CALIFORNIA ADAPTATION PLANNING GUIDE

PLANNING FOR ADAPTIVE COMMUNITIES

Cal EMA California Emergency Management Agency

California Natural Resources Agency

FEMA

California Adaptation Planning Guide

PREPARED BY:
California Emergency Management Agency
3650 Schriever Avenue
Mather, CA 95655
www.calema.ca.gov

California Natural Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814
resources.ca.gov

WITH FUNDING SUPPORT FROM:
Federal Emergency Management Agency
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

California Energy Commission
1516 Ninth Street, MS-29
Sacramento, CA 95814-5512

WITH TECHNICAL SUPPORT FROM:
California Polytechnic State University
San Luis Obispo, CA 93407

July 2012

Page Intentionally Left Blank

"It's time for courage, it's time for creativity and it's time for boldness to tackle climate change" - Governor Brown, September 2011

September 4, 2012

Dear reader,

We are pleased to present the "Climate Adaptation Planning Guide" prepared by California Emergency Management Agency and the California Natural Resources Agency. The Guide is designed to provide guidance and support for local governments and regional collaboratives to address the unavoidable consequences of climate change.

The State of California is leading the way on climate change adaptation in conjunction with local and regional efforts. Local and regional responses to climate change are identified in state-level planning documents including the California Emergency Management Agency's State Hazard Mitigation Plan, and the California Climate Adaptation Strategy. In addition, we anticipate on-going collaboration and engagement at the regional and local-scale. To that end, the Governor's Office of Planning and Research hosted a one-day conference earlier this year titled "Confronting Climate Change: A Focus on Local Government Impacts, Actions and Resources," and is promoting additional outreach and partnerships.

As climate change impacts your community, it is important for local governments to be prepared to meet this new reality. We hope you find this Planning Guide of value.

Sincerely,

Ken Alex
Senior Policy Advisor to Governor Edmund Brown and
Director of the Office of Planning and Research

John Laird
Secretary for Natural Resources Agency

Mark Ghilarducci
Secretary
California Emergency Management Agency

Page Intentionally Left Blank

Acknowledgements

The *Adaptation Planning Guide* (APG) has benefited from the ideas, assessment, feedback, and support from members of the APG Advisory Committee, local governments, regional entities, members of the public, state and local non-governmental organizations, and participants in the APG pilot program.

California Emergency Management Agency

Mark Ghilarducci	secretary	
Mike Dayton	undersecretary	
Christina Curry	assistant secretary	preparedness
Kathy McKeever	director	office of infrastructure protection
Joanne Brandani	chief	critical infrastructure protection division, hazard mitigation planning division
Ken Worman	chief	hazard mitigation planning division
Julie Norris	senior emergency services coordinator	hazard mitigation planning division
Karen McCready	associate government program analyst	hazard mitigation planning division

California Natural Resource Agency

John Laird	secretary	
Janelle Beland	undersecretary	
Julia Levin	deputy secretary for climate change	
Kurt Malchow	climate adaptation coordinator	

California Polytechnic State University – Project development team

Project Management

Adrienne Greve, Ph.D.	project director, co-principal investigator, associate professor	city and regional planning department
Kenneth C. Topping, FAICP	co-principal investigator, lecturer	city and regional planning department
Cindy Pilg	research support coordinator	city and regional planning department

Project Faculty and Staff

Michael Boswell, Ph.D., AICP	co-principal investigator, professor	city and regional planning department
William Siembieda, Ph.D.	co-principal investigator, professor, director	city and regional planning department planning, design, and construction institute
Christopher Dicus, Ph.D.	associate professor	natural resources management and environmental sciences
Kelly Main, Ph.D.	assistant professor	city and regional planning department
Robb Eric S. Moss, Ph.D., P.E.	associate professor	civil and environmental engineering department
Carol Schuldt	gis resources coordinator(ret.)	robert e. kennedy library

Graduate Research Assistants

Elizabeth Brighton	city and regional planning department
Megan Elovich	city and regional planning department
Michael Germeraad	civil and environmental engineering, city and regional planning department
Brian Provenzale	city and regional planning department
Jean Long	city and regional planning department, civil and environmental engineering
Steve Rogers	city and regional planning department

Consultants

Natalie Macris	planning editor
Monica Fiscalini	copy editor

Adaptation Planning Guide – Advisory Committee

Will Barrett	American Lung Association in California
Amy Vierra	Ocean Protection Council
Marian Ashe	California Environmental Protection Agency
Andrew Altevogt, PhD.	California Environmental Protection Agency
Abe Doherty	California Ocean Protection Council

Table of Contents

List of Figures

List of Tables

Page Intentionally Left Blank

Executive Summary

Planning for Climate Change

Climate change is already affecting California and is projected to continue to do so well into the foreseeable future. Current and projected climate changes include increased temperatures, sea level rise (SLR), a reduced winter snowpack, altered precipitation patterns, and more frequent storm events. These changes have the potential for a wide variety of impacts such as altered agricultural productivity, wildfire risk, water supply, public health, public safety, ecosystem function, and economic continuity.

The California Adaptation Planning Guide

The *California Adaptation Planning Guide* (APG), a set of four complementary documents, provides guidance to support communities in addressing the unavoidable consequences of climate change. The APG, developed by the California Emergency Management Agency and California Natural Resources Agency, introduces the basis for climate change adaptation planning and details a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development. The guide was developed to allow flexibility in the commitment of time, money, and scope.

California Adaptation Planning Guide Documents

START HERE

- *APG: Planning for Adaptive Communities* – Presents the basis for climate change adaptation planning and introduces a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development. All communities should start with this document.
- *APG: Defining Local and Regional Impacts* – This supplemental document provides a more in-depth understanding of how climate change can affect a community. Seven "impact sectors" are included to support communities conducting a climate vulnerability assessment.
- *APG: Understanding Regional Characteristics* – The impact of climate change varies across the state. This supplemental document identifies climate impact regions, including their environmental and socioeconomic characteristics.
- *APG: Identifying Adaptation Strategies* – This supplemental document explores potential adaptation strategies that communities can use to meet adaptation needs. Adaptation strategies are categorized into the same impact sectors used in the *APG: Defining Local and Regional Impacts* document.

Getting Started

Climate change has the potential to affect nearly all aspects of community function. To develop effective adaptation strategies, a team should be established made up of local and regional staff from multiple departments and community stakeholders. Also critical to the

process is community education and outreach. Climate adaptation requires a sustained, iterative process meaning both local and regional staff and community members should be engaged throughout the process.

Climate adaptation strategies can be implemented in a variety of ways from a freestanding adaptation plan to incorporation in existing plans and programs. Adaptation strategies can be incorporated into a variety of local plans including local coastal plans, local hazard mitigation plans, climate action plans, and general plans.

Steps in Climate Adaptation Strategy Development

The process of developing climate change adaptation strategies can vary from a short, initial qualitative process to a much more detailed, lengthy, comprehensive approach. Regardless of where a community falls in this spectrum, the basic steps are the same (Figure 1).

Vulnerability Assessment

1. Exposure: Identify the climate change effects a community will experience.
2. Sensitivity: Identify the key community structures, functions, and populations that are potentially susceptible to each climate change exposure.
3. Potential Impacts: Analyze how the climate change exposure will affect the community structures, functions, and populations (impacts).
4. Adaptive Capacity: Evaluate the community's current ability to address the projected impacts.
5. Risk and Onset: Adjust the impact assessment to account for uncertainty, timing, and adaptive capacity.

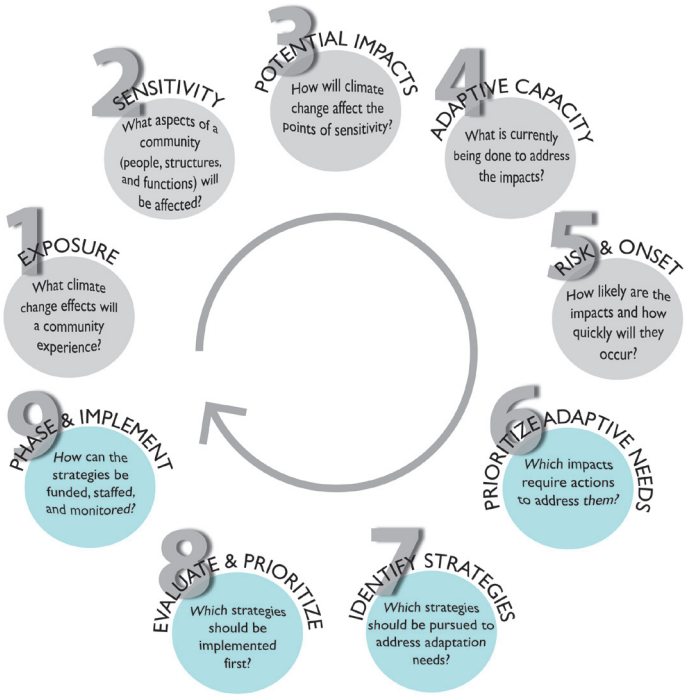


Figure ES-1. The nine steps in adaptation planning development. The gray steps are part of vulnerability assessment (steps 1-5) and the blue steps are adaptation strategy development (steps 6-9).

Adaptation Strategy Development

6. Prioritize Adaptive Needs: Based on the vulnerability assessment, prioritize the adaptive needs.
7. Identify Strategies: Identify strategies to address the highest priority adaptation needs.
8. Evaluate and Prioritize: Prioritize strategies based on the projected onset of the impact, projected cost, co-benefits, and other feasibility factors.
9. Phase and Implement: Develop an implementation plan that includes phasing of strategies and a monitoring system to assess effectiveness.

Introduction

The state of California began addressing climate change more than 20 years ago. Since that time, actions taken by the state have included scientific assessment, greenhouse gas emissions reduction measures, and climate change adaptation.

WHAT is the APG? WHO should use it? HOW should it be used?

The *California Adaptation Planning Guide* (APG), a set of four complementary documents, continues this effort by providing guidance to support communities in addressing the unavoidable consequences of climate change (see Box 1). This *APG: Planning for Adaptive Communities* document introduces the basis for climate change adaptation planning and details a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.

The APG is a step-by-step process with a series of support documents that was designed to be flexible. This flexibility allows communities to use it in a way that best serves their needs. It can be used to conduct a preliminary, broad look at adaptation issues or it can be used to conduct a detailed, formal planning process; the logic is the same.

The ***California Adaptation Planning Guide: Planning for Adaptive Communities*** is supported by three supplemental documents that communities can use in adaptation planning (see Figure 1):

- *APG: Defining Local & Regional Impacts:* This supplemental document provides a more in-depth understanding of how climate change can affect a community. Seven "impact sectors" are included to support local communities conducting a climate vulnerability assessment.

- *APG: Understanding Regional Characteristics:* The impact of climate change varies across the state. This supplemental document identifies the distinct climate impact regions, including their environmental and socioeconomic characteristics.

- *APG: Identifying Adaptation Strategies:* This supplemental document explores potential adaptation strategies that communities can use to meet adaptation needs. Adaptation strategies were categorized into the same impact sectors used in the *APG: Defining Local and Regional Impacts* document. *APG: Identifying Adaptation Strategies* includes examples from jurisdictions already pursuing adaptation strategies and offers considerations for tailoring strategies to meet local needs.

This introductory section addresses basic questions about adaptation planning and ways to get started in the strategy development process. Following this introductory section, the steps in vulnerability assessment and strategy development are presented.

Box 1

WHAT IS THE APG, WHO SHOULD USE IT, AND HOW SHOULD IT BE USED?

This document, *APG: Planning for Adaptive Communities*, presents a step-by-step process that communities can use to plan ways to adapt to climate change. The APG also includes a series of supplemental documents that provide local and regional information and planning tools.

The APG is designed to be flexible. This flexibility allows communities to use it in a way that best serves their needs. The APG can be used to conduct a preliminary, broad look at adaptation issues or to conduct a detailed, formal planning process.

