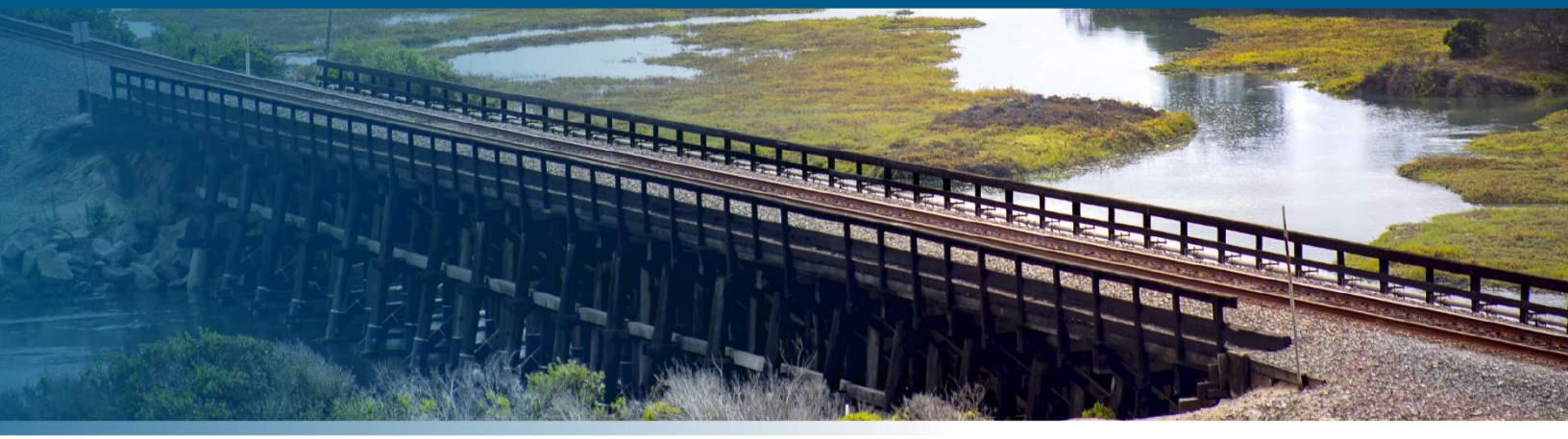
Assessing Climate Exposures and Measures to Reduce Vulnerabilities

CHAPTER 4



Introduction

This chapter provides a method to assess the potential benefits of different climate risk reduction measures at the project level. The climate exposures, sensitivities, and adaptive capacities of a project or asset all influence their vulnerabilities to current and expected impacts of climate change. This chapter presents a step-by-step process to identify and score these variables. These scores should be used to establish an initial vulnerability score, which will allow users to identify priority vulnerabilities, as well as measures to reduce these vulnerabilities. This chapter also provides descriptions of climate vulnerability reduction measures and guidance for assessing adaptive benefits of selected measures.

Climate change has already profoundly affected California's natural resources, communities, and infrastructure, and will continue to do so in the future. Existing and future developments must consider climate change in their planning processes to adequately prepare for anticipated hazards and risks. This chapter guides users through estimating their project's site- or regional-level climate vulnerability, as well as selecting risk reduction measures to address those vulnerabilities.

The *Adaptation Planning Guide* (APG) is the state's comprehensive guidance for assessing climate vulnerability at the local level. The APG is hosted on the California's Governor's Office of Planning and Research's (OPR) Resilient-CA website, where additional materials and local adaptation case studies can also be found. Resilient-CA is regularly updated as new climate vulnerability assessments are completed. To ensure alignment with the state's overall approach to vulnerability assessments, this chapter follows the structure and processes outlined in the APG, which was last revised in 2020 (OPR 2020).

The guidance presented in this chapter should be used as a starting point to help users understand and begin to analyze potential climate vulnerabilities. The methodology should not replace a full climate vulnerability assessment performed using the APG or other resources. Moreover, the scores alone should not be used to define or communicate the climate risks for a project. A climate vulnerability score of 5, for example, does not mean that a project will face certain climate catastrophe. Similarly, a score of 1 does not mean that a project will not face any climate hazards. The purpose of the Handbook scoring method is to aid users in prioritizing the most significant climate risks so that they can select appropriate risk reduction measures for their project. Users seeking a more thorough or tailored analysis should refer to the APG, the Resilient-CA website, or other resources (provided later in this chapter).

Assessing Climate Vulnerability and Risk Reduction

The step-by-step process detailed in this chapter is outlined below.

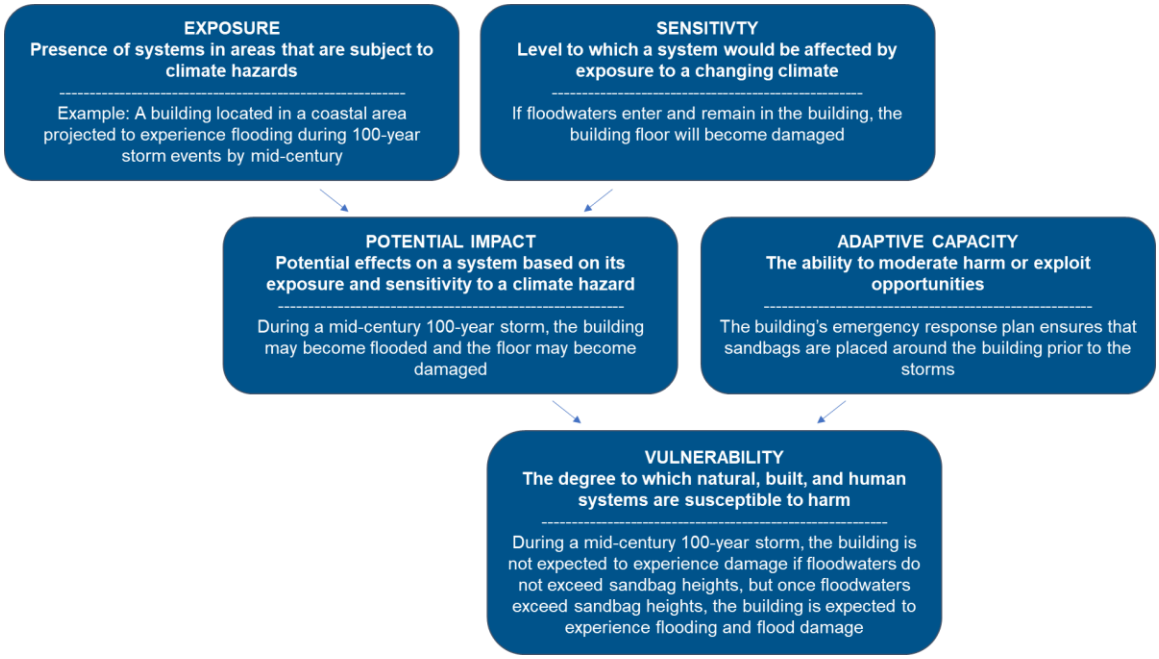
1. *Establish Initial Vulnerability Score* – this step guides the user through a high-level assessment of the contributing elements to a project's climate vulnerabilities, including exposure, sensitivity, and existing adaptive capacity to projected climate hazards. Steps for establishing the vulnerability score are as follows.
    a. Determine exposure score.
    b. Determine sensitivity score.
    c. Determine adaptive capacity score.
    d. Develop overall vulnerability score.
2. *Select Measures and Assess Vulnerability Reduction* – after establishing the initial vulnerability score, this step guides the user through selecting measures that can effectively reduce climate vulnerabilities. It also provides guidance for determining measure costs and benefits. Steps identifying and assessing vulnerability reduction measures are as follows.
    a. Select climate risk reduction measures.
    b. Identify adaptation benefits.
    c. Identify adaptation co-benefits.

Initial Vulnerability Score

Climate hazards, such as sea level rise, wildfire, flooding, and heat waves, will increasingly affect projects and project sites. The climate vulnerability of a project refers to the extent to which a project site or community is susceptible to harm from these climate hazards. In this step, users will establish a baseline for the current and projected vulnerabilities from climate hazards.

Developing an overall vulnerability score consists of combining three elements: exposure, sensitivity, and adaptive capacity. Figure 4-1 from the *California Adaptation Planning Guide* shows how these elements combine to determine climate vulnerability (Cal OES 2020).

Figure 4-1. Vulnerability Assessment Process in California Adaptation Planning Guide (Source: California's Governor's Office of Emergency Services 2020)



The following sub-steps provide guidance on developing scores to assess a project's exposure, sensitivity, and adaptive capacity. Users should first score these three components separately, using guidance provided below in the form of maps, tables, and guiding questions. Users will carry out the vulnerability scoring process in the following way.

1. Score the project's exposure to each climate hazard on a scale of 1 to 5.
2. Score the project's sensitivity to each climate hazard on a scale of 1 to 5.
3. Rate the project's adaptive capacity to each hazard using the ranking system of Low, Low–Med, Med, Med–High, and High. (Adaptive capacity is not scored from 1 to 5 to avoid confusion as the numeric scale for this component would be reversed from the scale for exposure and sensitivity.)

4. Average the project's exposure and sensitivity scores to develop a potential impact score for each climate hazard from 1 to 5.
5. Combine the potential impact scores and adaptive capacity ratings to develop a vulnerability score for each climate hazard from 1 to 5.
6. Select the highest-scoring vulnerabilities to address as priority climate vulnerabilities.

