awareness of sea-level rise related risks by a local politician, HASPA launched its climate adaptation process in 2008 (after experiencing local flooding and levee overtopping during a winter storm in 2006) with an initial assessment of the shoreline's vulnerability to projected sea-level rise. Through this study, the city realized that to adequately address its vulnerabilities, it needed to form partnerships with other jurisdictions both geographically (i.e. other cities to the north) and functionally (e.g. agencies with responsibility over water, flooding, harbor operations, and others). At the time of this study, the process had extended to include stakeholders from a larger geographic area with representatives from additional sectors. Following the study, with the guidance and financial support from BCDC, the collaborating institutions have conducted a more robust vulnerability assessment of sea-level rise impacts on the shoreline in anticipation of a pilot testing of promising adaptation options.

City/County of San Francisco

The City and County of San Francisco has several separate adaptation planning efforts underway at present. Water supply management by the San Francisco Public Utilities Commission (SFPUC) is the city's most advanced agency in its commitment to climate adaptation. It coordinates closely with other water districts around the US (leading the Water Utility Climate Alliance, http://www.wucaonline.org), has expert staff dedicated to climate change, and conducts advanced scientific assessments of how climate change could alter the timing and quantity of snowmelt runoff from the Sierra Nevada which supplies the city's drinking water. During the research period, the Port also conducted a sea-level rise vulnerability assessment for its shoreline property and infrastructure. The Department of Public Health, with federal funding from the Center for Disease Control, has partnered with local university scientists to assess the

city's vulnerability to extreme heat events. Other sectors with notable efforts include: wastewater management and flood protection, ground transportation, planning, and the international airport. City staff share a heightened sense of awareness of the need to develop an integrated adaptation strategy and are involved in ongoing communication across departments about developing one, but at the time of this study had not yet completed one.

Marin County

Several agencies in Marin County are involved in a small number of adaptation-related efforts across a range of departments, each with varying degrees of momentum, and with little coordination across them. The sustainability award-winning 2007 update of Marin's Countywide Plan (a 10-year general planning guidance document) contained strong language on the importance of adaptation, including a range of measures that should be adopted. However, most of these aspirations have not yet been implemented, partly because the plan was written by a single agency without buy-in from other agencies, partly because of insufficient staff, and major contention around shoreline land use. Two important advancements in the county include consideration of sea-level rise in land use and permitting of development along its Pacific coast and in assessing the sensitivity of its water supply to climate change.

Santa Clara County

In the fourth case study, Santa Clara County, efforts so far have focused on creating a coordinated foundation among communities within its jurisdiction, though very little specific adaptation planning or actions are apparent to date. The lead of this coordination is in the Office of Sustainability created by the County Executive Office in 2010. While individual departments of the county government are not yet explicitly engaged in adaptation planning, they exchange information, building fundamental capacity as they wait for regional leadership from the JPC.

One exception, however, is the county's agency in charge of water supply and flood protection, the Santa Clara Valley Water District (SCVWD). It has made dealing with climate change a priority since 2007. The SCVWD tries to incorporate climate change considerations into existing planning and operational efforts. The nature of climate change concerns differs among agency divisions (e.g. water supply, water quality, saltwater intrusion into coastal aquifers and wells, flooding and inundation from sea-level rise and storms). The agency also has assigned one staff to track the latest climate science, tools, and methods and share this information with others in the District.

5. RESULTS AND DISCUSSION

5.1 Overall Patterns of Barriers Encountered Across all Cases

Taking all cases together, the most frequent type of barrier encountered in this study are related to institutional or governance issues (e.g., being stove-piped, legal barriers, limited jurisdiction) (Figure 5). These are followed in overall frequency by barriers related to "attitudes, values and motivations" of the actors involved (e.g., lack of interest, status-quo mindset, inability to accept change, narrow self-interest). Resource and funding issues (e.g., the economic crisis of recent years, inaccessible funding, cuts with

implications for staff) are the third most common type of barrier, followed by a category entitled "politics" (e.g., lack of political will, rivalry, turfism, ulterior motives). Six types of barriers follow that were mentioned less frequently, but are still important, including issues related to leadership (e.g., lack, incompetence), issues specific to the adaptation process (e.g., lack of guidance, lack of feasible options), Lack of understanding of climate change science and impacts, science-related issues (e.g., lack of data, uncertainty, lack of relevance or access), lack of relevant expertise among involved actors, and communication (e.g., lack of or miscommunication, lack of clear message, lack of trusted messengers). Personality issues and technological or structural barriers (e.g., no feasible, affordable, or environmentally acceptable structural solution) feature the least in the cases studied here.