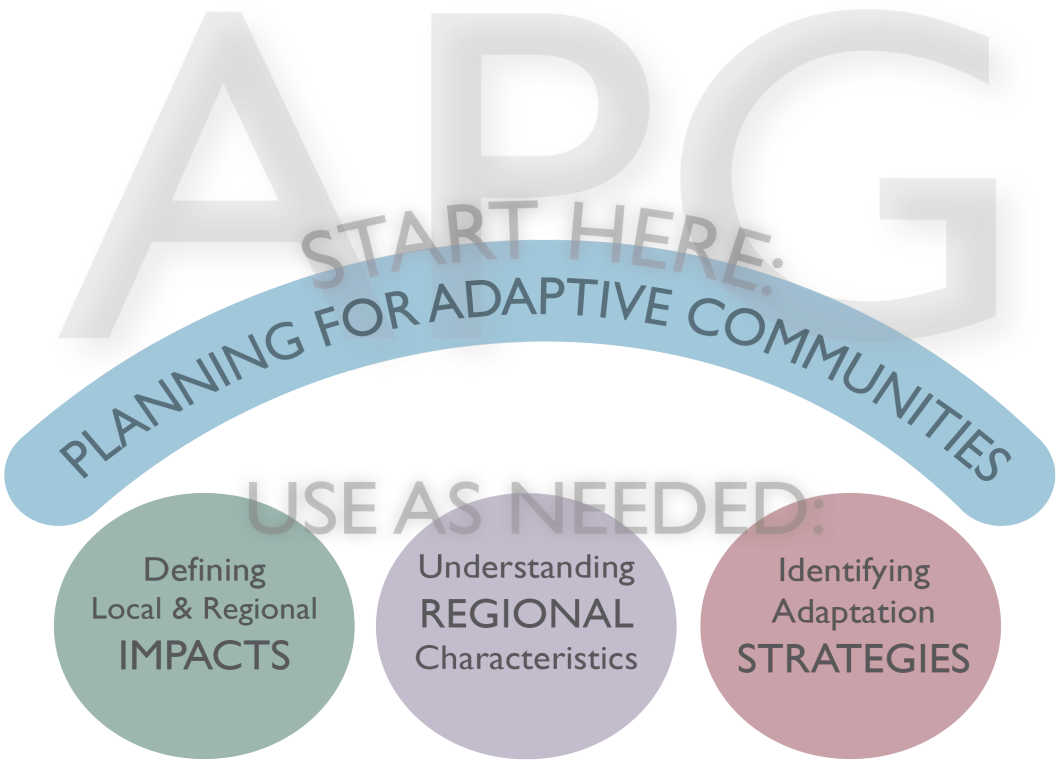


Figure 1. The four California Adaptation Planning Guide (APG) documents.
All APG users should start with the *Planning for Adaptive Communities* document. The other three documents support the process presented in the first document by providing additional information and greater detail.

How will California be affected by climate change?

Climate change is already affecting California and is projected to continue to do so well into the foreseeable future (CNRA, 2009; Moser et al., 2009). Current and projected climate changes include increased temperatures, sea level rise (SLR), a reduced winter snowpack, altered precipitation patterns, and more frequent storm events (see Box 2).

Over the long term, reducing greenhouse gases (GHG) can help make these changes less severe, but the changes cannot be avoided entirely. Unavoidable climate impacts can result in a variety of secondary consequences including detrimental impacts on human health and safety, economic continuity, ecosystem integrity, and provision of basic services (CNRA, 2009; CIG, 2007). These potential consequences can pose enough of a threat that they demand attention even if the outcomes are not certain.

Box 2

Climate Change Impacts of Concern to Communities

The 2009 California Climate Adaptation Strategy identified the following climate change impacts of concern:

- Climate change is expected to lead to increases in the frequency, intensity, and duration of extreme heat events and heat waves in California, which are likely to increase the risk of mortality and morbidity due to heat-related illness and exacerbation of existing chronic health conditions. Those most at risk and vulnerable to climate-related illness are the elderly, individuals with chronic conditions such as heart and lung disease, diabetes, and mental illnesses, infants, the socially or economically disadvantaged, and those who work outdoors. (p. 39)

- Higher temperatures will melt the Sierra snowpack earlier and drive the snowline higher, resulting in less snowpack to supply water to California users. (p. 84)

- Intense rainfall events, periodically ones with larger than historical runoff, will continue to affect California with more frequent and/or more extensive flooding. (p. 84)

- Droughts are likely to become more frequent and persistent in the 21st century. (p. 84)

- Storms and snowmelt may coincide and produce higher winter runoff from the landward side, while accelerating sea-level rise will produce higher storm surges during coastal storms. Together, these changes will increase the probability of levee failures in the Sacramento-San Joaquin Delta. (p. 85)

Box 2 (cont'd.)

- Warmer weather, reduced snowpack, and earlier snowmelt can be expected to increase wildfire through fuel hazards and ignition risks. These changes can also increase plant moisture stress and insect populations, both of which affect forest health and reduce forest resilience to wildfires. An increase in wildfire intensity and extent will increase public safety risks, property damage, fire suppression and emergency response costs to government, watershed and water quality impacts, vegetation conversions and habitat fragmentation. (p. 112)

- Sea-level rise will increase erosion of beaches, cliffs, and bluffs, threatening public and private property and structures and causing social, economic, and resource losses to coastal recreation and tourism through reduction in, or damage to, beaches, access ways, parks, trails, and scenic vistas. (p. 71)

- The economic cost associated with the required alteration, fortification, or relocation of existing infrastructure [due to sea level rise] is likely to be in the tens of billions of dollars. (p. 129)

Why do climate adaptation planning?

There are four primary reasons to pursue climate adaptation planning:

1. As stated in the 2009 California Climate Adaptation Strategy (CAS) (CNRA, 2009), the State of California recommends that "communities with General Plans and Local Coastal Plans should begin, when possible, to amend their plans to assess climate change impacts, identify areas most vulnerable to these impacts, and develop reasonable and rational risk reduction strategies using the CAS as guidance."
2. Many of the impacts of climate change will be localized and will vary based on a community's physical, social, and economic characteristics. Communities are best positioned to assess and address the implications of climate change at the local level.
3. Communities that begin planning now will have the best options for adapting to climate change. Although the impacts of climate change are already being felt in many communities, they are relatively small at this time. The onset of more significant impacts is likely many years away, but this is not a justification for inaction. Instead it calls for effective planning now while good options still exist. The longer communities wait, the greater the costs of the impacts and the costs to react to those impacts.
4. Many of the actions needed to reduce the impacts of climate change will provide additional benefits to the community, including increased public safety, reduced greenhouse gas emissions, and greater economic stability.

How can communities take action on climate adaptation?

One of the largest challenges to climate adaptation strategy development is the diversity in the potential impacts, which include effects on public health, economic vitality, ecosystem health, water supply, and natural hazards. Fortunately, many existing local and regional plans already address some of these impacts, meaning that communities are likely to have a good idea of the types of strategies likely to be most effective. In some cases, developing adaptation policy can simply involve bolstering existing policies through the periodic plan update process.

The ways to integrate climate adaptation strategies into policy documents can vary based on local adaptation needs and context (see Box 3). Adaptation policies can be integrated into local policy and programs in a variety of ways, from development of a stand-alone climate adaptation plan to integration of adaptation strategies into any number of local planning documents. The ultimate goal should be for climate adaptation to be included as one consideration in all local and regional policy-making processes.

Box 3

How should communities take action?

Communities have a range of possibilities available for taking action on climate change adaptation. Some common ways include:

1. Administrative policy, procedures, and initiatives: Strategies that do not require governing board action can be implemented by a coordinated approach within an agency.

2. General Plan: The community general plan, especially the safety element, is an appropriate document for codifying goals, objectives, and polices related to climate change adaptation. Other relevant policy areas within the general plan usually include land use, transportation, conservation, recreation and open space, public safety, and noise.

3. Local Hazard Mitigation Plan (LHMP): If the community has adopted an LHMP pursuant to the federal Disaster Mitigation Act of 2000, this would be an appropriate document for codifying adaptation strategies related to the mitigation of natural or human-caused hazards such as wildfire, flooding, coastal storms and erosion, drought, and heat emergencies.

4. Climate Action Plan (CAP): If the community has a CAP or other similar plan, this can be an appropriate document for codifying adaptation strategies.

5. Zoning Code and other land development codes, ordinances, and resolutions: Adaptation strategies that affect zoning and land use can be acted on through adjustments in the regulations and procedures governing these areas.

Box 3 (cont'd.)

6. Local Coastal Program (LCP): Local governments in the coastal zone must prepare a guide to development in the coastal zone that is consistent with the Coastal Act and certified by the Coastal Commission. LCPs contain the ground rules for future development and protection of coastal resources. Climate change issues, particularly sea-level rise and associated effects, should be addressed in the LCP.

7. Capital Improvement Plan/Program (CIP): For adaptation strategies that require capital expenditures (e.g., relocating a wastewater treatment plant, building a cooling center, etc.), The community CIP is an appropriate place to address priorities, funding, and scheduling of implementing adaptation strategies.

8. Climate Change Adaptation Plan: A community can choose to create a stand-alone adaptation plan to contain all of the background data and analysis as well as the adaptation strategies. With a stand-alone plan, all other plans and programs would slowly be adjusted to be consistent through periodic updates as they would normally occur.

9. Integrated Regional Water Management (IRWM) groups (48 in the state) are collaborative efforts to address regional water resources (http://www.water.ca.gov/irwm/). The regional approach supports local jurisdictions by providing coordination and information. The associated grant funding for the IRWM program supports adaptation strategy development and implementation.

What is the difference between greenhouse gas mitigation and climate adaptation?

Local planning documents can address climate change by establishing goals for greenhouse gas (GHG) emissions reduction (also called mitigation) and adaptation (Figure 2). These two goals should be pursued in parallel and, when possible, include strategies that serve both needs. While the two goals are complementary in most ways, there is potential for conflict (Moser, 2012). For example, a cooling center that provides relief for community members during extreme heat events may rely on air conditioning. Depending on the source of electricity, using air conditioning can increase GHG emissions. In addition, even when both goals are being met by a single strategy, the reasoning that led to the strategy can be different. For example, a tree-planting program will aid in sequestering carbon, a GHG reduction benefit, and help alleviate the effect of heat, which achieves both goals.

The challenge for local jurisdictions is to evaluate each strategy relative to local need. In a dense urban area where extreme heat also carries risks of decreased air quality and increased heat-related health consequences, a tree-planting

program alone may not be enough to address the threat posed by climate change on its own. For each strategy considered to address a climate adaptation need, GHG reduction should be viewed as a desirable co-benefit. Combining the two can lead to government efficiency, cost savings, and funding opportunities.

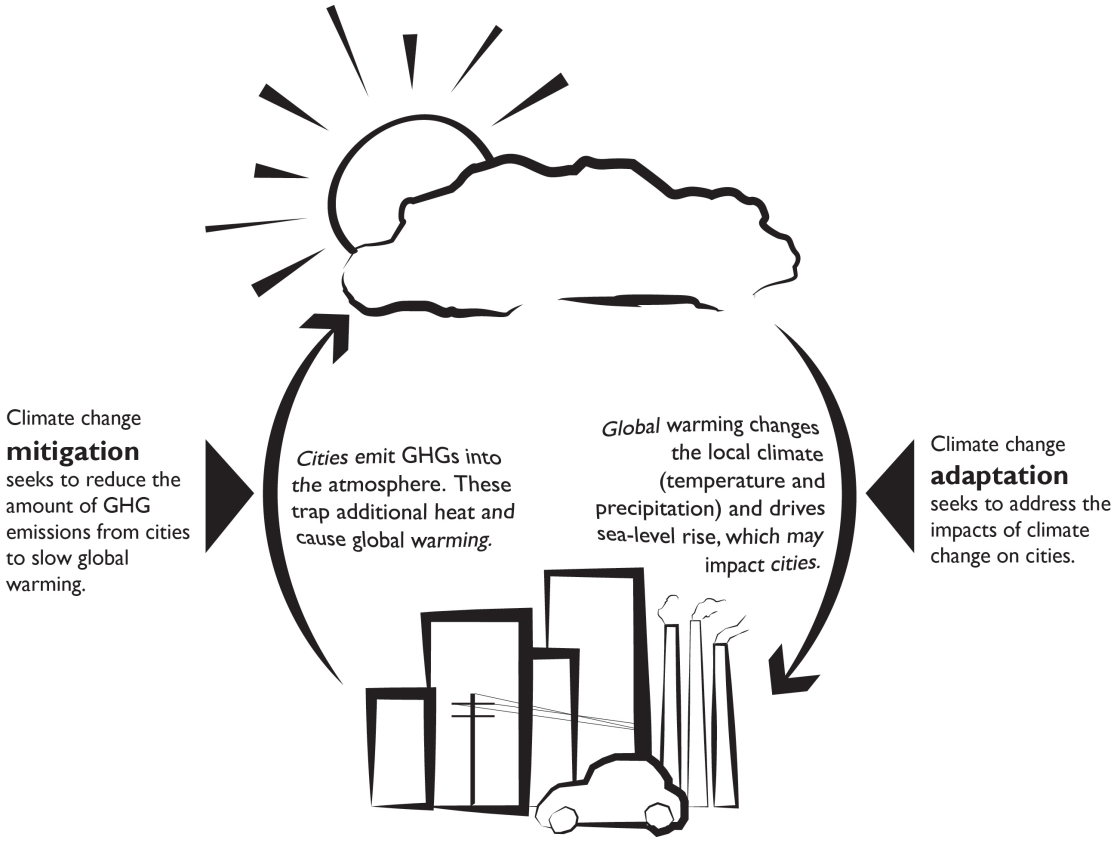


Figure 2. Illustration of the roles of mitigation, or greenhouse gas emission reduction, and adaptation in combating the causes and impacts of climate change.