This section also provides a *use case example* for a hypothetical affordable housing project in Los Angeles County to illustrate these sub-steps and how to arrive at a final vulnerability score. Users can follow along the example to understand how the scoring system works, what kind of project characteristics may justify a score, and how users can use their final vulnerability score to choose adaptation measures.

Determine Exposure Score

This section guides the user through the following sub-steps to determine the exposure score.

1. Identify key climate hazards based on the project site location.
2. Select initial regional exposure scores.
3. Refine initial regional exposure scores.

The following sections provide a high-level exposure map and accompanying table for users to identify key climate hazards. Guiding questions and resources to define the exposure score from 1 to 5 (with 1 being the least exposed and 5 being the most exposed) are then presented.

Identify Key Climate Hazards

Figure 4-2 shows the nine main climate regions of California as identified in the *California Fourth Climate Change Assessment* (Bedsworth et al. 2018).

Identify the climate region in which the user's project is located (Figure 4-2).

Use Case Example: The project is in the Los Angeles Region.

Figure 4-2. Illustrative Climate Hazards in Nine Climate Regions of California under the California Fourth Climate Change Assessment

Select Initial Regional Exposure Scores

For each of the nine regions, the *California Fourth Climate Change Assessment* identifies the most significant climate hazards, summarized in Table 4-1, along with initial regional exposure scores that allow users to screen for the hazards of greatest concern to their geography. These initial regional scores are based on an analysis of Cal-Adapt and the *California Fourth Climate Change Assessment's* summaries of the most relevant climate hazards in each region. Where given, a range reflects how much the vulnerability to climate change can vary within that region. For example, sea level rise does not occur everywhere in San Francisco (score of 1), but it can be a significant vulnerability (score of 5) for coastal areas.

Locate the climate region for the user's project in Table 4-1 and record the initial regional exposure score for each hazard.

Table 4-1. Initial Regional Climate Hazard Exposure Values [a]

Region	Sea Level Rise	Flooding	Temperature and Extreme Heat	Extreme Precipitation	Wildfire	Drought	Decrease in Snowpack	Air Quality Degradation
Central Coast	1–5	1–2	1–5	1–5	1–5	3–4	1–2	1–2
Inland Deserts	N/A	1–2	1–5	1–5	1–5	3–5	1–2	2–4
Los Angeles	1–5	1–3	1–5	1–5	1–5	4–5	2–3	3–5
North Coast	1–5	2–3	1–5	1–5	1–5	3–4	3–4	1–2
Sacramento Valley	N/A	3–4	1–5	1–5	1–5	3–4	2–3	3–4
San Diego	1–5	2–3	1–5	1–5	1–5	3–4	1	3–4
San Francisco Bay Area	1–5	2–4	1–5	1–5	1–5	2–4	2–4	3–4
San Joaquin Valley	N/A	2–3	1–5	1–5	1–5	3–5	2–4	2–3
Sierra Nevada	N/A	3–4	1–5	1–5	1–5	3–4	5	1–3

[a] Within the CalEEMod tool, some hazards (sea level rise, temperature and extreme heat, extreme precipitation, and wildfire) are evaluated in regional quantiles using Cal-Adapt data; to ensure consistency between this Handbook and CalEEMod, these four hazards have a score range of 1 to 5 here. The score range for the remaining four hazards (flooding, drought, decrease in snowpack, and air quality degradation) are based on a comparison of relevant hazards summarized in the *California's Fourth Climate Assessment* regional reports.

Use Case Example: The following climate hazards and initial regional exposure scores are applicable for the Los Angeles region.

- Sea level rise: 1–5
- Flooding: 1–3
- Temperature and extreme heat: 1–5
- Extreme precipitation: 1–5
- Wildfire: 1–5
- Drought: 4–5
- Decrease in snowpack: 2–3
- Air quality degradation: 3–5

Based on these initial regional scores, significant region-wide climate hazards for the Los Angeles region include sea level rise, temperature and extreme heat, extreme precipitation, wildfire, drought, and air quality degradation.

Refine Initial Regional Exposure Scores

Where Table 4-1 offers a range (e.g., 1–3) for a climate hazard exposure score, users can refine that range to a single score that is more specific to a project location. Table 4-2 provides key questions and considerations users could use to refine their exposure scores for their region. For example, a user with a site in the San Francisco Bay Area within the Coastal Zone Boundary that has experienced coastal flooding in the past should consider a "5" hazard rating for sea level rise.

Table 4-2 also indicates whether each question refers to a project area's past or potential future climate exposure. This distinction is important because susceptibility to climate hazards in the past is one factor indicating susceptibility to climate hazards in the future. However, the lack of past exposure does not mean future climate hazards will also be the same. As the climate changes, the frequency and severity of climate impacts increase, and climate risk areas extend beyond historic boundaries. Users should keep this in mind as they refine the initial exposure scores.

Table 4-2. Guidance Questions for Refining Initial Climate Hazard Exposure Scores

Past vs. Future	Question	User Answer	Exposure Score
Sea Level Rise			
Past	Has the project area experienced flooding in the past?	Yes	High
		No	Low–Med
Future	Is the project area projected to experience flooding under future sea level rise?	Yes	High
		No	Low–Med
Flooding			
Past	Is the project located in a 100-year Federal Emergency Management Agency (FEMA) floodplain?	Yes	High
		No	Low
Past	Is the project located in a 500-year FEMA floodplain?	Yes	Med
		No	Low
Past	Has the project area experienced flooding in the past?	Yes	High
		No	Low–Med
Future	Is the project area projected to experience an expansion in flood risk areas, increased flood depths, or increased extreme precipitation events?	Yes	High
		No	Low–Med
Temperature and Extreme Heat			
Past	Is the project located in an urban heat island? (Is the project located in a dense urban or suburban environment?)	Yes	High
		No	Med
Future	Is the project area projected to have higher projected temperature and extreme heat values compared to the region as a whole?	Yes	High
		No	Low–Med
Extreme Precipitation			
Past	Has the project area experienced extreme precipitation (e.g., over the 95th percentile) in the past?	Yes	High
		No	Low–Med
Future	Is the project area projected to have higher extreme precipitation values or changes in extreme precipitation compared to the region as a whole?	Yes	High
		No	Low–Med

Past vs. Future	Question	User Answer	Exposure Score
Wildfire			
Past	Is the project located in the wildland–urban interface (WUI) (as defined by CAL FIRE hazard and/or county WUI maps)?	Yes	High
		No	Low
Past	Is the project in or near an area that experiences high wind events?	Yes	High
		No	Low–Med
Past	Is the project area composed of vegetation that could serve as significant wildfire fuel?	Yes	High
		No	Low–Med
Past	Has the project area experienced wildfire in the past?	Yes	High
		No	Low-Med
Future	Is the project area projected to have higher wildfire risk compared to the region as a whole?	Yes	High
		No	Low–Med
Drought			
Past	Has or does the project area's local government impose water conservation requirements beyond the statewide requirements?	Yes	High
		No	Low-Med
Past	Has the project area experienced curtailments in water deliveries from local surface or groundwater sources in the past?	Yes	High
		No	Low-Med
Past	Has the project area ever been identified in a state drought emergency declaration?	Yes	High
		No	Low-Med
Future	Is the project area projected to experience an increase in the frequency or severity of drought in the future?	Yes	High
		No	Low-Med
Decrease in Snowpack			
Past	Does the project rely on annual snowfall directly (e.g., recreation facility relying on snow)?	Yes	High
		No	Low-Med
Past	Does the project depend on water sources that vary annually based on snowpack?	Yes	Med
		No	Low
Future	Is the project area projected to experience a decrease in future snowpack?	Yes	High
		No	Low-Med
Air Quality Degradation			
Past	Is the project area within a nonattainment area for federal or state ambient air quality standard?	Yes	High
		No	Low
Past	Is the project area within 0.25 mile of a major freeway?	Yes	High
		No	Low
Past	Is the project area within 0.25 mile of a major industrial zone or logistics center?	Yes	High
		No	Low
Past	Is this project area within the WUI?	Yes	High
		No	Low
Future	Is the project area projected to experience a decrease in future air quality due to climate change (e.g., due to increased smoke from wildfires)?	Yes	High
		No	Low-Med

When refining the exposure score, it may be useful to refer to climate projection tools to consider climate hazard exposure in the specific area where the project will be located. Users are also encouraged to consult any local climate vulnerability assessments, local hazard mitigation plans, or other climate planning documents for their region or project area. The following resources provide additional guidance on understanding climate exposures, as well as exposure maps, that can be used to further refine the exposure score. In some cases, selecting a refined exposure score may require users to make certain assumptions or judgements.

- **CalEEMod**: This model provides an exposure mapping tool that is based on data from Cal-Adapt and the Coastal Storm Modeling System (CoSMoS) (mentioned below).[29]
- Cal-Adapt: This is the official statewide climate hazard mapping tool. Use this tool to assess exposure to temperature, precipitation, and wildfire-related hazards by location.
- Our Coast, Our Future: A web visualization tool based on data from CoSMoS. Use this tool to assess exposure to sea level rise and coastal flooding hazards.
- Adaptation Planning Guide (APG): The California Governor's Office of Emergency Services (Cal OES) provides detailed guidance for conducting vulnerability studies that can help users expand on the baseline assessment here.
- Integrated Climate Adaptation and Resiliency Program (ICARP) Adaptation Clearinghouse: OPR's official database of adaptation case studies and technical reports. Users can search the ICARP database to look for detailed vulnerability assessments covering the project site.
- Caltrans 2019 Climate Change Vulnerability Assessments: The California Department of Transportation (Caltrans) has conducted climate change vulnerability assessments for each of its 12 regions. While the focus is on resilience of the state highway system, the climate hazard analysis and recommendations can be generalized to other land uses and projects. Each region also has an interactive map that provides localized climate impact projections.