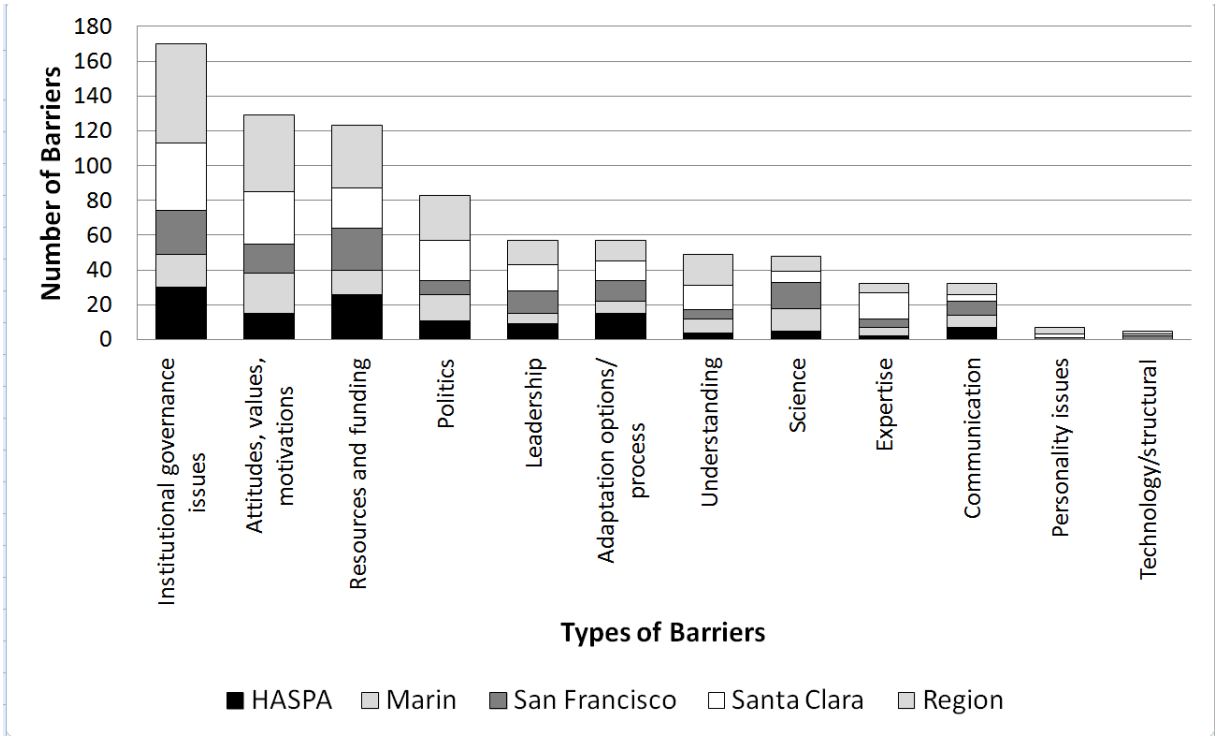

Figure 5: Frequency of Different Types of Barriers Encountered in the Five Cases

These results are notable in a number of ways. For example, the predominance of institutional issues at this early stage of adaptation planning is astonishing, yet may reflect the institutional issues involved in self-organizing for initiating and mobilizing adaptive change, the fact that institutions – by nature – aim to stabilize societal procedures and thus almost inevitably hinder change; and that some anticipated governance issues in yet-to-be-realized periods of the process are included here.

Resource and funding issues are—consistent with the literature—very important. The only surprise may be—against a backdrop of extensive literature reporting economic issues as the most important type of barriers—is that one may have expected them to be #1 rather than #3. However, while the rhetoric may be about lack of financial means, the roots of financial problem are often institutional or behavioral (e.g., [7, 9, 24]). Important to note here is that while this study was undertaken at the tail end of a major recession (with lasting effects), economic constraints are of such importance even in highly developed nations (not

just in developing nations), and even in some of the US' most affluent locations such as Santa Clara, Marin, and San Francisco.

As a barrier, lack, inadequacy or competition in leadership were of moderate importance, which is consistent with the observation that leaders in the five cases actually played critical roles in moving adaptation forward across all cases—a common observation in cases that can be described as pioneers. As the more detailed look at individual cases shows, those instances where leadership issues constituted greater barriers, less progress was indeed observed.

A greater surprise—at least at first glance—is the relative low importance of science as #8 among the barrier overall. Many scientists and practitioners frequently argue that lack of science is an impediment toward making more progress on adaptation. This is contradicted by the findings here. Based on the interview data obtained in this study, this can be explained principally by the early stage in the adaptation process. First, the leaders pushing adaptation onto the policy agenda were generally very well informed about climate change and its potential impacts; to them there was sufficient science to begin the adaptation process. Moreover, few of the actions proposed or taken to date actually required sophisticated scientific information. And finally, the Bay Area is relatively well endowed with scientific capacity and has a comparative wealth of studies that focuses either on California or the region. This was frequently acknowledged as sufficient to get started. Some of the scientific barriers identified included a lack of particular types of information that were anticipated to be needed at a future time. Thus, one may expect that some scientific barriers may be more significant or more detailed at later stages when adaptation strategies become more concretely formalized.

Finally, technological or structural barriers are far more frequently mentioned in the literature than they show up as impediments here. This, too, may be reflective of the early stages of the adaptation processes observed here. There is very little activity yet that falls within the implementation stage of adaptation. Those technological and structural barriers, however, that were mentioned by interviewees—particularly by knowledgeable engineers and others with technical expertise (e.g., challenges in protecting critical infrastructure such as the airports or raising the Embarcadero in San Francisco), suggest these issues will become significant in the future. Given the enormity of the challenge of protecting some of the Bay Area's critical infrastructure and highly developed shoreline (involving not just technological feats, but extraordinary cost, environmental impact assessments, stakeholder engagement processes and permitting issues), and the possibility of significant sea-level rise acceleration, this future may not be as far in the future as some currently think.

5.2 Adaptation Barriers by Phase in the Process

Many of the barriers reported in this study matched up easily with the phases within the adaptation cycle (i.e., understanding, planning, and managing), while others spanned multiple phases and/or stages (distinct times within each of these three phases). To the extent the barriers align with phases and stages in characteristic ways, this phase-specific break down could prove helpful as a way to give actors a "heads up" as they proceed through the adaptation process. Importantly, interviewees sometimes explicitly and sometimes implicitly associated certain barriers with the stages in the stylized decision-making cycle. In classifying barriers by stage, the context of the interview had to be taken into account when interviewees did not make this link explicit.