How is climate adaptation related to hazard mitigation planning?

Natural hazard impacts are only one area that may be affected by climate change. Other areas that may be affected include agricultural, forestry, and fisheries productivity; ecosystem structure and function; and public health. Planning in all of these areas should be done in light of potential climate change impacts. For Local Hazard Mitigation Plan (LHMP) development, climate change should be incorporated into the assessment of hazards risk. Ideally, measures identified in the LHMP will address both current hazards needs and future climate-change-affected hazards.

Box 4

Types of information required for conducting climate adaptation planning:

- Information from the web-based Cal-Adapt tool (cal-adapt.org) that shows the type, magnitude, and onset of various effects of climate change that a community will experience (e.g., the extent of coastal inundation from sea-level rise expected by 2050).
- Information from local agencies on the types of assets, resources, and populations that will be sensitive to various climate change exposures (e.g., the location of infrastructure in the coastal zone or the types of people in the community prone to heat stress).
- Information from local agencies on their current ability to deal with the impacts of climate change (e.g., firefighting capacity to handle anticipated future changes in wildfire regimes).

How complicated is the climate adaptation planning process?

Communities can do as much or as little as they desire. This guide allows for flexibility in commitment of time, staffing, money, and scope. If communities want to do a basic plan drawing on readily available data (see Box 4) and minimizing staff commitment, then the APG can support that approach. If the community wants to do a more in-depth plan, then the APG can support that approach as well. The logic is the same; what will differ is the sophistication of the vulnerability assessment and the extent of the strategy development.

What is the product of this effort and how will it be used?

The two basic products of a climate change adaptation plan are a vulnerability assessment and adaptation strategies. The vulnerability assessment is an exercise to identify what and how climate change will impact the community. The adaptation policies/strategies are developed through a collaborative process and address how the community will address the impacts identified in the vulnerability assessment given its resources, goals, values, needs, and regional context. The climate change adaptation strategies can then be codified and implemented through a number of instruments that already exist in the community (see Box 3).

Who needs to be involved?

It is important to get the right organizations, people, and resources assembled for adaptation planning. In general these can be thought of as encompassing three groups:

- Local: Local organizations, people, and resources are key for gathering and analyzing local information, developing robust climate adaptation strategies, building political support, and creating a more informed and active community. This includes building support from community elected officials and civic leaders.

- Internal: Since climate adaptation affects a wide variety of community populations and assets, there should be an "adaptation team" assembled from local agency staff who can provide data, insight, and strategy ideas. The most common government agencies/departments include planning, community development, building, engineering, public works, emergency management, police, fire, finance, public health, and environment. The level of commitment needed from the team will vary depending on the level of intricacy of the plan.

- Non-local: National, state and regional government agencies and non-profit organizations can provide data, guidance, and sometimes funding in support of climate adaptation planning. In addition, neighboring communities should be approached about collaborating on adaptation planning.

How can the public be engaged?

Engaging the community (see Box 5) is essential to ensuring that adaptation policies and strategies can be adopted, that they are equitable, and that they can be implemented efficiently. Local political processes require some level of consensus around approaches to climate change impacts, but it is likely that "public opinion regarding climate change is divided and fluid" (Boswell et al., 2012, pg. 66). Local agencies cannot take for granted simple acceptance or agreement. Public engagement offers the opportunity to educate and build commitment and consensus among local decision-makers and community members.

Communicating about climate change can be challenging. Many people still tend to view climate change impacts and solutions as global rather than local, meaning they may not understand the potential for local impacts or the importance of local approaches to adaptation. Communities also may not understand the "human" impacts of climate change, which may influence the relevance of these concerns for some (Maibach et al., 2011). A number of approaches to addressing these challenges and several suggestions for community engagement in climate change issues are listed in Box 5.

Box 5

Suggestions for Engaging the Public:

- Set clear goals for why you are communicating with the public (e.g., informing, motivating action, soliciting participation) and consider how and from where your audience receives information.
- "Localize" the issues. Frame the issues in terms of local impacts and solutions.
- Clarify the human impacts of climate change along with other impacts.
- Emphasize the co-benefits of solutions and adaptation measures. For instance many actions taken to address and adapt to climate change (e.g. transit-oriented development that produces more walkable communities, urban greening) benefit a community's health and livability.
- Partner with other local agencies, non-governmental organizations (NGOs), community organizations and groups, and others and build on existing relationships with local communities.
- Use both traditional media (newspapers and television) and relatively new forms (blogs and other social media) to reach your audience.
- Consider the diversity of local groups within your community (e.g. consider special needs and cultural traditions) to maximize the diversity of groups participating. Local health departments may have pre-existing relationships with low-income and underrepresented communities and working with them can make the engagement process more inclusive.
- Include community members early in the process and throughout the implementation process.

Are there any special or creative sources of funding for implementing climate change adaptation policies?

Adaptation can be funded in a variety of ways and potential sources of funding, such as grant programs, continually change. A series of potential funding sources are identified below.

- Leveraging or directing existing funding can be an effective approach. For example, a local government that has already programmed a bridge replacement should take into consideration possible climate change impacts such as the potential for increased flood heights. The bridge could then be designed and built with these impacts in mind, possibly with little or no change in cost.
- Local governments should identify strategies that meet multiple community goals or needs. This will make available a greater number of potential funding mechanisms. For example, many energy efficiency efforts have climate change adaptation benefits. Wetland restoration or low-impact design can reduce flood vulnerability and increase groundwater recharge.
- For projects designed to address climate change impacts that exacerbate natural hazards, local governments should investigate state and federal grant opportunities that could apply. Cal EMA maintains a listing of these grants: http://hazardmitigation.calema.ca.gov/grants. Other agencies that have funding opportunities include the California Department of Water Resources (DWR) through the Integrated Regional Water Management (IRWM) grant program and the California Energy Commission (CEC).
- Local governments should look to partner with other jurisdictions, regional organizations, and agencies to address climate change impacts. Many impacts cross political boundaries and may require collaboration for long-term solutions. Collaboration can result in economic efficiency and additional funding sources.
- Since all state agencies are required to plan for climate change, local governments may find opportunities for jointly funded projects.

What is the best way to get started?

The most important step in preparing to develop climate policy is establishing a climate change adaptation team (see Box 6) to promote communication and collaboration among departments and with stakeholders. This team can take multiple forms such as a task force, committee, or workshop series. Communities can determine the best approach to meet local needs based on duration of the policy development period, the level of local commitment to the process, and availability of staff.

Adaptation policy development requires information and feedback from the staff members most familiar with local or regional activities vulnerable to climate

change impacts. Assessing vulnerability requires an evaluation of secondary impacts of climate change, which have the potential to involve local conditions as varied as ecosystem health, economic viability, infrastructure maintenance, emergency response, and public health. In addition to evaluating potential impact, a critical task of the climate change adaptation team is assessing how well existing policies and programs respond to projected climate changes.

Box 6

The Climate Change Adaptation Team

The critical members of the climate change adaptation team will vary by community. Categories of expertise that should be considered when assembling the team include the following:

- Long-range planning or community development
- Emergency response and natural hazards planning
- Economic development
- Parks and open space
- Transportation or engineering
- Utilities (water, wastewater, etc.)
- Administration/finance
- Chamber of commerce
- Public health
- Social services
- Regional entities (e.g. air districts, metropolitan planning organizations, regional transportation planning agencies, etc.)
- Regional science organizations or universities
- Local non-governmental organizations (NGOs) (environmental, social, etc)
- Professional organizations (agricultural, fisheries, communications, etc.)

What is the State doing to address climate adaptation and how can the State assist local governments?

The State of California addresses adaptation to climate change in a variety of ways. The overarching guidance document is the 2009 California Climate Adaptation Strategy (CAS), which is being updated. The CAS summarizes the science of climate impacts, specifies comprehensive state adaptation strategies, and analyzes the impacts to a variety of strategic sector areas. In implementing the CAS, the State is also developing the documents of the Adaptation Planning Guide (APG) to provide a decision-making framework intended for use by local and regional stakeholders to aid in the interpretation of climate science and to develop a systematic rationale for reducing risks caused, or exacerbated, by climate change. The California Natural Resources Agency and the California Energy Commission have released Cal-Adapt (cal-adapt.org), a web-based tool

which enables city and county planners, government agencies, and the public to identify potential climate change risks in specific areas throughout California. Finally, most state agencies are in the process of preparing their own plans and resource documents for addressing climate adaptation.

Communities should use this APG and the Cal-Adapt website as their primary resources for analyzing the impacts of climate change and preparing adaptation strategies. In addition, communities can look to state and regional entities with specialized information about their regions. For example, communities where wildfire occurrence/intensity is expected to increase should look to CAL FIRE for tools, guidance, and coordination. Likewise, a Bay Area community facing sea level rise should look to entities such as the California Coastal Commission, the San Francisco Bay Conservation and Development Commission, and the Association of Bay Area Governments.

Who developed the guide and why?

The APG was developed by the California Emergency Management Agency and the California Natural Resources Agency with funding from the Federal Emergency Management Agency and California Energy Commission to assist local and regional government agencies in planning for climate change adaptation. An Advisory Committee made up of climate change experts from state agencies and state-level NGOs informed the APG. The APG was also pilot-tested in seven communities. A faculty-led team at California Polytechnic State University, San Luis Obispo assisted the state agencies in developing and testing the APG.

Climate Change Adaptation Planning Process

Climate change adaptation strategies seek to reduce vulnerability to projected climate changes and increase the local capacity to adapt (Turner et al., 2003). The process of developing climate change adaptation strategies can vary from a short, initial qualitative process to a much more detailed, lengthy, comprehensive approach. Regardless of where a community falls in this spectrum, the basic steps are the same. This section details the steps in vulnerability assessment and strategy development.

The adaptation strategy development process must be viewed as iterative and ongoing. The nine steps in the strategy development process are related and can overlap. The progression through the steps will be iterative, where completing one step may raise issues important in an already completed step. When this occurs, prior steps should be revisited before the process continues. In other cases, communities may decide that two steps are most efficiently addressed concurrently. To better navigate the process and anticipate subsequent steps, participants are encouraged to read through this *APG: Planning for Adaptive Communities* document before initiating the process.

Development of strategies to address climate change impacts follows a sequence of steps (see Figure 3): (1) assessing exposure to climate change impacts; (2) assessing community sensitivity to the exposure; (3) assessing potential impacts; (4) evaluating existing community capacity to adapt to anticipated impacts; (5) evaluating risk and onset, meaning the certainty of the projections and speed at which they may occur; (6) setting priorities for adaptation needs; (7) identifying strategies; (8) evaluating and setting priorities for strategies; and (9) establishing phasing and implementation.

Once strategies have been identified and implementation has begun, the process should be repeated. Climate change progresses though time. The science that aids understanding of climate change is continually refined and the local conditions in which strategies are implemented can also be dynamic. As a result, adaptation strategies must be regularly assessed for effectiveness and adequacy for addressing the challenges being faced by a community.