Answer the questions in Table 4-2 to refine the climate hazard exposure ranges and obtain a single score for each climate hazard.

Use Case Example: The Los Angeles project is an affordable housing building located in a highly urban area. Table 4-3 shows the initial regional exposure ranges per hazard outlined above, as well as refinements to the initial regional scores with justifications.

[29] This version of CalEEMod is still in development and will be released in 2022.

Table 4-3. Refined Exposure Scores and Justifications for Use Case Example

Climate hazard	Initial Regional Exposure Range	Refined Exposure Score	Justification for Refined Exposure Score
Sea Level Rise	1–5	1	The project is not located within an area previously subject to coastal flooding and is not in an area with projected future sea level rise.
Flooding	1–3	1	The project is not located within any Federal Emergency Management Agency flood zones or within future flood risk areas determined from local flood risk studies sourced from the Resilient-CA website.
Temperature and Extreme Heat	1–5	5	The project is in an urban heat island and in an area projected to become hotter in the future.
Extreme Precipitation	1–5	2	The project area has experienced few extreme precipitation events in the past and is not in an area projected to experience extreme precipitation in the future.
Wildfire	1–5	2	The project is not located in the wildland-urban interface or in an area projected to experience an increase in wildfire risk in the future.
Drought	4–5	5	The project relies on water that comes from imported sources and is in an area highly vulnerable to increased frequency and severity of drought in the future.
Decrease in Snowpack	2–3	3	The project relies on water that comes from imported sources that will face increased future risk under climate change.
Air Quality Degradation	3–5	5	The project is located near a major freeway and in a non-attainment area for the federal 8-hour ozone standard.

Determine Sensitivity Score

This section guides the user through determining the sensitivity score. The sensitivity score reflects the extent to which a project would be adversely affected by exposure to a climate hazard. There are multiple aspects of sensitivity to consider.

- **Physical**: How sensitive the project may be to physical damage from climate hazards. For example, wildfire can impair the structural integrity of buildings through incineration and exposure to extreme temperatures. Historical data on events for the project site and similar projects can provide insights for how sensitive the project may be to physical effects from different hazards.
- **Operational**: How sensitive the project may be to disruptions of regular operations from climate hazards. For example, flooding along roads may disrupt public transportation operations. Historical data on events for the project site, similar projects,

and critical interconnections (e.g., local energy utilities, transportation networks) will be helpful in understanding potential operational disruptions.

- **Safety**: How sensitive populations associated with a project may be to different climate hazards. For example, apartments in urban areas may become hot and not cool down easily during extreme heat events due to urban heat island effects, endangering the health of residents. Some projects may serve populations that are more vulnerable to climate hazards, such as hospitals or nursing homes.

The questions below allow the user to understand how project specifics and site historical data can help provide insights to the sensitivities of a project to climate hazards. Some of the questions, such as those on populations served by the project or project elements vulnerable to physical impacts, are specific to the project type and the user's knowledge of the project. Other questions may require the Handbook user to access existing reports for the project area. For example, historical data on hazard impacts for the project area and similar projects may be found in local hazard mitigation plans or through engaging local community planners and decision makers.

Users can take an average of their scores across the four questions below to obtain an overall sensitivity score. However, users do not necessarily need to weigh the four questions below equally. A user may, for example, weigh the question on vulnerable populations much higher than the other questions if that is the project priority. Similarly, questions below are not meant to be all-encompassing in capturing the different aspects of climate sensitivity. Users may find there are other characteristics of their project not listed below that also have a factor in determining the project's climate sensitivity. The following questions serve as guidance in helping a user think through and understand their project's climate sensitivity and address the most sensitive parts. This is important to note particularly if the scores for each question vary widely, such as projects that are not very physically sensitive to a hazard but may have highly sensitive operations.

Answer the following four questions to assign the project a sensitivity score of 1 to 5 for each climate hazard.

Question #1. How have similar projects to the user's and the project site been impacted by past extreme climate events?

Score Spectrum

- ○ Similar projects and the project area have experienced little to no effects from this hazard.
- ○ Similar projects and the project area have faced damage from this hazard that may have been major and/or permanent but does not significantly affect the project.
- ○ Similar projects and the project area have faced catastrophic damage from this hazard that resulted in permanent effects and significantly altered the project's functionality and local community.

Question #2. Does the project include elements that are susceptible to physical damage from the climate hazards (either at their historic or projected levels)?

Score Spectrum

- ○ The project has no elements that are susceptible to physical damage from this hazard, including projected severity over the project lifetime.
- ○ The project has some elements that may be physically damaged by the hazard as projected over its lifetime, but they are not significant to the functionality of the project.
- ○ The project relies significantly on elements that are likely to be physically damaged by the hazard as projected to occur over its lifetime.

Question #3. If the project includes an operational component (e.g., a utility), how might that be affected by the climate hazards (either at their historic or projected levels)?

Score Spectrum

- ○ The project does not contain an operational component that is likely to be affected the hazard.
- ○ The project has an operational component, but it will only face minor disruptions from the hazard.
- ○ The project has a significant operational component that will be affected by this hazard.

Question #4. Does the project serve vulnerable populations who may be particularly sensitive to certain climate hazards (e.g., a nursing home) at their historic and projected levels?

Score Spectrum

- ○ The project is not likely to serve any vulnerable populations.
- ○ The project serves the public, some of whom may be vulnerable populations.
- ○ The project almost exclusively serves vulnerable populations.

Use Case Example: The Los Angeles affordable housing project does not have a significant operational component, nor does it house many fragile systems. However, it is

a residence that serves a vulnerable population. We will give it the following sensitivity scores with justifications (Table 4-4).

Table 4-4. Sensitivity Scores and Justifications for Use Case Example

Climate Hazard	Question #1. (Impact of Past Events)	Question #2. (Elements Prone to Historic or Projected Damage)	Question #3. (Operations Vulnerable to Historic or Projected Hazards)	Question #4. (Populations Vulnerable to Historic or Projected Hazards)	Final Sensitivity Score
Sea Level Rise	1—Sea level rise impacts have not occurred in this location in the past	2—Building is slightly elevated, so inundation not likely to infiltrate units	3—Apartment operations may face minor disruptions from inundation, particularly if flooding occurs at a level not seen in the past	4—Serves low-income populations that may be sensitive to inundation from sea level rise, particularly if flooding occurs at a level not seen in the past	3
Flooding	4—Similar projects have faced damage or inaccessibility from flooding	2—Building is slightly elevated, so inundation not likely to infiltrate units	4—Apartment operations and access may face minor disruptions from inundation, particularly if flooding occurs at a level not seen in the past	4—Serves low-income populations that may be sensitive to flooding, particularly if flooding occurs at a level not seen in the past	4
Temperature and Extreme Heat	5—Other apartment buildings around this location have been affected by extreme heat in the past	2—Electrical equipment inside may be sensitive to extreme heat, but overall building is not	4—Cooling equipment may fail more frequently due to working outside of original design parameters	5—Serves low-income residents who may be especially sensitive to extreme heat due to cost of energy bills and lack of nearby access to cool locations and weatherization resources/services	5
Extreme Precipitation	1—Similar projects have not faced significant impacts from extreme precipitation	1—Project may experience light wear and tear, but no elements are highly sensitive to extreme precipitation	2—Apartment operations may face mild disruptions from extreme precipitation, particularly if rainfall occurs at an intensity level not seen in the past	3—Serves low-income residents who may face slight sensitivity to extreme precipitation, particularly if rainfall occurs at an intensity level not seen in the past	2
Wildfire	1—Wildfires have not occurred in this location in the past	4—Building may face damage from wildfire	4—Wildfire would affect apartment operations, particularly if wildfire occurs at a level not seen in the past; high building occupancy also makes this project sensitive	5—Serves low-income residents who may be highly sensitive to wildfire, particularly if wildfire occurs at a level not seen in the past	4

Climate Hazard	Question #1. (Impact of Past Events)	Question #2. (Elements Prone to Historic or Projected Damage)	Question #3. (Operations Vulnerable to Historic or Projected Hazards)	Question #4. (Populations Vulnerable to Historic or Projected Hazards)	Final Sensitivity Score
Drought	Unknown past impacts	2—Project does not have abundant landscaping that requires water	1—Drought unlikely to affect operations	2—Serves low-income residents who may be slightly sensitive to drought, particularly if drought occurs at a level not seen in the past	2
Decrease in Snowpack	Unknown past impacts	1—No elements prone to damage from decrease in snowpack	1—Decrease in snowpack unlikely to affect operations	1—Residents unlikely to be affected by decrease in snowpack	1
Air Quality Degradation	4—Other apartment buildings around this location have been affected by air quality degradation in the past	1—No elements prone to damage from air quality degradation	1—Air quality degradation unlikely to affect operations	5—Serves low-income residents who may be highly sensitive to air quality degradation due to cost of healthcare and lack of nearby access to clean air locations	4

Determine Adaptive Capacity Rating

The adaptive capacity of a project refers to its ability to manage and reduce vulnerabilities from projected climate hazards. For example, a housing development with heating, ventilation, and air conditioning (HVAC) throughout the building will provide residents with cooling and air filtration against projected increases in heat waves and smoke from wildfire events. Identifying the adaptive capacity of a proposed project will help users understand the degree to which vulnerabilities may be addressed before taking adaptation actions.