The prevalence of barriers per stage varied, with some managers facing more barriers in certain stages than in others (Figure 6). Given the particular timeline of activities in each case (i.e., the sequence of distinct periods and what happened in each), barriers were more prevalent in those stages that were passed through repeatedly. Thus, as an overall observation for the five cases examined here, the greatest number of barriers occurred in the first two Understanding stages (Problem Detection-U1, Initial Information Gathering-U2), the first and—to a lesser extent—the second Planning stages (Development of options-P1 and Assessment of options-P2), and the first Managing stage (Implementation of selected option-M1) (see also Figure 1 above to recall the stages of the stylized decision-making cycle). This finding is consistent with the observations made in previous sections that the dominant activities to date in the five cases include understanding the issue (climate risks and vulnerabilities), and exploring and assessing adaptation response options, with still little actual implementation activity on the ground. The relatively large number of barriers in the M1 stage thus reflects primarily *anticipated* barriers. The fact that the latter stages of the Managing phase (Monitoring-M2, Evaluation-M3) are hardly represented to date in this study further substantiates the early nature of the adaptation process. These patterns overall and in each case are discussed in more detail below.

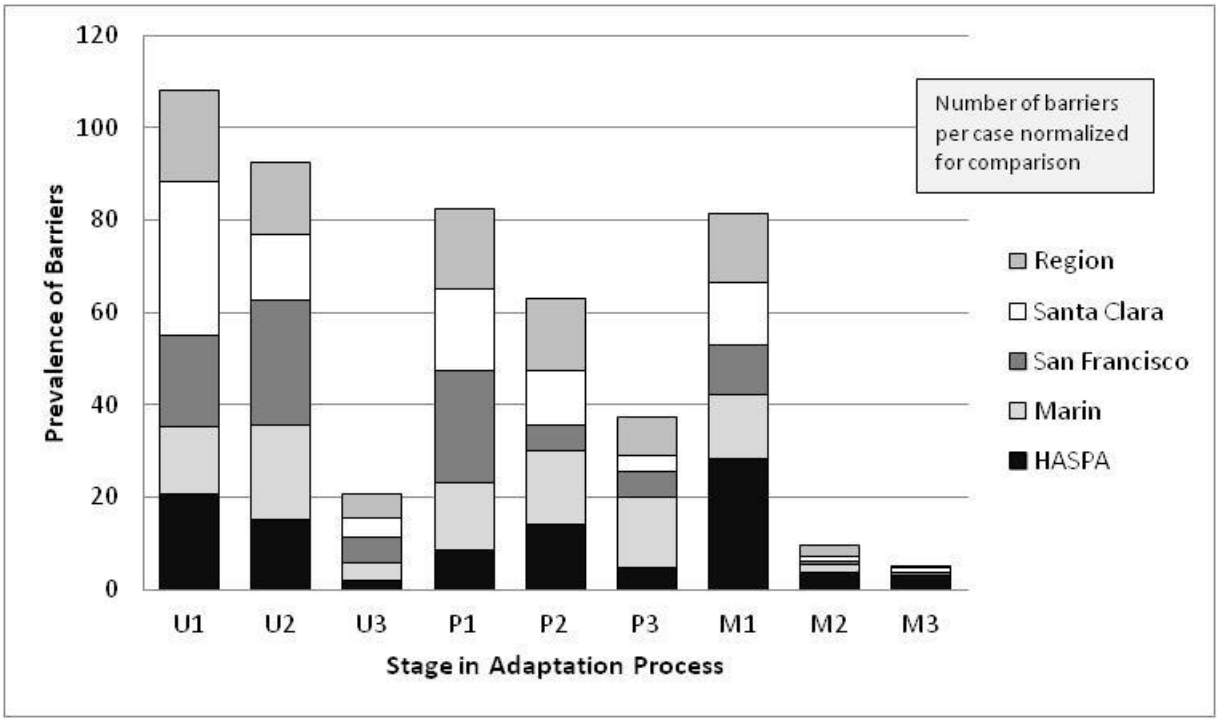

Figure 6: Prevalence of Barriers by Stage in the Adaptation Process As Identified Across All Cases Studied in the San Francisco Bay Area, California

5.2.1 Adaptation Barriers in the Understanding Phase

Given that several of the communities are still or repeatedly in the various sub-periods of the Understanding phase, it is not surprising that most of the barriers are found here. For the specific stages of U1 and U2, there were a few dominant types of barriers that arose across cases.

Problem Detection (U1): In this stage a range of barriers dominate, including

- Insufficient interest in, concern about, or understanding of the problem (urgency of climate change not realized, sea-level rise is viewed as a slow problem with impacts at least a generation away, no clear indication of local changes, etc.);
- Overwhelming other priorities are preventing people from taking notice, learning about, and focusing on climate change (more pressing current problems);
- People are unable to make the connection to this global problem;
- Lack of knowledge on how to start (problem viewed as too big, viewing climate change as a new and different issue);
- Lack of obvious solutions stops people from even starting to explore adaptation options (no good solutions story; problems without solutions don't attract political attention etc.);
- Lack of mandate or guidance from within departments or from other authorities (wait-and-see attitude) to begin dealing with it;
- Leadership has not brought adaptation to the fore, or made it a priority yet (directive to focus on more immediate priorities, assumption that someone else will provide leadership and give marching orders).