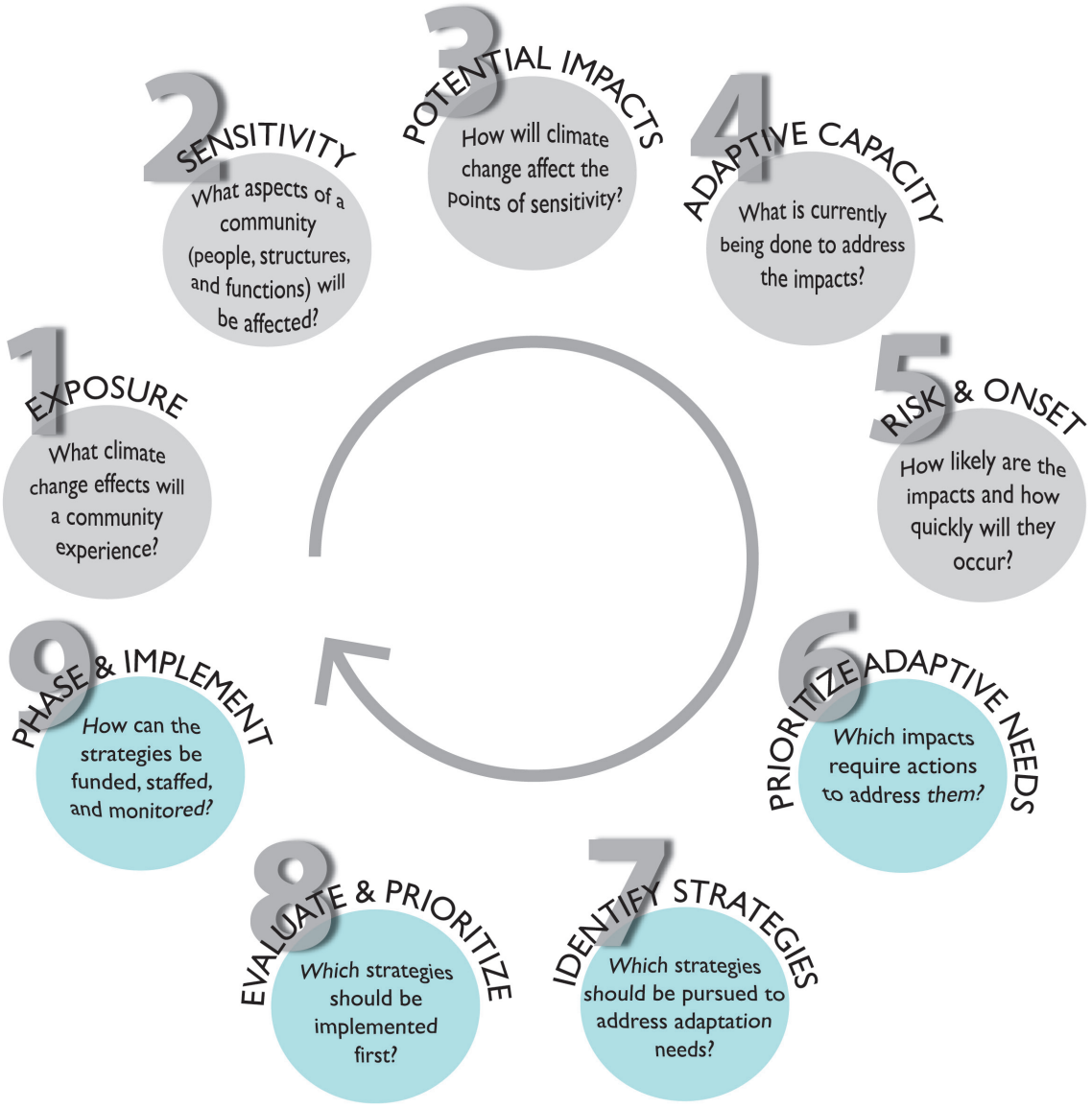


Figure 3. The nine steps in adaptation planning development.
The gray steps are part of vulnerability assessment (steps 1-5) and the blue steps are adaptation strategy development (steps 6-9).

The nine steps are arranged in sequence. The first five make up a vulnerability assessment (see Figure 3). Climate vulnerability assessment is a method for determining the potential impacts of climate change on community assets and populations. The severity of these impacts and the community's ability to respond will determine how these impacts affect a community's health, economy, ecosystems, and socio-cultural stability. Communities that understand these impacts can prepare climate adaptation policies and programs to increase resilience to climate change.

Climate Change Vulnerability Assessment

Vulnerability assessment involves the first five steps in climate change adaptation planning development (see Figure 3):

1. Exposure: What climate change effects will a community experience?
2. Sensitivity: What aspects of a community (people, structures, and functions) will be affected?
3. Potential Impacts: How will climate change affect the points of sensitivity?
4. Adaptive Capacity: What is currently being done to address the impacts?
5. Risk and Onset: How likely are the impacts and how quickly will they occur?

Climate change vulnerability assessment can require data collection and analysis. The level of detail required will depend on the depth desired by a community. Some of the data may be well documented for the community and some may exist only in the collective knowledge of community experts. The analysts conducting the vulnerability assessment will need to identify data needs and consider consulting a group of experts–i.e., a climate change adaptation team (see Box 6)–to create a robust assessment.

Step 1. Exposure: What climate change effects will a community experience?

Outcome: A list of the changes projected for each climate impact for 2050 and the end of the century. This list should identify the degree of change (difference from current conditions) and the location of the change.

The projected changes to the climate vary based on location. Communities or regions must first determine what climate change will mean locally. The direct changes include the following:

- Average temperature
- Annual precipitation
- Sea level rise

Severe storms and ocean acidification are also direct climate impacts, but projection data are less easily acquired. In the case of these impacts, potential local effects should be acknowledged.

Secondary impacts should be assessed as well. In California, three secondary impacts–heat wave frequency, wildfire risk, and snowpack (Cal-Adapt.org)–have been analyzed and projection data are available. For secondary impacts that do not have projection data, potential impacts can be identified based on the primary climate change impacts projected for a given location (see Table 1).

Table 1. Secondary impacts associated with primary impacts individually or in combination

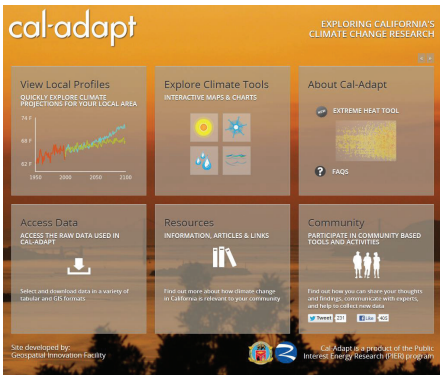
PRIMARY IMPACT	ASSOCIATED SECONDARY IMPACTS
Sea level rise	Inundation or long-term waterline change
	Extreme high tide*
	Coastal erosion*
	Saltwater intrusion*
Changed temperature and/ or precipitation patterns	Changed seasonal patterns*
Increased temperature	Heat wave
Increased temperature and/ or changed precipitation	Intense rainstorms*
Wildfire and/or increased precipitation	Landslide*
Increased temperature and/ or reduced precipitation	Drought*
	Wildfire
	Reduced snowpack

[*Indicate secondary impacts that do not have projections available through Cal-Adapt.org]
Source: IPCC. 2007. WG1 Physical Science Basis, Section 10 & 11.

For each of the projected changes, the goal is to answer the following questions:

- What is the difference between current conditions and those projected for 2050 and at the end of the century?
- How quickly are these changes projected to occur?
- Over how large an area are the changes projected to occur?

Communities should utilize the best available data for their location. If a university, science agency, or regional entity has developed a more specific assessment of local climate change, communities are encouraged to rely on this data.



Cal-Adapt.org and GIS

For a community that has staff with geographical information systems (GIS) expertise, the data displayed on Cal-Adapt.org can be downloaded by choosing the "Data Access" option. Combining climate projection data with local data layers such as land use may be helpful to communities conducting a vulnerability assessment.

In California, Cal-Adapt.org serves as a good starting point for determining climate exposure. It assembles a variety of data sources to show climate change scenarios for California at a regional level. The data can provide a general understanding of the types of changes that can be expected. All users of the tools should understand that the scenarios they are working with represent only a sample of the potential climate outcomes, contain a level of uncertainty, and become increasingly limited in usefulness as the area being assessed gets smaller.

Steps for Estimating Regional Climate Change Exposure

Communities can use the online Cal-Adapt tool (cal-adapt.org) or other regional data sources to determine local exposure to projected climate changes (use high emissions scenario in cal-adapt.org). While 2050 and 2100 serve as benchmarks, communities should also evaluate general plan buildout year and rate of change over time.

a. Sea level rise: Identify areas of the community that are currently subject to coastal flooding (100-year flood) and areas potentially subject to the 55-inch rise forecasted for 2100. Communities should be aware that while Cal-Adapt maps a 55-inch rise in sea level, this is an average value. The high emissions scenario can result in 43 to 69-inches of sea level rise (CO-CAT, 2010; NAS, 2012).
b. Precipitation: Identify the current annual precipitation and the forecasted change over time, specifically assessing 2050 and 2090. The rate of change should also be evaluated.
c. Temperature: Identify the current average seasonal temperatures and the forecasted change over time, specifically evaluating 2050 and 2100.
d. Heat waves: Identify the current number of extreme heat events and heat waves and the projected change through time.
e. Snowpack: Identify the current amount of water stored as snow during the winter and spring months and the projected change through time.
f. Wildfire: Identify the projected increase in area burned in 2020, 2050, and 2085.

Exposure Example 1

A community located in western Kern County identified the following changes as part of an evaluation of climate exposure using Cal-Adapt:

- Average temperature is projected to climb steadily, with increases of 2.5 ˚F by 2050 and 6.2 ˚F by 2100.
- The annual number of extreme heat days (with temperatures of more than 105˚F) is projected to increase from the current number of roughly 10 to nearly 30 by 2050 and over 65 by the end of the century (see Figure 4).
- Precipitation is projected to decline from the current annual total of 6 inches per year to 5 inches per year in 2050 and 4.5 inches per year in 2100.
- The location is also likely to experience altered seasons, drought, and intense rainstorms. These cannot be estimated on Cal-Adapt, but are acknowledged as possible outcomes.

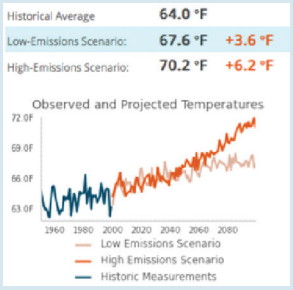


Figure 4. Example Cal-Adapt.org output for temperature

Exposure Example 2

A community located in Nevada County in the Sierra identified the following changes as part of an evaluation of climate exposure using Cal-Adapt:

- Average temperature is projected to climb steadily, reaching a 4.5˚F increase by 2050 and a 7.0˚F increase by 2100.
- Extreme heat is defined as days over 88˚F at this location. The number of extreme heat days is projected to increase from roughly 10 per year to 25 per year in 2050 and 65 per year in 2100.
- Heat waves (5 consecutive days over 88˚F) are projected to increase from 2 or fewer per year to roughly 3 per year in 2050 and more than 8 per year in 2100.)
- Precipitation is projected to decrease from annual total over 40 inches in 2010 to roughly 36 inches in 2050 and 33 inches in 2100.
- April snowpack is projected to decrease from roughly 6 inches of water equivalence to 2 inches in 2050 to less than 1 inch (a reduction of more than 85 percent) in 2100.
- Moderate increases in wildfire risk over current conditions are projected between 2020 and 2050 (1.17 and 1.46, respectively). A much larger increase in wildfire risk (2.65) is projected in 2100 (see Figure 5).
- The region is also likely to experience altered seasons, intense rainstorms, and landslides. Forecasts for these phenomena are not yet available on Cal-Adapt, but should be acknowledged as potential changes.

Figure 5. Example Cal-Adapt.org output for fire risk

Step 2. Sensitivity: What aspects of a community (functions, structures, and populations) will be affected?

Outcome: A list of potentially affected community resources.

This step involves a systematic evaluation to identify community structures, functions, and populations that may be affected by the projected exposure to climate change impacts. The evaluation requires nothing more than "yes" and "no" answers (potentially affected or not). The next step (Step 3) evaluates how the impacts will occur and how severe they may be.