Rather than use a numerical score, users will rate their adaptive capacity on a spectrum from Low to High. Like sensitivity, users can take an average of their scores amongst the four questions below to obtain an overall adaptive capacity score, but users do not need to weigh them equally and the questions provided do not necessarily capture all aspects of adaptive capacity.

Answer the following four questions to assign the project an adaptive capacity rating of Low, Low–Med, Med, Med–High, or High for each climate hazard.

Question #1. How have similar projects or other developments in the project area managed climate impacts in the past?

Score Spectrum

Low: Similar projects and developments in the project area were not able to manage climate impacts or required significant cost/effort in doing so.

Med: Similar projects and developments in the project area required a fair amount of cost and effort to manage climate impacts.

High: Similar projects and developments in the project area adapted to climate impacts with little cost and effort.

Question #2. Does the project have design elements that may mitigate climate impacts planned (e.g., drainage system, cool roof, modifications that can be made over time)?

Score Spectrum

Low: The project does not have any elements that may mitigate climate impacts.

Med: The project has some elements that partially address the most relevant climate hazards.

High: The project already has elements that address the climate hazard of most relevance.

Question #3. Are there already policies and standards that the project incorporates (e.g., local community or state climate resilience planning and design requirements) that require planning for climate change impacts?

Score Spectrum

Low: The project does not follow any standards related to planning for climate change impacts.

Med: The project follows some standards related to planning for climate change impacts.

High: The project follows many standards that incorporate climate change considerations into design.

Question #4. Can the project qualify for or access funding for climate adaptation and resilience activities?

Score Spectrum

Low: The project has no access to funding related to climate adaptation activities.

Med: There is some funding available for climate adaptation, but the project would still require additional funding beyond that to finance adaptation.

High: There is plenty of funding available for climate change adaptation activities.

Use Case Example: The Los Angeles affordable housing project will follow the latest building safety standards but does not have access to abundant funding for climate adaptation activities. We will give it the following adaptive capacity ratings with justifications (Table 4-5).

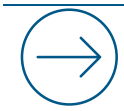
Table 4-5. Adaptive Capacity Scores and Justifications for Use Case Example

Climate Hazard	Question #1. (Impact of Past Events)	Question #2. (Elements that Mitigate Climate Hazards)	Question #3. (Climate Change Standards)	Question #4. (Climate Change Funding)	Final Adaptive Capacity Score
Sea Level Rise	High—Sea level rise has not been an issue in this location	Low–Med—Building managers could put out sandbags or temporary flood barriers, but these would be less effective in permanent inundation scenarios	Not applicable—Building does not follow any sea level rise standards since it is not located on a coast	Low—Little funding for climate adaptation activities	Med
Flooding	Low–Med—Similar projects have struggled to manage flood impacts	Med–High—Building managers could put out sandbags or temporary flood barriers and have pumps in low-lying areas	High—Building follows flood standards	Low—Little funding for climate adaptation activities	Med–High
Temperature and Extreme Heat	Low—Extreme heat has been an issue in this area for apartments	Low–Med—project is not currently designed to have air conditioning	High—Building follows latest standards	Low—Little funding for climate adaptation activities	Low–Med
Extreme Precipitation	High—Similar projects have held up well against extreme precipitation	High—Project has well-sealed windows and doors as well as a stormwater capture system	High—Building follows latest standards	Low—Little funding for climate adaptation activities	High
Wildfire	Low–Med—Wildfires are not a big issue in this location but apartments that do burn from structure fires do not have much adaptive capacity	Low—Project does not have many elements that mitigate wildfire risks	High—Building follows latest wildfire protection standards	Low—Little funding for climate adaptation activities	Low–Med
Drought	High—Apartments in this area have fared well against past droughts	High—Project is served by a utility that draws from multiple water sources to aid resilience	Not applicable for this hazard	Low—Little funding for climate adaptation activities	High

Climate Hazard	Question #1. (Impact of Past Events)	Question #2. (Elements that Mitigate Climate Hazards)	Question #3. (Climate Change Standards)	Question #4. (Climate Change Funding)	Final Adaptive Capacity Score
Decrease in Snowpack	High—This hazard has not been an issue in the past	High—Few impacts expected from this hazard	Not applicable for this hazard	Low—Little funding for climate adaptation activities	High
Air Quality Degradation	Med—Apartments in this area have applied some cost and effort to manage this issue	Low–Med—This project does not have air filters that allow individual operability	High—Building follows latest standards	Low—Little funding for climate adaptation activities	Med

Develop Potential Impacts Score

The exposure and sensitivity scores for each climate hazard should be averaged to develop potential impacts scores. If the result is a decimal score (e.g., 2.5), round up or down using best judgment of the potential impacts from that climate hazard on the user's project.



Calculate the project's potential impact scores by averaging the scores for exposure and sensitivity.

Use Case Example: Table 4-6 shows the potential impact score for each climate hazard and the associated justification.

Table 4-6. Potential Impacts Scores and Justifications for Use Case Example

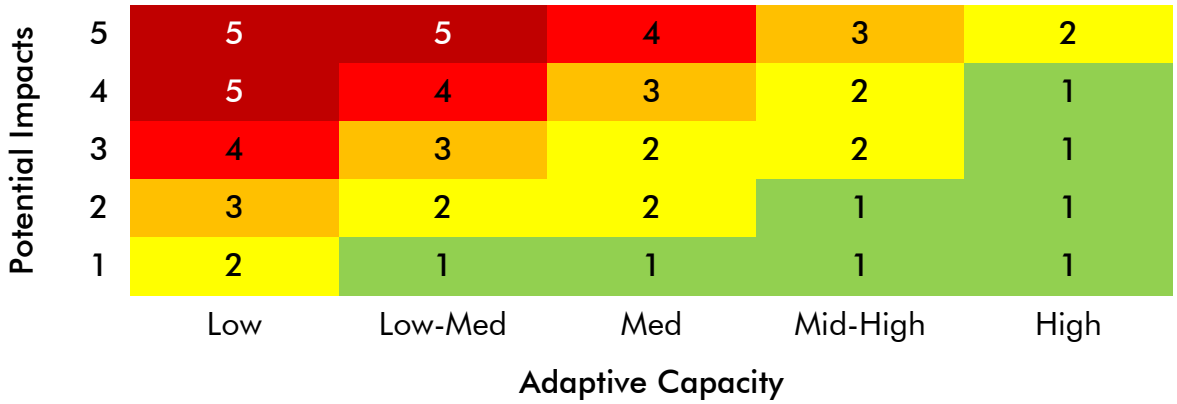
Climate Hazard	Exposure Score	Sensitivity Score	Potential Impact Score & Justification (if not a whole number)
Sea Level Rise	1	3	2
Flooding	1	4	2 (rounded down from 2.5); flooding is not a big concern in this area
Temperature and Extreme Heat	5	5	5
Extreme Precipitation	2	2	2
Wildfire	2	4	3
Drought	5	2	4 (rounded up from 3.5); drought impacts on water supply may become more significant, particularly when also considering extreme heat
Decrease in Snowpack	3	1	2
Air Quality Degradation	5	4	5 (rounded up from 4.5); air quality is a major issue in Los Angeles and residents are highly sensitive

Develop Overall Vulnerability Score

The potential impacts and adaptative capacity assessments should be combined to obtain an overall vulnerability score for each climate hazard. Figure 4-3 provides a matrix to convert the results of the two assessments into a single score. Users should locate their potential impacts score (1 to 5) in the first column and their adaptive capacity rating (low to high) in the bottom row. The intersection between these two data points is the resulting vulnerability score for the climate hazard.

Use the results from the potential impacts and adaptive capacity assessment to develop an overall vulnerability score for each climate hazard.