Initial Information Gathering (U2): In this stage, science and knowledge barriers and those factors that would support the production and expert use of science clearly (and logically) dominate:

- Lack of relevant, accessible, and understandable science (getting data at higher resolution, different model projections);
- Lack of adequate staff expertise on climate change and vulnerability assessments;
- Lack of funding (for doing initial threat or vulnerability assessments);
- Local or regional agencies do not keep data records that could support vulnerability assessments

(Re)Definition/Reframing of Problem (U3): In this stage little consistency was found because the stage was often difficult to tease out from the other stages within the phase (i.e., a reframing of the problem was not always apparent or explicitly stated). If anything, the reframing that occurred through the work in U2 often helped overcome barriers (e.g., making the issue more salient for key staff or elected leaders). Those barriers that repeatedly occurred in this stage involved:

- Inability to communicate risks to staff, elected officials or the public (e.g., lack of vision, lack of long-term perspective, not connecting to near-term priorities or interests);
- Inability to message the story in an appealing or politically salient way (e.g., avoidance of politically hot topic, fear of push back);
- Lack of critical mass or enough common interest to proceed (lack of coordination among different players);
- Sense of powerlessness (adaptation as defeat; climate change too big of a problem, someone else will find a solution)

5.2.2 Adaptation Barriers in the Planning Phase

The barriers in the Planning phase are predominantly institutional, attitudinal, and financial in nature, though differences among the different stages exist. Some interviewees—particularly those who served as leaders in their particular locations or departments—arrived in this phase having overcome at least an initial set of barriers in the Understanding phase. Others found themselves in a planning process, and

either became aware or were made aware of climate change and the need for adaptation. Thus, the question of whether or not climate change is worth bothering with was less of a barrier than whether or not there was good enough information to proceed, or how best to go about preparing for the expected impacts. Dominant types of barriers in this phase are listed by stage.

Development of Options (P1): To initiate an adaptation planning process, key informants reflected the challenges of really "getting into" adaptation planning. The dominant barriers reoccurring across the cases included:

- Lack of a process for adaptation planning (perceived novelty or lack of familiarity with this type of planning, lack of governance structure through which to initiate or formalize an adaptation planning process, risks involved in being first, lack of familiarity with how to do it);
- Lack of mandate or requirement to do adaptation planning;
- Lack of funding to undertake an adaptation planning process (not in work plan, not in budget, no outside funding);
- Lack of technical expertise or guidance;
- Institutional fragmentation;
- Lack of communication and/or coordination among institutions, agencies (lack of clarity on responsibility, leadership, turf issues, lack of agreement over options and goals of options)
- Lack of vision and/or openness (assumptions about politics, presumptions about public acceptability of solutions, short-term perspective limiting the range of initially considered options, status quo mentality)

Assessment of Options (P2): Assessing adaptation options—to the extent this has occurred to date at any depth at all—is affected by similar constraints as the U2 stage (see above), in that available resources, knowledge and expertise, and data or scientific understanding play a larger role in how deep or extensive such an options assessment is. Repeatedly observed or anticipated obstacles in this stage include:

- Lack of funds for detailed assessments (including legally required Environmental Impact Assessments for larger projects);
- Lack of coordination among departments, agencies, institutions (incl. lack of integrative or systems perspective; institutional fragmentation, stove-piping);
- Lack of knowledge and expertise among staff;
- Lack of data and science;
- Lack of leadership (e.g., no lead agency, guidance, directive or mandate to undertake assessment, short-term perspective that prevents effective integration of climate change);
- Lack of time or staff (competing priorities, capacity constraints);
- Options perceived as unpleasant, negative, politically or publically unacceptable

Selection of Options (P3): Finally, fewer barriers overall were encountered in this stage, in part because few actual decisions have been made to date. Common barriers encountered or anticipated include:

- Limited or lack of options (dislike of feasible options, cost of options, negative side effects of options, narrow range of options, limitation on innovation);
- Politics and the political process (e.g., property rights issues, political ambition of decision-makers, fear of legal repercussions, resistance to collaboration, people's values, narrow interests);
- Public or stakeholder opposition to choices (e.g., campaign against policy change);

- Lack of or limited actual jurisdiction over option;
- Lack of governance structure through which to make and implement decision

5.2.3 Adaptation Barriers in the Managing Phase

The majority of barriers encountered in the Managing phase feature in its first stage—the implementation process (M1). In and of itself, implementation is a complex, multi-tiered process involving a variety of actors and governance entities. Many of the barriers here are anticipated rather than actively encountered already, but some clear patterns emerge.

Implementing Option(s) (M1): There is a clear pattern of barriers in the first Management phase, with dominant barriers falling into the funding and institutional barriers, and several other types of barriers of secondary importance:

- Lack of funding to implement option (competition for funds with other jurisdictions, other priorities, overall budget cuts, economic crisis, lack of revenues, different revenue sources and funding structures);
- Legal barriers (current law preventing implementation of option, lengthy process of obtaining permits, bureaucracy, lack of state or federal mandate);
- Lack or fragmentation of governance structure (lack of regional policy or guidance, lack of decision-making structure that cuts across jurisdictions, resistance to regional approach, lack of coordination across agencies, divisions, jurisdictions, different missions);
- Resistance from affected parties (property rights issues, general resistance to regulation, power issues, greed, reluctance to cede local authority to higher-level authorities' regulation of land use for climate adaptation;
- Lack of political will and commitment (glasshouse syndrome, etc.)