Categories useful for this evaluation are described below (FEMA, 2001). The categories are those used for the evaluation of natural hazards. The process used for climate adaptation is similar. The checklist is focused specifically on assessing the community resources potentially affected by climate change. These categories explain some of the reasoning behind the items on the checklist that follows. The checklist is intended to ensure that less obvious secondary climate impacts are identified. Communities need only identify those items on the checklist potentially affected by the projected local climate exposure.

- **Essential Facilities** such as hospitals and other medical facilities, police and fire stations, emergency operations centers and evacuation shelters, and schools. These facilities are essential to the health and welfare of the whole population and are especially important following climate-influenced hazard events. The potential consequences of losing them are so great that they should be carefully inventoried.
- **Transportation Systems** such as airways (airports, heliports, highways); bridges; tunnels; road beds; overpasses; transfer centers; railways (tracks, tunnels, bridges, rail yards, depots); and waterways (canals, locks, seaports, ferries, harbors, drydocks, piers).
- **Lifeline Utility Systems** such as potable water, wastewater, fuel, natural gas, electric power, and communication systems.
- **High Potential Loss Facilities**, such as nuclear power plants, dams, and military installations, where damage would have large environmental, economic, or public safety consequences).
- **Hazardous Material Facilities**, including facilities housing industrial/ hazardous materials such as corrosives, explosives, flammable materials, radioactive materials, and toxins.
- **Vulnerable Populations** such as non-English-speaking people or elderly people who may require special response assistance or special medical care after a climate-influenced disaster.

- **Economic Elements** such as major employers and financial centers that could affect the local or regional economy if disrupted.
- **Areas of Special Consideration** such as areas of high-density residential or commercial development where damage could result in high death tolls and injury rates.
- **Historic, Cultural, and Natural Resource Areas** such as areas that may be identified and protected under state or federal law.
- **Other Important Facilitie**s that help ensure a full recovery from or adjustment to changed climate conditions. These would include government functions, major employers, banks, and certain commercial establishments such as grocery stores, hardware stores, and gas stations.

SENSITIVITY CHECKLIST

Communities can use the following checklists to evaluate those functions, structures, and populations potentially affected by the exposure identified in Step 1.

Functions

- ☐ Government continuity
- ☐ Water/sewer/solid waste
- ☐ Energy delivery
- ☐ Emergency services
- ☐ Public safety
- ☐ Public health
- ☐ Emotional and mental health
- ☐ Business continuity
- ☐ Housing access
- ☐ Employment and job access
- ☐ Food security
- ☐ Mobility/transportation/access
- ☐ Quality of life
- ☐ Social services
- ☐ Ecological function
- ☐ Tourism
- ☐ Recreation
- ☐ Agriculture, forest, and fishery productivity
- ☐ Industrial operations

Structures

- ☐ Residential
- ☐ Commercial
- ☐ Industrial
- ☐ Government
- ☐ Institutional (schools, churches, hospitals, prisons, etc.)
- ☐ Parks and open space
- ☐ Recreational facilities
- ☐ Transportation facilities and infrastructure
- ☐ Marine facilities
- ☐ Communication infrastructure
- ☐ Dikes and levees
- ☐ Water treatment plant and delivery infrastructure
- ☐ Wastewater treatment plant and collection infrastructure

Populations

- ☐ Seniors
- ☐ Children
- ☐ Individuals with disabilities
- ☐ Individuals with compromised immune systems
- ☐ Individuals who are chronically ill
- ☐ Individuals without access lifelines (e.g. car or transit, telephones)
- ☐ Non-white communities
- ☐ Low-income, unemployed, or underemployed communities
- ☐ Individuals with limited English skills
- ☐ Renters
- ☐ Students
- ☐ Seasonal residents
- ☐ Individuals uncertain about available resources because of citizenship status

Sensitivity Example 1

A community located along the central coast may experience between 43 and 69 inches of sea level rise. This increase in sea level (including the related coastal flooding, extreme high tide, coastal erosion, and storms) has the potential to affect a wastewater treatment plant, a local power plant, roadways in and out of the community, downtown commercial areas, the local harbor, park and open space areas, and a middle-income residential area. The points of sensitivity (potentially affected community resources) identified for this exposure include the following:

Functions

- ☑ Government continuity
- ☑ Water/sewer/solid waste
- ☑ Energy delivery
- ☑ Emergency services
- ☑ Public safety
- ☑ Public health
- ☑ Emotional and mental health
- ☑ Business continuity
- ☑ Housing access
- ☑ Employment and job access
- ☑ Mobility/transportation/access
- ☑ Quality of life
- ☑ Ecological function
- ☑ Tourism
- ☑ Recreation
- ☑ Agriculture, forest, and fishery productivity
- ☑ Industrial operations

Structures

- ☑ Residential
- ☑ Commercial
- ☑ Industrial
- ☑ Parks and open space
- ☑ Recreational facilities
- ☑ Transportation facilities and infrastructure
- ☑ Marine facilities
- ☑ Wastewater treatment plant and collection infrastructure

Populations

- ☑ Seniors
- ☑ Children
- ☑ Individuals with disabilities
- ☑ Individuals with compromised immune systems
- ☑ Individuals who are chronically ill
- ☑ Individuals without access lifelines (e.g. car or transit, telephones)

Step 3. Potential Impacts: How will climate change affect the points of sensitivity?

Outcome: A list of potential impacts, each rated low, medium, or high.

This step can be completed with varying level of detail and relies heavily on the expertise of the staff and stakeholders on the climate change adaptation team. It is closely related to the following step of evaluating adaptive capacity. Vulnerability is assessed by determining how an identified point of sensitivity would affect a community (Step 3), and then evaluating existing tools to address this impact (Step 4).

The Federal Emergency Management Agency (FEMA), in its "how-to" guides, establishes methods for creating detailed assessments of hazard impacts (FEMA, 2001). Although these could be applied to climate and climate-related hazards, the required level of detail is high. Moreover, the uncertainty of climate scenarios lessens the usefulness of this approach. Given that climate change exposures at the community scale are inherently uncertain, it is recommended that communities conduct a qualitative assessment that describes the potential impact based on the exposure.

Accurately describing potential impacts relies on input from the climate change adaptation team (staff members and stakeholders most familiar with each of the affected sectors). The same impact can have very different meanings in different communities. Factors to consider in defining these terms should include the spatial and temporal extent of the impact, the degree to which it yields permanent or reversible consequences and/or endangers local population (physical safety, health, etc.), and the extent to which the impact would disrupt typical community function such as provision of services or economic continuity.

The climate change adaptation team can help assess the potential impacts of climate change by developing general descriptive scenarios. These scenarios should assess structural integrity and content value, as well as the effects on the interruption of the functions. Vulnerability is based on the service housed in a structure rather than simply its physical integrity. For example, if a particular facility such as a community center is threatened by climate change impacts, the facility and also the local residents reliant on that facility should be identified as at risk. Each description should include the following for each identified point of sensitivity:

a. The temporal extent of the impact
b. The spatial extent of the impact
c. The permanence of the impact
d. The level of disruption to normal community function

Potential Impacts Example 1: San Clemente, CA

In San Clemente, California, the city's marine safety building is located on the beach just north of the municipal pier. The building houses a number of activities, including administrative offices, public restrooms and showers, classrooms for lifeguards, emergency warning systems and response equipment, and beach maintenance operations. The building is already at risk for sea level rise damage during winter high tide events. The beach adjoining the building is a popular community and tourist destination.

San Clemente Marine Safety Building outlined in red

To identify potential impacts, San Clemente's adaptation team not only evaluated the physical threat to the structure, but also the potential impact on community members reliant on the services housed by the building. Table 2 shows a sample of the spreadsheet developed by the City to identify potential impacts resulting from water damage or destruction of the building. The City organized the impacts into categories: service level, lifeguard operations, and beach maintenance. Table 2 shows the potential impact ratings for service level impacts. In subsequent steps, each of the potential impacts was assessed based on the City's ability to provide these services to the identified populations elsewhere.

Potential Impacts Example 1 (cont'd.)

Table 2. Sample assessment of potential sea level rise impact on Marine Safety Building in San Clemente, CA

POTENTIAL IMPACTS	SENSITIVITY	TEMPORAL EXTENT	SPATIAL EXTENT	RATING
Water damage and destruction of marine safety building	Marine safety building	4 years+	One area (MS)	high
Service level impacts				
Loss of on-site offices–staff less available to respond to public emergencies	Potential impact on any of 2.5 million annual visitors to beach	4 years+	Entire beach	high
Loss of on-site supervision and reduced oversight	Potential impact on any of 2.5 million annual visitors to beach	4 years+	Entire beach	high
Loss of advanced first aid facilities for public	Impact on injured citizens	4 years+	One area (MS)	high
Loss of hot showers for hypothermic patients and lifeguards	Impact on public and employees	4 years+	One area (MS)	high
Loss of building providing public walk-in assistance	Impact on public and employees	4 years+	One area (MS)	medium
Loss of training facility/classroom for junior lifeguards	Impact on 650 students annually	4 years+	One area (MS)	medium
Loss of swimmer observation facility	Impact on approximately 30% of beach population	4 years+	One area (MS)	high
Loss of public clock visible to 50% of beach	Impact on approximately 50% of beach population	4 years+	50% of beach	low

Step 4. Adaptive Capacity: What is or can be currently done to address the impacts?

Outcome: The current capacity for a community to address each of the potential impacts is assessed and rated low, medium, or high.

Adaptive capacity is the current ability of a community to address the potential impacts. Many communities have existing policies, plans, programs, resources, or institutions that are already in place or can be implemented with little effort to adapt to climate change and reduce potential impacts. Step 4 asks that communities carefully evaluate existing measures to determine level of preparedness for projected impacts. Based on this information, adaptive capacity should be rated high, medium, or low. The adaptation team, comprised of local and regional staff and other stakeholders, should make these determinations. High adaptive capacity indicates that measures are already in place to address projected changes, where a low rating indicates a community is unprepared.

For example, a community that identifies reduced water supply due to rainfall and snowpack changes may already be developing new water sources or setting aside money to do so. This community has a high adaptive capacity in the case of water supply since a solution to the climate change impact is being developed or can be readily implemented. These existing resources should be identified to inform additional policy and program development.

For each policy or program that addresses a potential impact, the following tasks should be undertaken:

- Identify actions in progress, planned, or readily implemented to address the issue.
- If the policy or program is not yet implemented, evaluate the time and resources needed for implementation.
- Assess the extent to which the existing policy or program addresses potential impacts ("is it enough?").
- Note the degree to which the existing policy or program could be strengthened.

In addition to identifying measures that already directly address a climate change impact, an assessment of local plans and programs can provide insight into the type of actions most successful in a given community. The following types of city and county documents should be included in an audit of local measures (adapted from Boswell, Greve, and Seale, 2012):

Plans

General Plan
Climate Action Plan
Climate Adaptation Plan
Area and Specific Plans
Local Hazard Mitigation Plans
Local Coastal Plans
Urban Water Management Plan
Downtown Plan
Transit Plan
Sustainable Community Plans (SB375)
Regional Transportation Plans
Integrated Regional Water Management

Standards, Ordinance, and Programs

Capital Improvement Program
Zoning Code
Building Code
Fire Code
Tree Ordinance
Floodplain Ordinance
Stormwater Management Program

Adaptive Capacity Example 1: Heat-related health in Central Valley

A community in the Central Valley is projected to see a 7°F increase in average temperature by 2100 with an increase of one to three heat waves per year by 2050 and nearly 10 heat waves per year by 2100, according to Cal-Adapt.org. In this area, a heat wave is defined as four or more days over 102° F. Based on the 2010 U.S. Census, this community is 47 percent Hispanic, with an average household income well below the California average.

The community identified several points of sensitivity associated with the projected temperature changes, including the local economy due to agricultural impacts and public health concerns, particularly with respect to heat waves. Potential impacts associated with public health included cardiovascular disease; exacerbation of asthma, allergies, and chronic obstructive pulmonary disease (COPD); increased risk of skin cancer and cataracts; premature death; cardiovascular stress and failure; and heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones. The evaluation of these impacts included identification of the populations most vulnerable, including the elderly, children, those who lack access to air conditioning, and those who work outdoors in agriculture or construction.

Adaptive Capacity Example 1 (cont'd.)