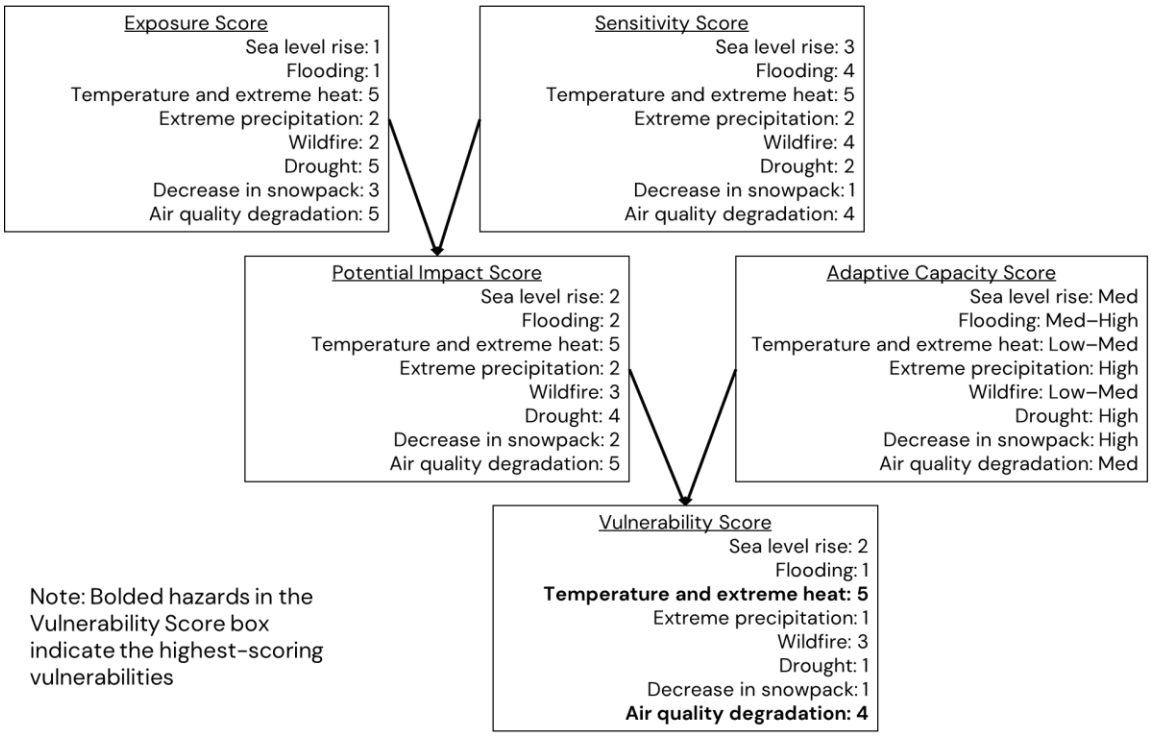
Figure 4-3. Vulnerability Score Matrix



Note: Color coding indicates severity of the score, with green cells showing the lowest (least vulnerable) scores and dark red showing the highest (most vulnerable).

Use Case Example: Figure 4-4 shows how the exposure and sensitivity scores were combined to develop the potential impacts score, and then how the potential impacts score and adaptive capacity rating were combined to develop the overall vulnerability score for each climate hazard.

Figure 4-4. Hypothetical Exposure, Sensitivity, Potential Impact, Adaptive Capacity, and Vulnerability Scores for An Affordable Housing Unit in Los Angeles



Select Highest-Scoring Vulnerabilities

From the previous sub-steps, users should now have a climate vulnerability score between 1 and 5 for the following climate hazards.

1. Sea level rise.
2. Flooding.
3. Temperature and extreme heat.
4. Extreme precipitation.
5. Wildfire.
6. Drought.
7. Decrease in snowpack.
8. Air quality degradation.

Next, users should choose the priority climate hazards based on the final vulnerability scores. These priority hazards will be the focus for reducing vulnerabilities through adaptation measures in the following section.

Use Case Example: Figure 4-4 shows the vulnerability scores for the Los Angeles housing project example. Because the project scored a 5 for Temperature and Extreme Heat and a 4 for Air Quality Degradation, we will select these two as priority climate hazards.

It may be helpful to use a vulnerability score threshold (e.g., all hazards exceeding a score of three) for identifying priority climate hazards. This threshold may depend on the user's risk tolerance. For example, if a user has a high risk tolerance, the user may only wish to look at adaptation measures for climate hazards for which there was a vulnerability score of 4 or above. If the user has a lower risk tolerance, the user may wish to also consider addressing climate hazards for which the user's vulnerability score was 3 or above.

Once the user has chosen the priority climate risks that the user wants to address, the user can begin to choose and analyze adaptation measures.

Estimating Risk Reduction and Co-Benefits from Adaptation Measures

Following a similar process to establish a baseline vulnerability score, this section outlines steps that Handbook users can take to identify the reduction in vulnerability associated with specific adaptation measures. With this information, users can better prioritize and select adaptation actions to manage climate risks threatening their project. Users should consider priority climate risks and project budget in assessing measures and their benefits. Refer to *Climate Risk Reduction Measures* for a comprehensive list of potential measures.

Identify Adaptation Benefits

The following steps provide guidance on assessing the impact of a measure on overall vulnerability. Users can follow these steps using the worksheet provided in Appendix D, *Climate Vulnerability Worksheets*.

After selecting a climate hazard from the identified priority climate hazards, users will determine risk reduction from an adaptation measure in the following steps.

1. Identify the extent of the measure's reduction of potential impacts.
    a. Determine the exposure reduction.
    b. Determine the sensitivity reduction.
    c. Assess the overall effect of the measure on potential impacts on a scale of 0–4 reduction points (No effect, Low, Medium, High, and Very High).
2. Evaluate the extent to which the measure bolsters adaptive capacity on a scale of 0–4 reduction points (No effect, Low, Medium, High, and Very High).
3. Estimate impacts on the vulnerability score by considering the measure's effect on reducing exposure and sensitivity (i.e., potential impacts), and increasing adaptive capacity.

Use Case Example: The proposed affordable housing unit being developed in Los Angeles has a high vulnerability to temperature and extreme heat (5) and low-medium adaptive capacity. The developer elects to incorporate adaptation solutions by improving the

building envelope efficiency to protect against extreme heat, such as by installing well-sealed doors and windows, adding window treatments such as solar shades, and increasing shading through enhanced landscaping.

The following section outlines guiding questions and applies the framework to adaptation measures for the use case discussed above. Measures may impact all the components of vulnerability to a hazard, or only target exposure, sensitivity, and/or adaptative capacity.

Determine Exposure Reduction

As discussed in the section *Determine Exposure Score*, the primary driver of exposure is location. A project's proximity to areas susceptible to a hazard will affect the extent to which the project will be subjected to a climate hazard. For example, a project located in a flood zone or in the WUI will be exposed to flooding and wildfire, respectively. While location primarily drives exposure, Handbook users can use adaptation actions to lessen the degree to which a project is exposed to a hazard. The degree to which an adaptation measure lessens the amount of exposure determines its exposure reduction. The following guiding questions can help users determine the extent to which a measure lowers exposure to a specific hazard.

- How does the measure remove exposure (e.g., relocating a project)?
- How much does the measure change the project design to reduce future exposure (e.g., raising a building to reduce flood exposure)?
- Does the measure change post-construction operations and management to reduce future exposure (e.g., wildfire fuel removal or management)?

Use Case Example: Enhancing building envelope efficiency does not change the location or otherwise reduce the exposure of the project. It instead reduces its sensitivity (see *Determine Sensitivity Reduction* section). Not all measures apply to each component of vulnerability.

In this use case example, exposure from the priority hazards of extreme heat and impaired air quality cannot be avoided without physically relocating the project, which is not feasible. The project developer can seek to reduce vulnerabilities by decreasing sensitivity or increasing adaptive capacity through adaptation measures.

Determine Sensitivity Reduction

To lower sensitivity, a measure must reduce the degree to which a project is affected by exposure to a hazard. The following guiding questions can support users in determining the extent to which a measure decreases harm to a project.

- How much does the measure mitigate the hazards' effect on fragile or critical components of the project (e.g., cooling systems for equipment sensitive to overheating)?
- Does the measure lower the hazard's effect on individuals, particularly members of vulnerable populations (e.g., greater access for underserved populations to parks)?

- Does the measure lower the impact to an operational component affected by the climate hazard (e.g., conduct regular cleaning and maintenance of storm drains along key roadways)?

Use Case Example: The measure reduces how severely building occupants will experience extreme heat. Given that the project is for affordable housing, the measure also has the potential to provide protection from heat events for those in vulnerable communities. Overall, the measure has a low sensitivity reduction.

Determine Potential Impact Reduction

To qualitatively determine the degree to which the measure reduces potential impacts from a climate hazard, Handbook users should consider the extent to the which the measure lowers each component of the potential impacts score (i.e., sensitivity and exposure). Then, users should combine the benefits of the measure's mitigation of sensitivity and exposure to determine the net effect using the following reduction rating scale.

0 = No Effect

1 = Low

2 = Medium

3 = High

4 = Very High

Points associated with the scale (0–4) will be used to assess vulnerability reductions. However, no measure, with the exception or relocating a project, can completely remove the threat from a particular climate hazard with a defined geographic footprint (e.g., floodplain). Measures mitigate, rather than remove, potential impacts from a hazard. The extent to which a measure will lower potential impacts from a climate hazard depends on the Handbook user's project.

Use Case Example: The building envelope enhancement measure has no effect on exposure to the hazard but has a relatively low effect on reducing building occupants' sensitivity to increased temperature and heat events. Combined, the measure provides a low potential impacts reduction rating (which results in a one-point reduction).

Identify Adaptive Capacity Gains

Adaptation measures can also increase a project's adaptive capacity. A measure provides adaptive capacity benefits if it improves the project's capacity to take advantage of opportunities or mitigate the hazard's consequences. These guiding questions support Handbook users in considering how a measure bolsters adaptive capacity.

- Does the measure add climate resilient components to the project (e.g., drainage system, cool roof)?
- Does the measure incorporate policies or standards that account for climate change (e.g., adopt or update heat emergency plan)?

- How does the measure improve the project's management of climate hazards (e.g., incorporating projected changes in precipitation and flooding into planned wastewater systems)?
- Does the measure reduce how project users are exposed to the hazard (e.g., using a notification system to provide evacuation information)?

After evaluating the measure's impacts using the guiding questions, the user should determine the net effect of the measure on adaptive capacity using the following rating increase scale.

0 = No Effect

1 = Low

2 = Medium-Low

3 = High

4 = Very High

Points associated with the scale (0–4) will be used to assess adaptive capacity gains. As with potential impacts, no measure can increase adaptive capacity to the extent to which overall vulnerability is eliminated. Rather, measures can only strengthen a project's overall adaptive capacity score.