Monitoring Option, Outcomes and Environment (M2): Fewer barriers were mentioned in this stage, largely because there are already very limited (or even declining) resources spent on monitoring of existing conditions and few adaptation options have been implemented for which impacts and effectiveness can be tracked. The barriers that were mentioned appear to be similar to the challenges affecting monitoring at present:

- Lack of leadership (no lead agency to implement, coordinate monitoring);
- Lack of funds (locally, from state or federal government, competition for limited available funds, state budget crisis);
- Lack of attention to certain issues (e.g., lack of saltwater intrusion monitoring)
- Lack of guidance and different requirements (overlapping requirements, data not published, establishing monitoring stations, maintaining them, keeping transmission frequencies open, evaluating the data);
- Scientific uncertainties (not sure what to monitor, sea-level rise projections)

Evaluating (M3): Finally, very little is usually done, and has been done to date specifically in evaluating the effectiveness of an implemented adaptation options. Thus, very little can be said here, other than about informants' predominately anticipated barriers, including:

- Financial concerns (need to show reasonable/positive return on investment);

- Attitudes (people do not want to know about failure, negative impacts, personal or political interest getting hurt);
- Scientific uncertainty (if reality turns out different than projections, risk of misspending of public funds)

5.3 Sources of Barriers: Actors, Governance and Systems of Concern

The next step in the analysis involved deciphering what caused the observed (or anticipated) obstacles. The barriers were mapped on to one or more of the three fundamental structural elements: governance, actor, and system of concern (Figure 2).

To enable comparison across cases, given the uneven number of barriers identified in each case, the sources of barriers were normalized by the total number of barriers per case (i.e., expressed as percent). Results are shown in a series of simple figures—one per case—below.

One overarching finding from this categorization is that the dominant source of observed and anticipated barriers was "governance/context" whereas the "system of concern" was the source of the fewest barriers. This observation holds true for each individual case and overall (an average of 55 percent are governance/context barriers). This finding lends further confidence to the strong overall importance of institutional, resource and process-related barriers noted above (Section 3.1). Structures and context strongly constrain (and enable) individual actors' decisions and activities. The relative unimportance of barriers stemming from the systems of concern (9 percent overall) may reflect a number of situational facts: given the relatively early state of climate change impacts materializing in the mid-latitudes, the systems to be managed are not so different yet from those which managers have dealt with in the past. This means, they understand the systems sufficiently well to manage them at present. Moreover, adaptation is relatively new for most managers, and thus the level of understanding still relatively superficial (see the discussion above corresponding to the limited number of science and information-related barriers (see Figure 5). A clear exception is the case of San Francisco, where greater sophistication about the science has surfaced many more "system" related barriers. Moreover, very few actual adaptive management changes have taken place to date that take uncertain future states of the systems into account. Thus, the many unknowns about the systems to be managed—while the central focus of much research—are simply not yet fully understood by those who are just beginning to think about possible changes and needed shifts in management.

The most variable structural source of adaptation barriers is the "actor" (36 percent overall, ranging from 28 percent to 40 percent in individual cases). Relatively speaking then, the actors in each case make the biggest difference. This observation corresponds with an earlier finding of the surprisingly large importance of actor-related barriers such as attitudes and motivations, leadership, expertise, understanding, communication, and personality issues (Section 3.1).

5.4 Origins of Barriers

The third component of the diagnostic framework aims to locate the origin of the barrier vis-à-vis the actor's current position and influence as an important step in identifying leverage points to overcome them (see Figure 3). The matrix locates this origin—and thus the locus of control over them—along a temporal and a spatial/jurisdictional axis.

Similar to the classification of the sources of barriers, it was not always easily apparent where to locate the origin of a barrier. Both the explicit explanations by interviewees and the implicit context of the interviews were used to arrive at the classification for each case. The key issue was to locate the origin of the barrier relative to the actor, as he or she experienced or saw it. In some instances, the origin was in the past but continues to the present, and thus both categories were marked down (e.g., current funding challenges can stem from decisions made previously, or constitute a continuing challenge such as a multi-year economic recession). Similarly, a barrier occasionally could not be pinned down to a remote or proximate source (e.g., when the interview context left unclear whether funding failed to come from local funds or state and federal sources). In such instances, too, both categories were marked (about 80 percent of all barriers could be categorized uniquely as falling into just one of the four categories, with the remainder spanning more than one). Several overarching findings can be observed, before highlighting specifics about each case.

5.4.1 Overarching Findings on the Origin of Adaptation Barriers

Figure 7 combines the results for all cases. The first pattern that emerges from this summative view is that the majority of barriers (67 percent) are local in origin (i.e., at or near the actor's point of influence), whereas the smaller portion (33 percent) stems from remote origins. This can be viewed (at first glance) as good news in that a barrier originating from local sources can more easily be influenced by local actors than ones that are created remotely. A second overarching pattern is that legacy barriers (i.e., those that stem from decisions made in the past) are more common (57 percent) than contemporary barriers (i.e., those that are created and/or can be influenced at present) (43 percent). This may indicate just how influential and persistent those past decisions were and how difficult they are to change. When viewed in combination with the fact that the overwhelming majority of barriers identified in this study are institutional and attitudinal in nature, this result does not surprise, but in fact is confirmatory. Most institutions were built previously and thus constrain actors now as they attempt to adapt to climate change. Similarly, attitudinal barriers, rooted as they are in longstanding worldviews, beliefs, and values of individuals, tend to affect individuals not just sporadically but quite consistently over time, and many are not easily changeable.