Adaptive capacity was assessed by evaluating the extent to which these potential impacts were already being addressed. The evaluation included the following:

- ☐ Have agencies and organizations been contacted that can identify and reach vulnerable populations and provide them with information on what they need to know about the risks of climate change and what can be done to address them?
- ☐ Are early warning systems in place for extreme heat events?
- ☐ Are cooling centers readily accessible and located in familiar places, both in terms of locale and transportation options, for vulnerable populations?
- ☐ Are there vulnerable members of the community without air conditioning? Are there programs available to provide air conditioning units?
- ☐ Do plans require or promote additional open space, green space, shade cover, urban forests, community gardens, parks, and trees and other vegetation that address the impacts of heat islands and heat events upon agricultural and tourism workers?
- ☐ Has the community considered adoption of community-level cooling strategies such as white or green roofs, cool pavements, cool parking lots, and land use and building design that can result in cooling?
- ☐ Does the local health department or department responsible for emergency preparedness have community-wide assessments of the location of the most vulnerable populations?
- ☐ What type of public education and community outreach efforts are underway and are they accessible to diverse groups and through a diversity of agencies and media?
- ☐ Are local employers and business associations participating in local efforts to address climate change and health and socioeconomic impacts upon employees?

Based on this evaluation, each potential impact associated with public health was rated high, medium, or low taking into account the adaptive capacity. High was defined as currently prepared to address the projected changes and low as unprepared for the temperature and heat wave projections.

Step 5. Risk and Onset: How likely are the impacts and how quickly will they occur?

Outcome: Each potential impact rated low, medium, or high based on certainty and rated near-term, mid-term, and long-term based on onset.

Although this is listed as a fifth step, it will likely be conducted in tandem with the previous two steps of identifying impacts and local capacity. This step asks the climate change adaptation team to rank impacts based on the level of risk and the projected timeframe.

Risk

Risk is the likelihood or probability that a certain magnitude/extent/scale of potential impact will occur. This is an assessment that combines the estimated certainty of the science projecting the climate change impact and the certainty of the sector sensitivity. In general, impacts with higher probability should be ranked at a higher priority for community action.

The following task is recommended:

1. For each impact, assign a low, medium, or high uncertainty, based on the certainty of the primary or secondary exposure estimated in Step 1 (see Table 3 and Table 4).

Table 3. Probability based on global models

DRIVER	% PROBABILITY (IPCC)	CERTAINTY RATING
Temperature change	> 90% probability	High
Precipitation change	> 66% probability	Medium
Sea level rise	> 90% probability	High
Snow season and depth change	> 90% probability	High

Source: IPCC, 2007.

Table 4. Secondary impact associations.

PRIMARY IMPACT	ASSOCIATED SECONDARY IMPACTS	CERTAINTY RATING
Sea level rise	Inundation or long-term waterline change	High
	Extreme high tide	High
	Coastal erosion	High
	Saltwater intrusion	High
Changed temperature and/or precipitation patterns	Changed seasonal patterns	Medium
Increased temperature	Heat wave	High
Increased temperature and/or changed precipitation	Intense rainstorms	Medium
Wildfire and/or increased precipitation	Landslide	Medium
Increased temperature and/or reduced precipitation	Drought	Medium
	Wildfire	Medium
	Reduced snowpack	High

Estimated based on most conservative driver from Table 3
Source: IPCC, 2007.

Timeframes

In general, impacts with a quicker onset should be ranked at a higher priority for community action. Like factors in other assessment steps, timeframe cannot be precisely estimated. However, it is possible to categorize impacts as near-, mid-, and long-term. These timelines can be obtained from the Cal-Adapt tool (www.cal-adapt.org).

The following task is recommended:

1. For each impact, designate the timeline for expected impacts:
    a. Current: Impacts currently occurring
    b. Near-term: 2020-2040
    c. Mid-term: 2040-2070
    d. Long-term: 2070-2100

Adaptation Strategy Development

The strategy development phase translates the identified climate vulnerability and risk into implementable actions. This process is difficult due to uncertainty of the projected changes and impacts, potentially high policy implementation costs, and the wide range of competing interests in any community. One way to navigate what can be a complex, time-consuming process is to use decision matrices. A decision matrix can aid a community in balancing adaptation needs against uncertainty, other community goals, and time and funding concerns. Setting priorities for adaptation needs and strategies must be based on the local social, political, economic, and environmental context. The same adaptation need may be critically important in one community and viewed as moderately important in another. These distinctions must be made collectively by community staff, key stakeholders, and concerned residents. The climate change adaptation team should lead this process.

This section outlines Steps 6 through 9 in the adaptation strategy development process (see Figure 3), as follows:

6. Prioritize Adaptive Needs: Which impacts require actions to address them?
7. Identify Strategies: Which strategies should be pursued to address adaptation needs?
8. Evaluate and Prioritize Strategies: Which strategies should be implemented first?
9. Phase and Implement: How can the strategies be funded, staffed, and monitored?

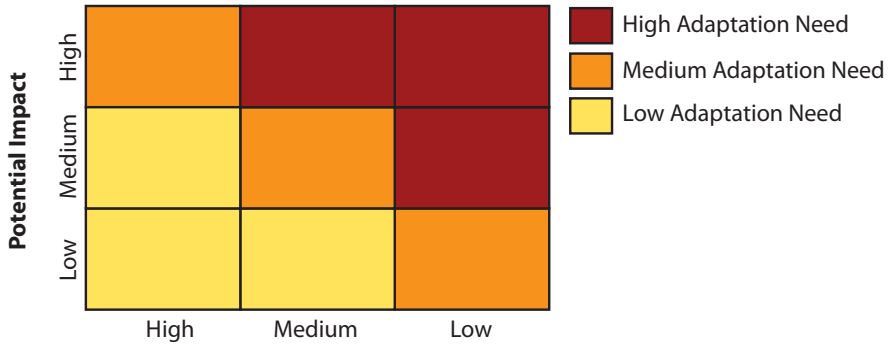
Step 6. Prioritize Adaptive Needs: Which impacts require actions to address them?

Outcome: Potential impacts divided into three categories: (1) develop strategies, (2) evaluate further, and (3) monitor.

The first step in adaptation strategy development is to identify the climate-related impacts that require action. Some identified impacts might not require immediate action because existing measures already address the impact, the certainty of the impact is low, or the projected onset of the impact is in the distant future. Other impacts might call for immediate action due to the potential severity of the impact, the low cost of addressing it, or the time that effective policy implementation may take. Setting priorities for adaptation needs increases a community's ability to dedicate the necessary staff and funds because the efforts do not need to occur all at once.

The prioritization of adaptation needs combines three pieces of information from the vulnerability assessment: potential impact, adaptive capacity, and risk and onset. The following tasks are recommended for combining these three sources of information.

1. Collect the categorical ratings for potential impacts (Step 3) and adaptive capacity (Step 4). The following risk matrix combines the assessment of impact with current capacity to address that impact (see Figure 6). Additional resources should not be allocated to an impact that is already being addressed. Instead, those impacts with far-reaching consequences for which a community is least prepared should be addressed first. The climate change adaptation team should determine the high, medium, and low ratings for the adaptation needs.



Adaptive Capacity - The current community capacity to address a potential impact.
[High = community is well prepared for an impact;
Low = community is unprepared for an impact]

Figure 6. A sample adaptation need matrix.
This matrix combines the ratings for the extent of impact and the current community capacity to address the impact. Those impacts with the most severe consequences and lowest local capacity to address them are rated the highest adaptation need.

2. Identify the level of certainty associated with climate change impacts. This is the information from Step 5. The following decision matrix balances certainty, or risk, with community priorities (see Figure 7). This approach allows room for strategy development to address impacts with the potential to be so disruptive that they deserve action even if the impacts are unlikely. The climate change adaptation team should determine the shading in the matrix.

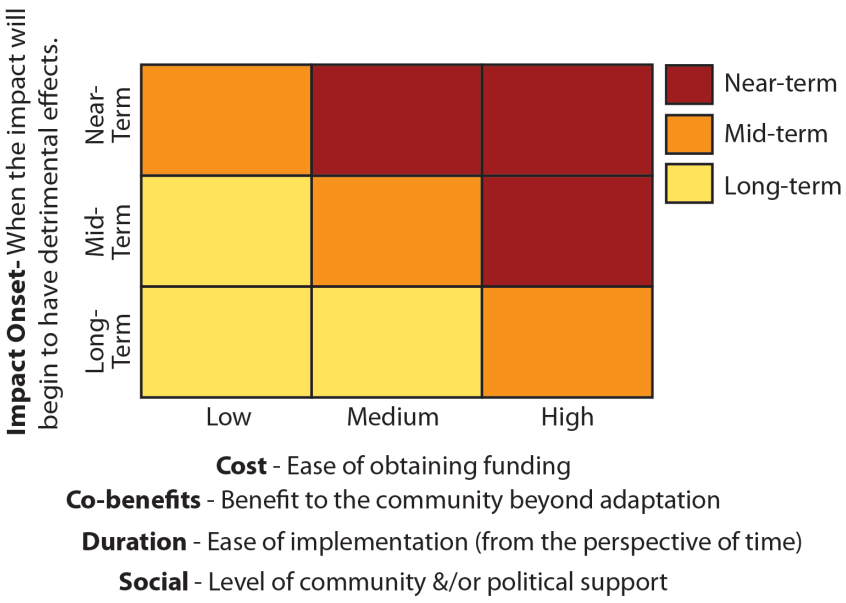


Figure 7. A sample decision matrix.
Intended to be adjusted depending on community characteristics. The sample matrix combines adaptation need with scientific certainty and community sensitivity to a given impact.

3. Using the decision matrix, develop a list of adaptation impacts that have been identified for immediate strategy development. In a sense, a jurisdiction should be able to organize all of its identified impacts (adaptation needs) into one of the cells on the matrix. The rating for each impact will vary by jurisdiction based on the jurisdiction's location and community characteristics.

Prioritize Adaptive Needs Example 1

A community located in the Sierras, with an economy largely reliant on the ski industry and other recreational endeavors, identified reduced snowpack as a critically important climate exposure, with the local economy and ecosystems being two aspects identified as sensitive to the loss of snowpack. These points of sensitivity relate to a far-reaching set of potential impacts, from ecosystem health, to hazards, to the economy. The potential impact of a more than 80 percent loss of spring snowpack by 2100 on the local economy is severe enough that the impact was labeled high by the local adaptation team.

EXAMPLE 1 (CONT'D)

While some measures have been enacted to diversify the local economy away from snow-based recreation, the measures are poorly developed. The adaptive capacity was defined as low because, while some actions have been taken, they are not at a scale adequate to address the severity of the projected snowpack reduction. The combination of high impact and low capacity makes the economic impact of snowpack reduction a high adaptation need.

Snowpack reduction is rated as a high certainty projection (see Table 4). Snowpack impacts on the local economy were designated for adaptation strategy development.

Step 7. Identify Strategies: Which strategies should be pursued to address adaptation needs?

Outcome: A strategy or set of strategies to address each adaptation need identified for strategy development.

Developing adaptation strategies is challenging because they address impacts that can be difficult to accurately predict and that may occur many years in the future. These strategies must be as varied as the biophysical settings and community types in the state. In addition, community and political support for these strategies may require that they address community needs above and beyond climate adaptation.

APG: Identifying Adaptation Strategies lists potential adaptation strategies and some of the necessary considerations for tailoring them for local use. The collection of strategies included in that document is not exhaustive. Jurisdictions should think creatively about the best way to address a community's adaptive needs.

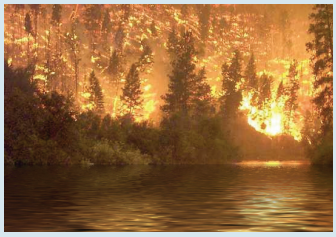
Good adaptation strategies include the following characteristics (Smit et al., 2000; de Loe, Kreutzwiser, and Moraru, 2001; Smit and Wandel, 2006; Boswell, Seale, and Greve, 2012):

- **Flexible.** Adaptation planning occurs in a setting that is continually changing. Climate science is uncertain and evolving with new reports and updates being released regularly. Local conditions also evolve over time. As a result, adaptive policy should be robust, meaning it will be applicable even if conditions change. Strategies should be adjustable over time as conditions and projects change.
- **Cost-Effective.** Communities have a wide range of needs above and beyond climate adaptation. Setting priorities for adaptation planning development is made

even more difficult because successful implementation (benefits) may be in the distant future. As a result, the best adaptation strategies meet multiple community needs and provide both short- and long-term benefits.