Use Case Example: The building envelope enhancement measure improves adaptive capacity and climate resilience because it protects occupants more effectively from heat events and keeps cool air inside the building. Overall, the measure has a medium increase rating for adaptive capacity (which result in a 2-point increase).

Estimate Measure's Effect on Overall Vulnerability

After evaluating the measure's effect on potential impacts and adaptive capacity, the user can estimate the extent to which the measure reduces overall vulnerability. To determine a measure's overall reduction of overall vulnerability, the user should do the following.

1. Subtract the points associated with the potential impact reduction rating (0–4) from the existing potential impact score to get a net potential impacts score.
2. Add the points associated with the adaptive capacity increase rating (0–4) to the existing adaptive capacity score to get a net adaptive capacity score.

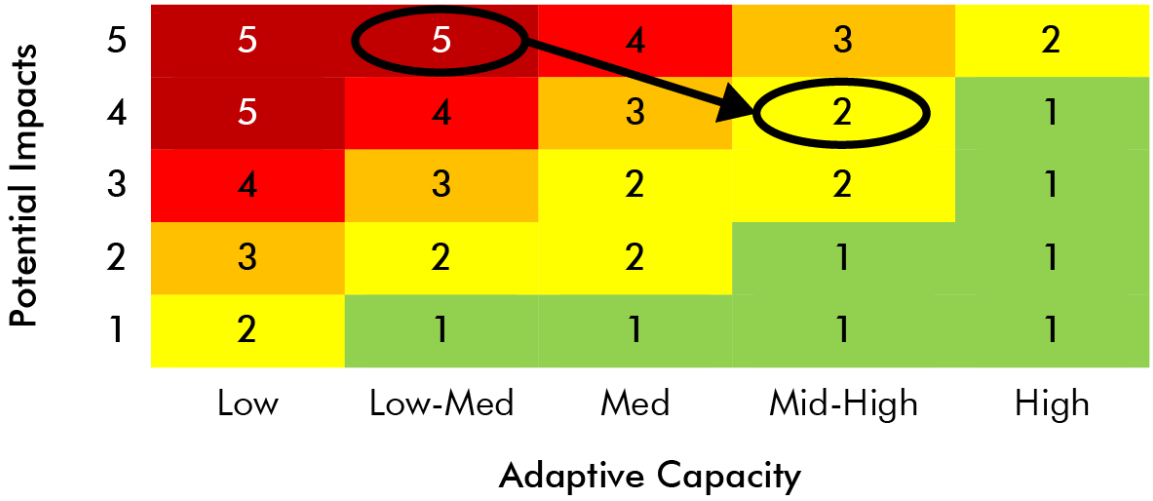
By adopting a measure, the Handbook user can move the project down and right in the vulnerability matrix (see Figure 4-5) as the measure lowers potential impacts and increases adaptive capacity respectively. The evaluation of net changes in potential climate impact and adaptive capacity scores help guide the user in considering the extent to which a measure can decrease the overall vulnerability of a project.

The Handbook user should remember that the rating points act as a guide to estimate the overall effect of an adaptation measure on vulnerability and are not an absolute determination of the measure's effect on the project's vulnerability. The Handbook user

should apply this process with careful consideration. For example, if a project has a potential impacts score of 4, and the measure has a high potential impacts reduction rating (3 reduction points), the net potential impacts score could be 1. However, the Handbook user might believe that the project could be considerably affected by a hazard despite adopting the measure and determine the net potential impacts score is 2. The example below highlights how a Handbook user can follow the process as a guide to determine the project's overall vulnerability score after applying a measure.

Use Case Example: The measure provides a low potential impacts reduction rating (1 reduction point) and a medium adaptive capacity increase rating (2 addition points). Given the project started at a vulnerability score of 5, the measure reduces the project's vulnerability score to a 2, as seen in Figure 4-5.

Figure 4-5. Vulnerability Score Matrix for Use Case Example



Identify Adaptation Co-Benefits

Adaptation measures may also result in co-benefits for a project, as shown in *Climate Risk Reduction Measures*. Possible co-benefits include improved air quality, energy and fuel savings, VMT reductions, water conservation, enhanced pedestrian or traffic safety, improved public health, improved ecosystem health, enhanced energy security, enhanced food security, and social equity. Some of these co-benefits are qualitative, while others are quantifiable. Chapter 3, *Measures to Reduce GHG Emissions,* includes methodologies to estimate measures' co-benefits specifically related to energy and fuel savings, VMT reductions, and water conservation. Additionally, the California Air Resources Board provides an expansive set of methodologies to evaluate co-benefits (CARB n.d.).

Climate Risk Reduction Measures

This section includes 99 potential climate risk reduction measures. All measures include the following descriptors.

- **Climate Hazard**: Identifies the climate hazard(s) for which the measure reduces risk. Most measures address multiple climate hazards. Hazards include sea level rise, flooding (coastal and inland), temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.
- **Climate Risk Reduction Benefit**. Describes which aspect of overall vulnerability the measure addresses. Each measure could have one or more of the following risk reduction benefits.
  - **Reduces exposure**: Reduces the presence of project elements in areas that are subject to climate hazards.
  - **Reduces sensitivity**: Reduces the degree to which a project element would be affected by exposure to a changing climate.
  - **Increases adaptive capacity**: Increases the ability of a project element to moderate harm or take advantage of risk reduction opportunities.
- **Potential Co-Benefits**. Describes the anticipated co-benefits achieved by the measure.
- **Action Type**. Identifies the required project action to successfully implement the risk reduction measure. Options include the following.
  - **Infrastructure Improvements and Projects**: Involves physically altering a current design or developing a new project element to address climate risks. These projects could range from minor (e.g., changing appliances) to major (e.g., sea wall).
  - **Education, Outreach, Coordination**: Involves initiating or expanding partnerships with relevant organizations, including intentional community engagement to communicate or share information that is culturally and linguistically appropriate, and expanding awareness with the public.
  - **Evaluation**: Involves conducting new or updated assessments to improve data/information, input, or feedback.
  - **Operational**: Involves changes to or development of new operational and maintenance protocols.
  - **Plans, Regulations, and Policy Development**: Involves developing or revising policies, plans, regulations, or guidelines, which will have project-level benefits if implemented.
  - **Programmatic**: Involves creating new or expanding existing programs, activities, or initiatives.

Table 4-7 identifies the risk reduction measures and their descriptors. Each measure is listed alphanumerically with the hazard serving as the letter code (e.g., SLR = sea level rise). For simplicity and ease of tabular review, the measure descriptors have been abbreviated as follows:

- Dark blue shaded rows identify the **climate hazard** for each group of measures, while light blue shaded rows identify the **action type** applicable to the measures that follow. Within the *Infrastructure Improvements and Projects* action type, an asterisk (*) is used to denote activities with extensive infrastructure investments that may require designing and constructing new project elements.
- The **scale of application** is abbreviated as one of the following:

  - P/S = Project/Site
  - P/C = Plan/Community.
  - All = Project/Site and Plan/Community.

  Project/Site refers to measures that reduce risk at the scale of a parcel, employer, or development project. *Plan/Community* refers to measures that reduce risk at the scale of a neighborhood (e.g., specific plan), corridor, or entire municipality (e.g., city or county-level).

- The **climate risk reduction benefit** columns identify how the measure reduces climate vulnerability, where:
  - ● = may be achieved by the measure.
  - ○ = likely not achieved by the measure.
- Remaining columns identify applicable **co-benefits**, where:
  - ● = achieved by the measure.
  - ⊙ = may be achieved by the measure depending on local implementation specifics.
  - ○ = not achieved by the measure.

Table 4-7, below, includes a more detailed description of each measure.

Table 4-7. Summary of Climate Risk Reduction Measures and Descriptors

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
Multiple Hazards															
Infrastructure Improvements and Projects															
MH-1.	Strengthen Energy Infrastructure*	P/C	0	2-4	0	●	○	○	○	○	○	○	●	○	⊙
MH-2.	Use Climate-Resilient Design for Infrastructure	P/C	0	1-3	1-3	○	○	○	⊙	●	⊙	○	○	○	○
MH-3.	Coordinate Redundant Transportation Access*	P/C	0	0	2-4	○	○	○	○	●	⊙	○	○	○	○
MH-4.	Strengthen Building Structures	P/S	0	1-3	0	○	○	○	○	○	○	○	○	○	○
MH-5.	Use Green Infrastructure for Stormwater Management*	All	2-3	0	1-3	○	○	○	●	○	○	●	○	○	○
MH-6.	Upgrade Water Systems*	P/C	0	0	2-3	○	○	○	●	○	○	●	○	○	○
MH-7.	Construct Water Storage Facilities*	P/C	0	0	2-3	○	○	○	○	○	○	○	○	○	○
MH-8.	Decrease Road Vulnerability to Landslides	All	0	1-3	0	○	○	○	○	○	○	○	○	○	○
Education, Outreach, Coordination															
MH-9.	Support Business Resiliency	P/C	0	0	1-3	○	○	○	○	○	○	○	○	○	●
MH-10.	Implement Community-wide Climate Change Outreach Program	P/C	0	0	1-3	○	○	○	○	○	○	○	○	○	●
MH-11.	Encourage/Actively Engage Community in Local Planning	P/C	0	0	1-2	○	○	○	○	○	●	○	○	○	●
MH-12.	Enhance Community Network Support	P/C	0	0	1-2	○	○	○	○	○	○	○	○	○	●
MH-13.	Support Local Food Systems	All	0	0	1-2	○	○	○	○	○	●	○	○	●	●
MH-14.	Maintain Trails and Parks	P/C	0	1-2	1-2	○	○	○	○	○	●	○	○	○	●
MH-15.	Identify Alternative Activities in Climate Sensitive Recreation Areas	All	0	0	1-3	○	○	○	○	○	○	○	○	○	○