Summary of the Origins of Barriers (all combined)
(in percent)

		temporal	
		contemporary	legacy
spatial/ jurisdictional	proximate	A - 31%	C - 36%
	remote	B - 12%	D - 21%

Figure 7: Summary of the Origins of Barriers (all cases combined)

A finer look at the matrix and the underlying data reveals that the plurality of barriers are proximate/legacy barriers (36 percent) and stem primarily from issues related to the actors, such as attitudes, expertise, staffing levels and capacity, and from the local context and governance system, including political dynamics or decisions, and institutional set-ups and fragmentation. Thus, even though a change could be made locally by relevant actors, both institutional and attitudinal issues can be very difficult to change among local actors alone. It is here where some degree of intervention from non-local actors can be helpful in shifting local politics or personal and interpersonal dynamics; alternatively very strong local leadership may be needed to overcome this type of barrier.

The proximate/contemporary barriers (with 31 percent a close second) are theoretically the barriers that can be affected most easily by actors locally now. A closer look at the underlying data reveals that they relate primarily to the actors (such as level of understanding of climate change or adaptation, and communication issues) and the governance/context (e.g., prioritization of adaptation or not, not knowing how to do adaptation planning or having a clear process for it yet). These barriers appear to be most amenable to being addressed through trainings, information sharing, funding support, and help with locally salient framing of the issues.

By contrast, remote/contemporary barriers (12 percent) relate frequently to the surrounding political climate, current funding allocations, missed opportunities (such as lack of coordination or cooperation), and turn-over in leadership of relevant players. While they can be changed now, they are not directly under the actor's control. Thus, intervention by a higher level of governance through mandates and funding or strong leadership can help. But it is also in this context where political maneuvering by actors (i.e., leaders-in-action, not necessarily from positions of authority) can help foster a political climate or knowledge environment that can lead those in positions of power to take action.

Finally, remote/legacy barriers (21 percent) are those barriers that are most difficult to address in the "here and now,", as the locus of control is elsewhere and the origin of the barrier in the past. The three dominant types of such barriers include institutional ones such as the existing or missing governance structure and laws, economic and funding issues (such as the global economic crisis or state budget cuts), and attitudinal issues (the public's attitude, awareness and understanding of climate change, or longstanding personality conflicts). Intervention in this case is remedial and compensatory by local actors: those who can and those who take it upon themselves "make lemonade" from the lemons they have been given.

5.5 Aids and Advantages

In this study we found that all communities have certain aids, assets and advantages that help them avoid certain barriers or are helpful in overcoming them. Among these useful "resources" are: ongoing or concurrent work on climate change mitigation and/or sustainability, existing science, strong leaders holding values that focus on the common/regional good, and good timing (e.g. for upgrading infrastructure or bringing adaptation into the planning processes as occurred in Marin County). In fact, such existing and relevant policies and planning processes, and the momentum they already had, clearly propelled adaptation forward. Having worked on climate action plans and sustainability issues were frequently noted as having fostered awareness among staff and elected leaders for adaptation.

5.6 Strategies to Overcome Barriers

When faced with a particular set of barriers and equipped with certain aids, assets and advantages, what do actors do to circumvent or overcome their challenges? This question guides this final subsection.

A first and overarching answer to this question—at least at this early stage in the adaptation processes studied here—is that the strategies employed to overcome or avoid adaptation barriers are the adaptation strategies each is pursuing. For example, where there is no governance structure to support regional adaptation, efforts are underway to build one; where there is not enough public awareness of climate change risks or buy-in into an adaptation effort, efforts are underway to compile scientific information and/or to conduct a risk assessment to show what is at stake. Where money to conduct a vulnerability assessment is lacking, fundraising or pooling available resources are possible strategies. Where leadership from individuals in positions of power is challenged or lacking, someone steps up to try to influence or mobilizes pressure on those in positions of power. Alternatively, people undertake all sorts of political maneuvers to make initiation of an adaptation process or passage and implementation of a policy more likely.

Importantly, the use of different strategies—even if categorized here into 16 distinct types—is both context- and barrier-specific and thus fine-tuned to the specific situation, including whether it is needed earlier or later in the adaptation process. This will be demonstrated with some examples for each of the cases below.

Figure 8 summarizes for the study as a whole and for each of the case studies what common strategies are being used by different actors.