- **Specific.** Adaptation needs often have specific characteristics by addressing, for example, a particular region of impact, speed of onset, or scale of consequences. The most effective strategies are tailored for these characteristics.
- **Integrative.** The most important impacts for a community are often secondary impacts such as wildfire, crop yield, or human health. These impacts commonly result from the interaction of multiple aspects of climate change (e.g., the interaction of temperature and precipitation). Local and regional entities often do not have the jurisdictional control to affect climate change directly. For example, no individual city is going to stop rising average global temperature or ocean acidification. As a result, climate change adaptation strategies should focus on secondary impacts by preparing an affected sector to be more resilient. For example, many climate change impacts have the potential to harm the local economic base.
- Adaptation policy, in this case, may be an economic diversification effort that will lessen the impact of climate-related economic outcomes. The outcome from this step should be a strategy or suite of strategies for each of the impacts identified in Step 6 as warranting policy development.

Strategy Identification Example 1



A community located in Siskiyou County is projected to experience an almost eight-fold increase in wildfire over 2010 levels. The adaptation team in this region identified this increased risk as a high potential impact due to the threats to infrastructure, public safety, ecosystem health, and other areas. The adaptive capacity evaluation evaluated existing wildfire policy including the general plan safety element and Local Hazard Mitigation Plan. Building and zoning codes were also evaluated to assess the vulnerability of areas at the wildland-urban interface (WUI). Finally, current fire response emergency procedures were evaluated.

Following this evaluation, it was determined that existing policy was inadequate for the size of increase in wildfire risk projected for the region. The adaptation team identified a set of complementary policies to prepare for the increased fire risk in the future. These strategies included the following:

- Update the general plan safety element and Local Hazard Mitigation Plan to reflect the changing risk profile for wildfire including emergency response capabilities and evacuation plans (Based on Strategy CA 1 from *APG: Identifying Adaptation Strategies*, p. 9.)

EXAMPLE I (CONT'D.)

- Adopt fire-safe development and landscaping standards for WUI areas. These measures were adapted for Northern California settings based on lessons learned from communities such as Rancho Santa Fe that have detailed, effective fire suppression and homeowner safety practices. (Based on Strategy FR 5 from *APG: Identifying Adaptation Strategies*, p. 42.)
- Establish a fuel load reduction program through thinning and brush removal. (Based on Strategy FR 6 from *APG: Identifying Adaptation Strategies*, p. 44.)
- Establish an ongoing public education program to raise awareness of the new standards for landscape management around homes in the WUI areas. (Based on Strategy CA 2 from *APG: Identifying Adaptation Strategies*, p. 10).

Step 8. Evaluate and Prioritize Strategies: Which strategies should be implemented first?

Outcome: For each strategy identified define the implementation timing: near-term, mid-term, and long-term.

This step is based on characteristics of the impact being evaluated and the strategies devised to address it. Similar to setting priorities for adaptation needs (Step 6), this step also relies on a decision matrix. The matrix not only aids in making decisions in the context of complexity, but also makes the strategy development process transparent and easier to communicate to community staff and residents. The relevant information about each climate change impact has already been identified through earlier steps in the process. The information needed for each strategy includes projected costs of implementation, community co-benefits, duration of implementation, and social acceptance. The information regarding each strategy should be developed by the climate change adaptation team. This step is likely most efficiently addressed if completed simultaneously with Step 7 as an iterative process.

The following tasks are recommended:

1. Evaluate each strategy. Information helpful for systematic assessment includes the following (Smit et al., 2000; Smith, Vogel, and Cromwell, 2009; Boswell, Seale, and Greve, 2012):
    a. **Costs.** This should include the initial costs, as well as any ongoing personnel or funding requirements. If possible, potential sources for the funding should also be identified.
    b. **Community Co-Benefits.** The other benefits that a community may experience if the strategy is implemented should be identified. These can include greenhouse gas reduction, economic improvement, and many other potential community goals. These co-benefits, particularly those

experienced in the near term, are often helpful in garnering community and political support for a strategy.

c. **Duration of Implementation.** Consider (1) the period of time necessary to initiate implementation, and (2) the length of the implementation period. Some strategies may rely on technological advancements or require policy change prior to implementation. This will delay the initiation of a strategy. Similarly, implementation duration can vary widely. Updating the building code to reduce fire vulnerability will take much less time than the eventual relocation of a coastal water reclamation facility.

d. **Social Acceptance.** This refers to the fact that many adaptation policies will be housed in plans that require community feedback, advisory board approval, and adoption by elected officials. To successfully navigate this process, a strategy's likely level of approval should be assessed. This does not mean that less popular strategies should be abandoned but that, if these strategies are pursued, additional time or outreach efforts should be developed to accompany the strategies.

2. Using the sample matrix in Figure 8, evaluate the ease of implementation (e.g., cost and time) in relationship to the impact onset. Create a series of individual matrices or a table that displays all of the potential considerations (see Table 4). The Figure 8 matrix combines impact potential and factors that influence strategy feasibility. As with the matrix in Step 6, the specifics should be determined by the climate change adaptation team. In particular, the adaptation team should determine the definition of near-, mid-, and long-term from a policy development perspective.

3. Organize the strategies according to when they need to be implemented (near-, mid-, and long-term; see Figure 8).

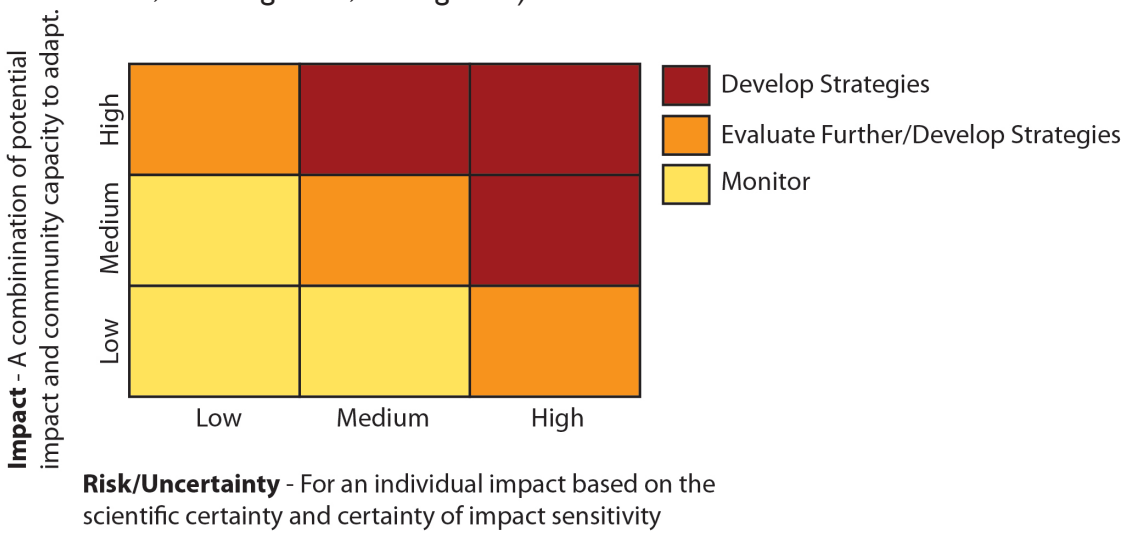


Figure 8. Sample adaptation strategy prioritization matrix.
[adapted from Boswell, Greve, & Seale, 2012]

Evaluate and Prioritize Strategies Example 1

A coastal community concerned about sea level rise has identified a series of potential strategies and completed a table identifying co-benefits and other feasibility considerations. The adaptation team completed the table. Based on this evaluation, strategies were identified as near-, mid-, and long-term (see Table 5).

Table 5. Example co-benefit and feasibility table for determining strategy phasing.

STRATEGY	IMPACT ADDRESSED	CO-BENEFITS	IMPACT ONSET	IMPLEMENTATION COST	FUNDING AVAILABILITY	PREPARATION TIME	IMPLEMENTATION TIME	COMMUNITY SUPPORT	IMPLEMENTATION PHASE
Strategic retreat – easement	SLR	Ecosystem & Biodiversity	Mid-term	High	Low	Medium	Medium to High	Moderate	Mid-term, as parcels available
Undeveloped land preservation	SLR	Ecosystem; Recreation & Open Space; Tourism	Mid-term	Medium	Medium	Medium	Medium	High	Near-term
Move roadway inland	SLR	Public Safety	Mid-term	Low to Medium	Medium	High	Medium	Medium	Mid-term
Re-locate water reclamation facility	SLR	Public Health	Long-term	High	Medium	High	High	Medium	Long-term

SLR: sea level rise.

Evaluate and Prioritize Strategies Example 2:

City of Santa Cruz Wastewater Treatment Facilities

The City of Santa Cruz evaluated potential climate impacts including wildfire, erosion, sea level rise, and more as part of preparation of a City Adaptation Plan.

The evaluation of impact was assessed based on two rating systems (City of Santa Cruz, 2012, p. 33-34):

Cost ratings

- High: Existing funding levels are not adequate to cover the costs of the proposed action and would require an increase in revenue through an alternative source to implement.
- Medium: The action could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the action would have to be spread over multiple years.
- Low: The action could be funded under the existing budget. The action is part of, or could be a part of, an existing, ongoing program.

Benefit ratings

- High: Action would have a significant impact on the reduction of risk exposure to life and property.
- Medium: Action would have an impact on the reduction of risk exposure to life and property or action would provide an immediate reduction in the risk exposure to property.
- Low: Long-term benefits of the action are difficult to quantify in the short term.

The outcome of the evaluation resulted in the City concluding "Wastewater Treatment Facility appears to be the highest potential dollar loss under current climate science," (p. 10). As a result of the climate impact assessment the following strategies were defined (p. 34).

- A-4 Protect wastewater facility from ground water infiltration Public Works
- A-5 Seal wastewater pipes throughout system Public Works
- A-6 Seal pump gallery at wastewater treatment facility Public Works
- A-7 Monitor all wastewater and storm water pumping station sites Public Works

Source: City of Santa Cruz. (2012). City of Santa Cruz Climate Adaptation Plan. Retrieved from http://www.cityofsantacruz.com/Modules/ShowDocument.aspx?documentid=23643

Step 9. Phase and Implement: How can the strategies be funded, staffed, and monitored?

Outcome: An implementation plan and monitoring program for each of the identified strategies.

As with other types of planning strategies, success in phasing and implementation of climate change adaptation strategies depends on a number of factors. A responsible or lead department, staff member, or entity should be defined as responsible for implementation; a phasing program should be established; a funding source should be identified and obtained; and a monitoring program should be developed. In addition to these factors, long-term effectiveness relies on strong political leadership. Adaptation policies often address impacts projected to occur in the future and are unlikely to yield observable benefits in the short term. Successful implementation therefore relies on consistent and sustained support. Strong leadership is needed due to the diverse nature of adaptation planning and the necessity for continual updating. In the long term, actions by many departments must continue to be coordinated.

The following tasks are recommended:

1. **Identify the responsible party.** Defining a specific individual, department, agency, or organization as responsible for implementation is one component of assuring that a strategy is implemented rather than simply included in a plan or guidance document. The climate change adaptation team can define the responsible parties and can also provide a forum for implementation progress to be shared.

2. **Identify funding**. Perhaps the most difficult and important component of assuring implementation is identifying a funding source to support identified strategies. Each strategy should have an associated estimated cost that includes material cost of the strategy, staff time, administrative support, associated outreach, and long-term monitoring. Adaptation strategies must compete with all of the other needs in the community. This is why identifying strategies that can meet multiple community needs is suggested. There are a variety of ways in which adaptation strategies can be funded including government grants, general funds, taxes and fees (including impact fees), bonds, and more.

3. **Establish systems for monitoring and diffusion of information and technology.** Adaptation occurs in a dynamic setting. As a result, even while individual strategies require monitoring to assess effectiveness, the science that projected the impact being addressed is changing as well.

A comprehensive adaptation program must track scientific updates as well as the tools and technology available to address the impact projections. The State of California has established web resources that make available the findings from ongoing research on climate change and the tools available to address it. Communities should make an effort to stay informed of these advances.