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
Evaluation															
MH-16.	Identify At-Risk Transportation Corridors	P/C	0	0	1-3	○	○	○	○	●	○	○	○	○	○
MH-17.	Identify Alternative Routes for Transit Service	P/C	0	0	1-3	○	○	⊙	○	●	○	○	○	○	⊙
Operational															
MH-18.	Maintain Soil Health	All	0	1-2	1-2	○	○	○	○	○	○	●	○	●	○
MH-19.	Stabilize Burned Slopes in Key Assets	All	0	1-2	0	○	○	○	○	○	○	○	○	○	○
MH-20.	Improve Medical Facility Preparedness	P/C	0	0	1-4	○	○	○	○	○	○	○	○	○	○
MH-21.	Ensure Homeless Services' Availability in Hazardous Conditions	P/C	0	1-3	2-4	○	○	○	○	○	●	○	○	○	●
MH-22.	Improve Poor Drainage	All	0	1-3	0	○	○	○	○	○	●	○	○	○	○
Plans, Regulations, and Policy Development															
MH-23.	Landscape with Climate Considerations	All	0	1-2	0	○	○	○	●	○	○	●	○	○	○
MH-24.	Develop Climate Emergency/Business Resilience Plan	All	0	0	1-3	○	○	○	○	○	○	○	○	○	○
MH-25.	Revise Emergency Plans	P/C	0	0	1-3	○	○	○	○	○	○	○	○	○	○
MH-26.	Integrate Climate Change Considerations into Public Safety and Emergency Planning	All	1-3	1-3	1-4	○	○	○	○	○	○	○	○	○	●
MH-27.	Provide Greater Affordable Housing Options	P/C	0	1-2	1-3	○	○	○	○	○	●	○	○	○	●
MH-28.	Transition to Climate-Smart Energy	All	0	2-3	2-3	○	○	○	○	○	○	○	●	○	○
MH-29.	Identify Climate Hazard Overlay Zones	All	2-4	1-3	1-3	○	○	○	○	○	○	○	○	○	○
MH-30.	Establish Community Resilience Hubs	P/C	0	0	2-3	○	○	○	○	○	○	○	○	○	●
MH-31.	Improve Transportation Maintenance	P/C	0	1-3	0	○	○	○	○	●	○	○	○	○	○
MH-32.	Establish Urban Tree Management Plan	All	1-2	1-2	0	●	●	○	○	○	●	●	○	○	●

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
MH-33.	Implement Park and Natural Resources Protection	P/C	1-2	1-2	0	○	○	○	●	○	○	●	○	○	○
MH-34.	Implement Integrated Watershed Management	P/C	1-4	0	0	○	○	○	●	○	○	●	○	○	○
MH-35.	Increase Parks in Underserved Communities	P/C	1-2	2-3	0	○	○	○	○	○	●	○	○	○	●
MH-36.	Decentralize and Localize Energy Production and Storage	All	0	1-3	2-4	●	○	○	○	○	○	○	●	○	●
Programmatic															
MH-37.	Develop Climate Hazard Notification System	P/C	0	0	1-3	○	○	○	○	○	●	○	○	○	●
MH-38.	Integrate Climate into Health Programs	P/C	0	0	1-4	○	○	○	○	○	●	○	○	○	●
MH-39.	Implement Pervious and Climate-Smart Surfaces	All	0	1-3	0	⊙	●	○	●	○	⊙	●	○	○	○
MH-40.	Address Energy/Water Efficiency Funding Barriers	P/C	0	1-2	1-3	○	●	○	●	○	○	○	○	○	●
MH-41.	Expand Urban Greening/Agriculture	P/C	1-2	1-2	1-2	⊙	○	○	⊙	○	●	○	○	●	●
MH-42.	Provide Vaccinations for Changed Transmission Vectors	P/C	0	1-2	1-3	○	○	○	○	○	●	○	○	○	●
Sea Level Rise and Coastal Flooding/Erosion															
Infrastructure Improvements and Projects															
SLR-1.	Implement Engineering Solutions*	All	2-4	0	0	○	○	○	○	○	○	○	○	○	○
SLR-2.	Raise Building Floor Elevations	P/S	2-4	1-4	0	○	○	○	○	○	○	○	○	○	○
SLR-3.	Implement Natural Coastline Infrastructure*	All	1-4	0	2-3	○	○	○	○	○	○	●	○	○	○
SLR-4.	Strengthen Building Against Flood	P/S	0	2-3	0	○	○	○	○	○	○	○	○	○	○
SLR-5.	Use Moveable Infrastructure	P/S	0	2-3	0	○	○	○	○	○	○	○	○	○	○

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
Evaluation															
SLR-6.	Develop Adaptive Management Plan	All	0	0	2-4	○	○	○	○	○	○	○	○	○	●
Plans, Regulations, and Policy Development															
SLR-7.	Require Consideration of Sea Level Rise for New Development	All	2-4	2-4	0	○	○	○	○	○	○	○	○	○	○
SLR-8.	Develop Setbacks	All	1-3	0	0	○	○	○	○	○	○	○	○	○	○
SLR-9.	Develop Regional Sediment Management	All	0	1-2	2-3	○	○	○	○	○	○	●	○	○	○
SLR-10.	Sell off High-Risk Area Development Rights	All	1-3	0	2-3	○	○	○	○	○	○	○	○	○	○
SLR-11.	Site Outside Coastal Hazard Zone	All	2-4	0	0	○	○	○	○	○	○	○	○	○	○
SLR-12.	Limit Basements in Flood Zones	P/S	0	2-3	0	○	○	○	○	○	○	○	○	○	○
SLR-13.	Provide Removal Options in Flood Zones	All	1-2	1-3	0	○	○	○	○	○	○	○	○	○	○
SLR-14.	Coordinate with Regional Planning Efforts	All	1-3	1-3	1-3	○	○	○	○	○	○	○	○	○	○
SLR-15.	Alert Public of Storm Surge Risk	P/C	0	1-2	0	○	○	○	○	○	○	○	○	○	○
Extreme Precipitation and Inland Flooding															
Infrastructure Improvements and Projects															
EP-1.	Incorporate Runoff Projections in Hydrologic Designs	All	1-3	0	0	○	○	○	○	○	●	●	○	○	○
EP-2.	Install Stormwater Outfall Pumps/Lift Station for Water Drainage	All	0	1-3	0	○	○	○	○	○	●	●	○	○	○
EP-3.	Install Stormwater Cistern/Retention Basin	All	0	1-3	0	○	○	○	●	○	○	○	○	○	○
EP-4.	Waterproof Operational Equipment	All	0	2-4	0	○	○	○	○	○	○	○	○	○	○
EP-5.	Upgrade Wastewater Systems	All	0	0	2-3	○	○	○	●	○	○	●	○	○	○

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
Plans, Regulations, and Policy Development															
EP-6.	Site Outside Floodplain	All	2-4	0	0	○	○	○	○	○	○	○	○	○	○
Operational															
EP-7.	Maintain Stormwater Infrastructure on Key Routes	All	0	1-2	0	○	○	○	○	●	○	○	○	○	○
Wildfire															
Infrastructure Improvements and Projects															
WF-1.	Implement Fire-Safe Landscaping	All	0	1-2	0	●	○	○	○	○	●	●	○	○	○
WF-2.	Install Fire Suppression Systems and Improve Structural Strength	P/S	0	1-3	0	●	○	○	○	○	●	○	○	○	○
WF-3.	Strengthen Vulnerable Assets in High Wildfire Risk Areas*	All	0	2-4	0	○	○	○	○	○	○	○	○	○	○
Education, Outreach, Coordination															
WF-4.	Educate on Wildfire Resistant Landscaping	P/C	0	0	1-2	○	○	○	○	○	●	○	○	○	○
WF-5.	Site Outside Wildland-Urban Interface (WUI)	All	2-4	0	0	○	○	○	○	○	●	○	○	○	○
Evaluation															
WF-6.	Designate and Strengthen Wildfire Emergency Routes	P/C	0	0	1-3	○	○	○	○	○	●	○	○	○	●
WF-7.	Develop Fire Risk Assessment for New Development	All	1-2	1-2	0	○	○	○	○	○	●	○	○	○	○
Operational															
WF-8.	Implement Fuel Management	All	2-3	0	0	●	○	○	○	○	●	○	○	○	○
WF-9.	Install Air Filters	All	0	1-3	1-2	●	○	○	○	○	●	○	○	○	○
WF-10.	Adopt WUI Building Standards	All	0	1-3	1-2	○	○	○	○	○	●	○	○	○	○