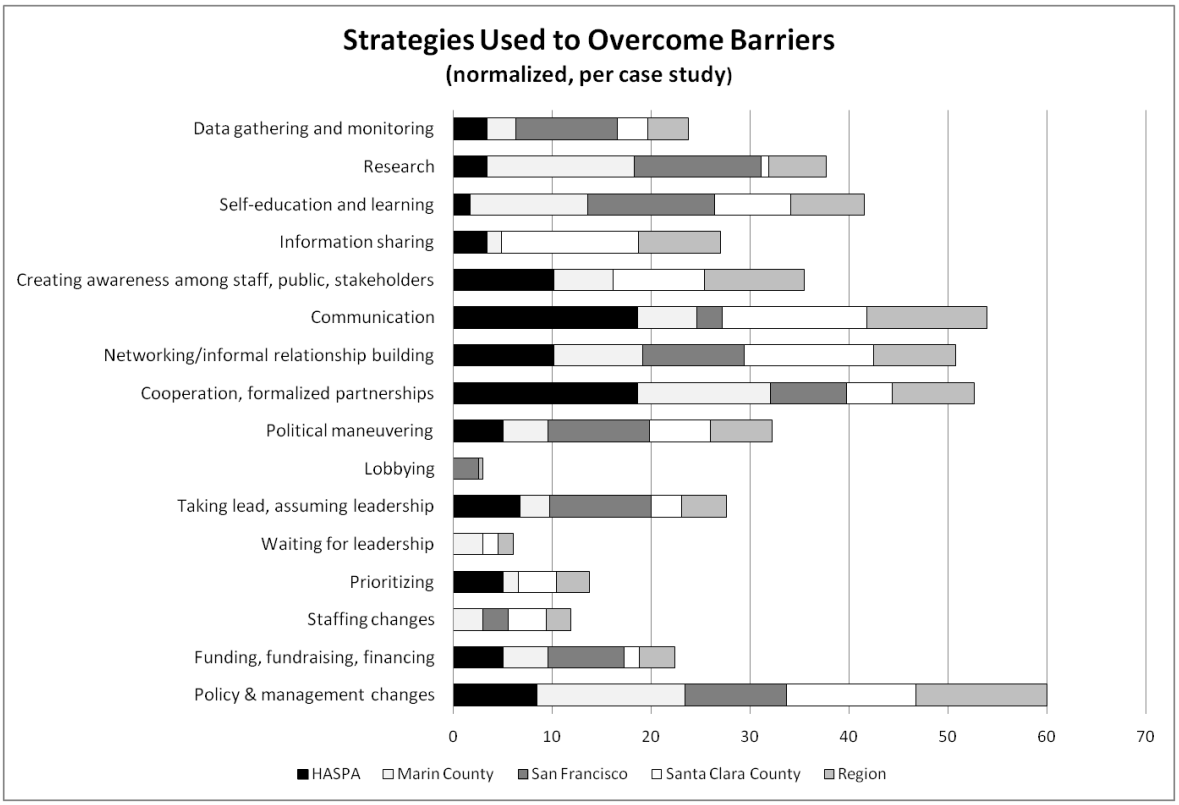

Figure 8: Strategies Used to Overcome Adaptation Barriers

The prevalence of different strategies must be read within the context of the detailed descriptions of the adaptation processes in each case [18]. Differently put, "policy and management changes," for example, may refer to far reaching or minor changes and for specifics, it is necessary to return to the in-depth insights gained in the interviews. Suffice it to say here that the set of dominant strategies is quite different from case to case, consistent with the different institutional complexity, set of actors, and the range of systems for which adaptation planning is underway. The differences are also related to the length of time that the process has been underway and the intended goal that actors have in each instance. For example, a rather different set of challenges are encountered when trying to change the policy of a regulatory agency, than when trying to upgrade infrastructure, undertake a detailed risk assessment, or get past permitting hurdles to pilot an innovative adaptive strategy.

It is remarkable to note that the most common type of strategy involves policy, planning and management changes, including efforts to build new or change existing governance structures. Most often these changes are actually quite minor in and of themselves, but can be considered—and are viewed as such by the actors involved—as foundational, as "getting a foot in the door." Examples include setting an overarching theme for a general plan, asking for more studies in a plan update, building governance coalitions without asking for any political or financial commitments, making small and piecemeal changes in infrastructure or development decisions, or requiring development applicants to assess risks under different sea-level rise scenarios. Most often, these strategies garnered positive public attention, left much room for flexibility and interpretation, and involved relatively small actual changes in decision-making. Most informants, however, viewed them as essential as a basis for bigger changes in the future when elected officials and the public are more receptive to, or see a greater need for, more substantive changes.

The second most frequent type of strategy employed involves conscious and strategic communication. This is sensible in light of the polarized and politicized quality of the public discourse on climate change in the US, and the need for making climate change real and tangible for lay and audiences. Santa Clara, for example, decided to frame its climate protection efforts (mitigation and adaptation) as efforts to build local "resilience." Interviewees there emphasized how starting a conversation with climate change often is more alienating than inviting. And "adaptation"—to them—had a connotation of reactivity and survival, and thus was not a winning frame.

The next most important set of interrelated strategies involves informal networking and relationship building, and forming more formal partnerships and cooperative agreements. It is a notable finding just how much of this informal activity goes on in support of moving adaptation forward. While intuitively not surprising, the prevalence of the informal political process, the forming of coalitions and alliances, and the countless efforts to overcome stove-piping, fragmentation and lack of formal interaction within government, across scales of governance, and among practitioners, scientists and stakeholders speaks volumes as to the importance of actors, the needed alignment of influence and authority, and the dominance of governance and institutional barriers reported on earlier.

Self-education and learning, data gathering and undertaking more research to fill knowledge gaps, raising awareness among others, and sharing information are clear indications of the early stage of adaptation

research and reflect the still-limited climate change and adaptation expertise and knowledge among many practitioners at this time.

A number of formalized and less formalized political actions constitute another set of strategies, including political maneuvering around individuals, interest politics, and limiting rules or cumbersome procedures, active political lobbying at higher levels of governance, choices around taking or waiting for leadership, and setting priorities. The latter occurred in several cases (e.g., SCVWD, SFPUC), while most informants bemoaned that adapatation was not really prioritized yet. Often, they entailed staffing changes—e.g., assigning individuals to take clear responsibility for climate change planning, including adaptation.

Fundraising or shifting, pooling and prioritizing funds is an important supportive strategy. While outside funding served as a motivator to begin adaptation, having the necessary funds for assessing the threats and vulnerabilities, for a comprehensive planning process, much less for implementation and monitoring of a selected option is a necessity. It is reflective of the early stage that this strategy is simply not yet dominant but it can be expected to become a more frequently used one as adaptation rises on the political agenda.