4. **Establish feedback loops**. Monitoring strategy effectiveness and science advancements is only valuable if used to adjust adaptation strategies when necessary. An adaptation strategy should integrate periodic review and updates into its implementation plan. Given the uncertainty inherent in climate projections and impact assessment, an adaptive approach is critical to long-term policy effectiveness and efficient use of resources.

Completed Project Example: IRONHORSE AFFORDABLE APARTMENTS

In Oakland, the Ironhorse at Central Station Affordable Apartments provides a great example of a project that addressed a variety of community needs in addition to several climate change adaptation priorities. This multi-faceted project was able to acquire funding from multiple sources due to the diversity of community needs served by the project. The 1.6-acre project is part of a 29-acre master plan on former industrial land near the Port of Oakland and includes 99 units, all of which are designated for families at or below 50 percent of the median income in the area.

The project earned Bay-Friendly (landscaping) and Green-Point (green building) ratings and includes the following features:

- Solar panels and green roofs on the tops of buildings, providing the following benefits:
  - Runoff control (adaptation)
  - Reduced water need (adaptation)
  - Improved climate control and reduced need for heating and cooling for residents (adaptation and greenhouse gas emissions co-benefit)
  - Improved air quality (adaptation and public health co-benefit)
  - Reduced urban heat island (adaptation)
  - Renewable energy (adaptation and greenhouse gas emissions co-benefit)

Completed Project Example (cont'd.)

- Multi-function landscaping that serves to provide the following benefits:
  - Stormwater treatment (adaptation and water quality co-benefit)
  - Habitat (adaptation)
  - Reduced water demand (adaptation and greenhouse gas emissions co-benefit)
  - Food for residents (adaptation)

Ironhorse at Central Station: http://www.stopwaste.org/docs/ironhorse_final_090810.pdf
Bay-Friendly Rated Landscapes: http://www.stopwaste.org/home/index.asp?page=1115
Green Point Rated: http://www.builditgreen.org/greenpoint-rated/

Impact Sector Summary

The supporting documents for the APG (see Page 1) use sectors to categorize potential climate change impacts. These sectors can help assure a comprehensive assessment of climate vulnerability. The following discussion summarizes the seven sectors and potential impacts associated with each. Understanding the range of potential impacts can aid a community in conducting a vulnerability assessment and developing strategies. These sectors overlap, but they represent one way to organize the diversity of potential impacts. The document *APG: Defining Local & Regional Impacts* has a section focused on the assessment of vulnerability for each sector. The document *APG: Identifying Adaptation Strategies* organizes adaptation strategies based on sector. Where possible, points of overlap between the sectors are identified using the icons below.

Public Health, Socioeconomic, and Equity Impacts

Ocean and Coastal Resources

Water Management

Biodiversity and Habitat

Forest and Rangeland

Agriculture

Infrastructure

Public Health, Socioeconomic, and Equity Impacts

This sector includes the public health and socioeconomic impacts and related equity issues associated with climate change impacts. Public health impacts include the short-term effects of climate-related hazards—heat events, intense rainstorms and flooding, wildfires, and high tide and storm surges—and long-term impacts such as cardio-respiratory morbidity and mortality, food-, water- and vector-borne diseases, food insecurity and water contamination (Maibach et al., 2011). Socioeconomic impacts include potential effects upon California's economic growth (Sanstad et al., 2011; CEC, 2009) and on specific industries within the state, such as agriculture (Medillin-Azuara et al., 2011; Deschenes and Kolstad, 2011) and tourism (Pendleton et al., 2011). These changes increase the vulnerability of local populations that rely on these industries. Equity concerns are based on the idea that some populations bear a disproportionate burden of the climate change effects (Morello-Frosch et al, 2009).

Ocean and Coastal Resources

Changes such as sea level rise, intensification of coastal storms, and ocean acidification may affect ocean and coastal resources. Potential environmental impacts of these changes include coastal flooding/inundation, loss of coastal ecosystems, coastal erosion, shifts in ocean conditions (pH, salinity, etc.), and saltwater intrusion. The combination of sea level rise and possible intensification of coastal storms presents a threat to coastal development and infrastructure. Climate-related changes to marine ecosystems may result in altered population and ranges of fish species, which affect productivity and the commercial fishing industry. With 85 percent of California's residents living in coastal counties, sea level rise could potentially damage whole communities by affecting tourism, the provision of basic services (e.g. wastewater treatment), and recreational economies.

Water Management

Climate change may result in flooding, drought, and/or reduced water supply in communities. Although the scientific evidence regarding increased flooding related to climate change remains uncertain, it is prudent for communities to recognize that changes to precipitation regimes and rate/timing of snowmelt may increase flooding. The water supply includes both surface water and ground water, along with the infrastructure necessary for management, conveyance, and treatment. Water supply is expected to be affected in areas that experience less precipitation and areas dependent on snowpack.

Biodiversity and Habitat

Climate change may affect terrestrial and freshwater aquatic habitats and the species that depend on them. California is a unique hot spot of biodiversity (CEC, 2009). Changes in the seasonal patterns of temperature, precipitation, and fire due to climate change can dramatically alter ecosystems that provide habitats for California's native species. These impacts can result in species loss, increased invasive species' ranges, loss of ecosystem functions, and changes in growing ranges for vegetation.

Forest and Rangeland

Climate can have an influence on wildfire and forest health. In forest ecosystems, climate change can alter the species mix, moisture and fuel load, and number of wildfire ignitions. Changes in species mix and moisture due to dry periods can alter wildfire timing (seasonality and frequency), spatial distribution (fire size and complexity), and magnitude (intensity, severity, and type). These changes in wildfire character are related to a range of forest health indicators such as growth rate, invasive species, erosion, and nutrient loss.

Agriculture

The threats posed by climate change have the potential to influence crop and livestock productivity. These changes can have far-reaching impacts, from altering the local economy to affecting food supply. Climate change can affect agriculture through extreme events (e.g., flooding, fire) that result in large losses over shorter durations, or through more subtle impacts such as changes in annual temperature and precipitation patterns that influence growing seasons or livestock health. These impacts also have the potential to result in a range of associated consequences such as altered pest and weed ranges, reduced air quality, and reduced farm worker safety (heat and air quality).

Infrastructure

Infrastructure provides the resources and services critical to community function. Roads, rail, airports, marine ports, water (supply, storm, and sewer), electricity, gas, and communication systems are all needed for community function. Climate change increases the likelihood of both delays and failures of infrastructure. Temporary delays or outages can result in inconvenience and economic loss while larger failures can lead to disastrous economic and social effects. Climate impacts include direct events such as fire, flood, or landslide. Climate change can also alter the level of demand and required maintenance necessary to manage these systems.

Adaptation Resources

The following list of documents and websites is a resource that can aid a community developing climate change adaptation strategies. If a particular area of concern emerges during vulnerability assessment, these documents can provide additional information and guidance. The other three APG documents also supply information to further support the adaptation planning process.

Resources providing state guidance and recent studies

- General guidance on integration into local government policy: www.OPR.ca.gov
- Other climate change resources: www.climatechange.ca.gov

Climate adaptation resources developed by California State Agencies

California Department of Fish and Game (CDFG). 2007. *California Wildlife: Conservation Challenges - California's Wildlife Action Plan*. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html

California Department of Fish and Game (CDFG). 2011. *Unity, Integration, and Action: DFG's Vision for Confronting Climate Change in California*. Retrieved from http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=37647&inline=true

California Department of Public Health (CDPH). 2012. *Climate Action for Health: Integrating Health into Climate Action Planning*. Retrieved from http://www.cdph.ca.gov/programs/CCDPHP/Documents/CAPS_and_Health_Published3-22-12.pdf

California Department of Water Resources (DWR). 2011. *Climate Change Handbook for Regional Water Planning.* Retrieved from http://www.water.ca.gov/climatechange/docs/Climate_Change_Handbook_Regional_Water_Planning.pdf

California Emergency Management Agency (Cal EMA). 2010. *State of California Multi-Hazard Mitigation Plan.* Sacramento, CA: Retrieved from http://hazardmitigation.calema.ca.gov/docs/2010_SHMP_Final.pdf

California Natural Resources Agency (CNRA). 2009. *2009 California Climate Adaptation Strategy.* Retrieved from http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf

Moser, S., J. Ekstrom, and G. Franco. 2012. *Our Changing Climate 2012 - Vulnerability & Adaptation to the Increasing Risks from Climate Change in California.* California Energy Commission [CEC], CEC-500-2012-007, Retrieved from http://www.climatechange.ca.gov/adaptation/third_assessment/

Russel, N. & G. Griggs. 2012. *Adapting to Sea Level Rise: A Guide for California's Coastal Communities.* California Energy Commission Public Interest Environmental Research Program, Retrieved from http://calost.org/pdf/announcements/Adapting%20to%20Sea%20Level%20Rise_N%20Russell_G%20Griggs_2012.pdf

Page Intentionally Left Blank

References

Boswell, MR, AI Greve, & TL Seale. (2012). Local Climate Action Planning. Washington D.C.: Island Press, 284 p.

California Energy Commission [CEC]. (2009). The Impact of Climate Change on California's Ecosystem Services. Retrieved from: http://www.energy.ca.gov/2009publications/CEC-500-2009-025/CEC-500-2009-025-F.PDF

California Natural Resources Agency. (2009). 2009 California Climate Adaptation Strategy. Retrieved from: http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf

Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT). 2010. *State of California Sea-Level Rise Interim Guidance Document.* Retrieved from http://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20110311/12.SLR_Resolution/SLR-Guidance-Document.pdf

de Loe, R, R Kreutzwiser, & L Moraru. (2001). Adaptation Option for the Near Term: Climate Change and the Canadian Water Sector. Global Environmental Change, 11: 231-245.

Deschenes, O. & C. Kolstad. (2011) Economic impacts of climate change DOI 10.1007/s10584-011-0314-3

Federal Emergency Management Agency. (2001). Understanding Your Risks: Identifying Hazards and Estimating Losses. FEMA 386-2. Retrieved from: http://www.fema.gov/library/viewRecord.do?id=1880

IPCC. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. Retrieved from: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm

Maibach E, Nisbet M, & Weathers M. (2011) Conveying the Human Implications of Climate Change: A Climate Change Communication Primer for Public Health Professionals. Fairfax, VA: George Mason University Center for Climate Change Communication.

Medellín-Azuara, J, R. Howitt, J. Duncan, J. MacEwan & J. Lund. (2011) Economic impacts of climate-related changes to California agriculture. Climatic Change, 109 (Suppl 1):S387–S405

Moser, S, G Franco, S Pittiglio, W Chaou, & D Cayan. (2009). The Future is Now: An Update on Climate Change Science Impacts and Response Options for California. California Energy Commission Report CEC-500-2008-071. Retrieved from: http://www.energy.ca.gov/2008publications/CEC-500-2008-077/CEC-500-2008-077.PDF

National Academy of Sciences (NAS). 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Retrieved from http://www.water.ca.gov/climatechange/docs/NRC_SLR_Draft-06-22-2012.pdf

Pendleton, L. P. King, C. Mohn, D. Webster, R. Vaughn & P. Adams. (2011). Estimating the potential economic impacts of climate change on Southern California beaches. Climatic Change, 109 (Suppl 1):S277–S298. DOI 10.1007/s10584-011-0309-0

Smit, B & J Wandel. (2006). Adaptation, Adaptive Capacity and Vulnerability. Global Environmental Change, 16: 282-292.

Smit, B, I Burton, R.J.T. Klein, & J. Wandel. (2000). An Anatomy of Adaptation to Climate Change and Variability. Climatic Change 45: 223-251.

Smith, JB, JM Vogel, & JE. Cromwell III. (2009). An Architecture for Government Action on Adaptation to Climate Change: An Editorial Comment. Climate Change, 95: 53-61.

Snover, AK, LW Binder, J Lopez, WJ Kay, D Howell, & J Simmonds. (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. In association with and published by ICLEI – Local Governments for Sustainability, Oakland, CA.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christenson, L., Eckley, N., Kasperson, J.X., Luer, A., Martello, M.L., Polsky, C., Pulsipher, A., & Schiller, L. (2003). A framework for analysis in sustainability science. Proceedings of the National Academy of Sciences of the United States of America, 100(14): 8074-8079.