6. IMPLICATIONS FOR CLOSING THE ADAPTATION DEFICIT

The results reported in this study offer an improved understanding of barriers to adaptation to climate change, and thus a more systematic understanding of why there is a persistent adaptation deficit. Scientific evidence of already occurring impacts of climate change and particularly the projections of future impacts support the need for governments and private sector actors to incorporate climate change into their ongoing planning and decision-making. However, clear evidence of adaptation to contemporary climate change is only beginning to emerge [1, 5, 25]. This study aimed to answer the overarching question what is delaying this process, and how, if at all, these hurdles can be overcome so as to improve communities' readiness for climate change impacts. The analysis yielded several important and novel insights.

First, there is significant opportunity to affect and overcome barriers "here and now." The analysis shows that a plurality of barriers is made up of proximate/legacy barriers which stem primarily from the actors involved, such as attitudes, expertise, staffing levels and capacity, and from the local context and governance system, including political dynamics or decisions, local institutional set-ups, institutional fragmentation etc. The second most important category of barriers in terms of their origin is made up of proximate/contemporary barriers. These barriers appear to be most amenable to being addressed through trainings, information sharing, funding support, and help to frame the issue in salient ways. To the extent that these barriers involve setting up institutions for the future, it will be critical for actors to avoid creating future legacy barriers. Those observed barriers that align in characteristic ways with certain phases and stages in the adaptation process, could give actors a "heads up" as to what challenges may lie ahead as they proceed with their adaptation effort.

Second, local communities need outside intervention to address "legacy" and "remote" barriers. Remote/legacy barriers are those that are most difficult to address in the "here and now," as the locus of control is elsewhere and the origin of the barrier in the past. The three dominant types of such barriers include institutional, economic/funding and attitudinal issues and outside intervention may take some time to take effect. Remote/contemporary barriers relate frequently to the political climate, current

funding allocations, missed opportunities with others, and turn-over in leadership of relevant players. While they can be changed now, they are not directly under local control. Thus, intervention by a higher level of governance through mandates, funding, political maneuvering or strong leadership can help.

Third, all communities have assets, aids and advantages that can help them avoid barriers. It is important not to lose sight and make better use of the many assets—human, institutional, economic, and natural—that counterbalance the challenges that hinder or delay progress in adaptation planning. The most important advantage this study found that a community might have to make progress on adaptation is people with certain personal qualities. These qualities include being interested in serving the common good, rather than narrow self-interests, being a networker, a good collaborator and communicator, an innovator or early adopter, having a broad, long-term and/or integrative perspective, being passionate, knowledgeable, experienced, visionary, committed, strategic, progressive, and caring, and bringing a systems and forward-thinking mind to the issue. The second most important aid or advantage is related to having relevant plans and policies in place (e.g., preceding or concurrent state or federal policies, laws, and mandates) that facilitate integration of adaptation and climate change. People and institutions, yet again, make the biggest difference.

Fourth, evidence for adaptation to contemporary climate change to date lies not in "shovel-ready" projects, but in the strategies for overcoming barriers to change. When faced with a particular set of barriers and equipped with certain aids, assets and advantages, leading actors circumvent or overcome their challenges in creative ways. At least at this early stage in the adaptation processes studied here this study revealed that adaptation is not necessarily visible in big new policies or structural changes, but instead in the very strategies employed to overcome or avoid early adaptation barriers.

Finally, the most important strategies employed to overcome adaptation barriers involve small, incremental policy, planning and management changes, including efforts to build new or change existing governance structures so as to create the action space orfoundation for the continued adaptation process. The second most frequent type of strategy relates to conscious and strategic communication which is sensible in light of the polarized and politicized quality of the public discourse on climate change in general, and the need for making climate change real and tangible for the lay audiences. Finally, informal networking and relationship building, and forming more formal partnerships and cooperative agreements are crucial complementary strategies at this time to overcome institutional barriers and to build the necessary political momentum.

7. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

One objective of this study was to test the value of the diagnostic framework for identifying barriers and ways to overcome them. Overall, it served this purpose well, and produced a much richer and more systematic understanding of barriers than previously available. There are, however, several areas for refinement and extension. Maybe most importantly among them would be additions that help identify a) the relative importance of certain barriers, and b) the ease or difficulty with which they can be overcome. In the meantime, and as a step in that direction, it should be possible to increase confidence in the substantive findings established in this study if other researchers applied the tools and analyses used here both in other geographic locations and with different sectoral emphasis.

As communities and other entities advance in the adaptation process, it will be interesting and valuable to examine whether new types of barriers emerge, how the balance of barrier types shifts, how the aids and advantages change over time, and how consistent or not the strategies to overcome barriers are over time, and in different contexts.

In addition to refining and applying the framework further and in other contexts, this study revealed some interesting details about localities' adaptive capacity. Interventions to overcome adaptation barriers may well be indicative of adaptive capacity, and at the same time a way of building greater adaptive capacity. Considerably more work is needed to confidently establish the relative importance of different components of adaptive capacity and to refine the understanding of the role of individuals. Of particular interest here is the role of leadership – what type of leadership is helpful when in the process? When is leadership inadequate or even an obstacle (see [26, 27])? How can the emergence of (the right kind of) leadership be fostered? Together, such advances could help reform the concept of adaptive capacity in important ways.

Finally, critical further work is needed in moving from a diagnostic framework toward a "predictive," one, i.e., from learning what constitutes and creates barriers to helping inform the establishment of processes and institutional structures that avoid creating future legacy barriers. As the climate continues to change, governments and private sector actors will increasingly require governance mechanisms and institutions "built for change." Local and state level governments will serve as the laboratories for experimentation to meet this challenging task.

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