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
Temperature/Extreme Heat															
Infrastructure Improvements and Projects															
EH-1.	Install Green Infrastructure*	All	1-3	1-3	0	●	⊙	○	○	○	●	●	○	○	●
EH-2.	Provide Heat Mitigation for Public Walkways and Transit Stops	All	2-4	0	0	●	○	○	○	○	●	○	○	○	●
EH-3.	Install Heat-Reducing Roof	All	2-3	0	0	●	●	○	○	○	●	○	○	○	●
EH-4.	Enhance Building Envelope Efficiency	P/S	0	0	1-3	●	●	○	○	○	●	○	○	○	⊙
EH-5.	Upgrade to Efficient Equipment/Infrastructure	All	0	0	1-3	○	●	○	○	○	○	○	○	○	○
EH-6.	Install Refillable Water Stations	All	0	0	1-2	○	○	○	○	○	●	○	○	○	●
EH-7.	Install Equipment Cooling System	All	0	2-3	0	○	●	○	○	○	○	○	○	○	○
EH-8.	Use Alternative Pavement Surfaces	All	0	1-2	0	○	●	○	○	○	○	○	○	○	○
EH-9.	Expand Urban Tree Canopy	All	1-2	1-2	0	●	●	○	○	○	●	○	○	○	⊙
EH-10.	Install Covered Parking	P/S	0	0	1-2	●	○	○	○	○	●	○	○	○	○
Education, Outreach, Coordination															
EH-11.	Work with Schools to Reduce Heat Exposure	P/C	1-3	1-3	0	○	○	○	○	○	●	○	○	○	●
Plans, Regulations, and Policy Development															
EH-12.	Provide Backup Power for Cooling Centers	All	0	1-2	1-3	○	○	○	○	○	●	○	○	○	●
EH-13.	Develop Heat Emergency Plan	P/C	0	0	2-4	○	○	○	○	○	●	○	○	○	●
Programmatic															
EH-14.	Develop Low-Income Energy Programs	P/C	0	1-2	2-3	○	●	○	○	○	●	○	○	○	●
EH-15.	Provide Low-Income Air Conditioning	All	0	2-4	2-4	○	○	○	○	○	●	○	○	○	●
EH-16.	Establish a Shuttle System to Cooling Centers	P/C	0	1-2	2-3	○	○	○	○	○	●	○	○	○	●

#	Measure Title	Scale of Application	Risk Reduction Benefit			Co-Benefits									
			Reduces Exposure	Reduces Sensitivity	Increases Adaptive Capacity	Improved Air Quality	Energy and Fuel Savings	Vehicle Miles Traveled Reductions	Water Conservation	Enhanced Pedestrian or Traffic Safety	Improved Public Health	Improved Ecosystem Health	Enhanced Energy Security	Enhanced Food Security	Social Equity
Drought															
Infrastructure Improvements and Projects															
D-1.	Install Water Efficient Appliances	P/S	0	0	1-3	○	○	○	●	○	○	○	○	○	●
D-2.	Install Water Reuse Infrastructure	P/S	0	0	1-3	○	○	○	●	○	○	○	○	○	○
Education, Outreach, Coordination															
D-3.	Install Drought Resistant Landscaping	P/S	0	1-2	1-2	○	○	○	●	○	○	○	○	○	○
D-4.	Educate on Water Conservation	P/C	0	0	1-2	○	○	○	●	○	○	○	○	○	○
D-5.	Outreach to Educate About Recycled Water Safety	P/C	0	0	1-2	○	○	○	●	○	○	○	○	○	○
D-6.	Build Alternatives Forms of Water Recreation	All	0	0	1-2	○	○	○	○	○	○	○	○	○	○
Plans, Regulations, and Policy Development															
D-7.	Diversify Water Supply Sources	P/C	0	0	2-4	○	○	○	○	○	●	○	○	○	●
D-8.	Develop Groundwater Sustainability Plan	P/C	0	0	2-4	○	○	○	○	○	○	●	○	○	○
D-9.	Implement Local Water Recycling	All	0	0	1-4	○	○	○	●	○	○	○	○	○	○

Climate hazard abbreviations: MH = multiple hazards; SLR = sea level rise; F = flooding; EH = temperature/extreme heat; EP = extreme precipitation; WF = wildfire; D = drought; DS = decrease in snowpack; AQ = air quality degradation.

For action type, major infrastructure improvements and projects are noted with an asterisk (*).

Scale of application column abbreviations: P/S = Project/Site; P/C = Plan/Community; All = Project/Site and Plan/Community.

Risk reduction benefit and co-benefits columns symbols: ● = may be achieved by the measure; ⊙ = may be achieved by the measure depending on local implementation specifics; ○ = likely not achieved by the measure.

Table 4-8 provides an overview of each measures' descriptions and benefits. These measures are organized by the climate hazard(s) that they address. Measures that can help reduce risk to multiple hazards (categorized as "Multiple Hazard Measures") are presented first. Most climate risk reduction measures fall under this category, followed by measures that address individual climate hazards or, in some cases, two similar hazards (e.g., extreme precipitation and flooding). The measure descriptions broadly summarize the measure at a high level. Where applicable, an implementation example is provided.

Table 4-8. Description of Climate Risk Reduction Measures

Climate Risk Reduction Measures
Multiple Hazards
MH-1. Strengthen Energy Infrastructure. Strengthen energy infrastructure systems against damage from climate-related effects and expand redundancy in the energy network. For example, retrofit infrastructure components; ensure redundant energy systems (e.g., backup generators, multiple transmission lines feeding a given area). Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, and wildfire.
MH-2. Use Climate-Resilient Design for Infrastructure. Use the best available science and resilient design features in infrastructure to improve resiliency to extreme climate events. For example, special sealants and other materials on roadways can help prevent roadways from softening during extreme heat. Another example to maintain a state of good repair, minimize breaks, and ensure structural integrity in the face of climate change hazards is to use high density polyethylene (HDPE) pipes, which are less expensive and easier to install than metal cast iron pipes. Other resilient design features include choosing appropriate materials for wildfire-prone areas and treating critical outdoor infrastructure pieces to be heat-resistant. Infrastructure reinforcement, stormwater improvements and drainage upgrades, and pumping and water storage facilities can also be installed to increase resiliency to flooding and wave action by coastal storms. Design features should be incorporated to match asset vulnerabilities. The California Department of Transportation (Caltrans) completed a vulnerability assessment of its assets by district, which can serve as a useful resource (Caltrans 2020). Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, and wildfire.
MH-3. Coordinate Redundant Transportation Access. Coordinate with regional transportation agencies to ensure redundancy of critical transportation routes to allow for continued access and movement in the event of an emergency. Have multiple points of ingress and egress to improve evacuation and emergency response access. Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, and wildfire.
MH-4. Strengthen Building Structures. Ensure building structure is strengthened against severe weather impacts through building design. Relevant Hazards: Flooding, extreme precipitation, and wildfire.
MH-5. Use Green Infrastructure for Stormwater Management. Use green infrastructure to reduce stormwater volume and enhance stormwater capture and infiltration. For example, low-impact development, such as the installation of bioretention elements in parking lots and on the street margin, can be implemented through landscape codes, green street standards, and off-site standards. Other examples include rainwater harvesting, permeable pavements, and bioswales. Relevant Hazards: Flooding, extreme precipitation, and drought.

Climate Risk Reduction Measures

MH-6. Upgrade Water Systems.

Upgrade water systems to accommodate projected changes in water quality and availability. For example, wells and intake systems may be too shallow to effectively pull enough water supplies from groundwater aquifers and surface water bodies, higher levels of water contaminants may exceed the capacity of water treatment systems, and water storage tanks may not be able to hold enough water to meet demand if there is a supply interruption. In all these cases, the water system could be upgraded to address the risk.

Relevant Hazards: Flooding and drought.

MH-7. Construct Water Storage Facilities.

Construct additional water storage facilities and improve existing facilities to augment surface and groundwater supplies that can capture excess flows and add protections against flooding and high stormwater flow events. For example, install a dedicated groundwater recharge facility for utilizing excess flows in wet years.

Relevant Hazards: Flooding, extreme precipitation, drought, and decrease in snowpack.

MH-8. Decrease Road Vulnerability to Landslides.

Use retaining walls, slope stabilization techniques, and other strategies to make roads less vulnerable to landslides, mudflows, and erosion. Emphasize resiliency for roads and trails that are on or below steep slopes and have a history of being damaged or blocked by landslide events and affected by erosion.

Relevant Hazards: Extreme precipitation, and wildfire.

MH-9. Support Business Resiliency.

Collaborate with local and regional partners to support business resiliency through preparedness education, trainings, and resources. Target support to small businesses, minority-owned business, and businesses in underserved communities.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, air quality degradation.

MH-10. Implement Community-wide Climate Change Outreach Program.

Collaborate with local, regional, state, and federal partners to develop a community-wide outreach program to educate a diverse community on how to prepare for and recover from climate change effects. An example program would be a climate preparedness outreach program focused on vulnerable populations that provides information on staying healthy and safe during hazardous events.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-11. Encourage/Actively Engage Community in Local Planning.

Explore opportunities to incorporate resident empowerment, leadership, and decision-making such as training programs, guided reviews of plans, neighborhood scans, and mapping activities as part of resident-led planning. For example, fund or solicit participation from schools, faith-based communities, neighborhood-based groups, health equity or environmental justice groups, and businesses in climate resilience planning. Allow and encourage residents to be the decisionmakers in planning.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

Climate Risk Reduction Measures

MH-12. Enhance Community Network Support.

Support and strengthen community social networks and other assets to build climate resilience. For example, support community-driven efforts by assisting with outreach, and learning from and disseminating best practices developed by community groups or local jurisdictions (Deas, Hoverter, & DeWeese 2017).

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-13. Support Local Food Systems.

Support local farmers and local food network. Increase access to healthy food markets, farmer's markets, and other local food sources. Encourage community gardens.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-14. Maintain Trails and Parks.

Collaborate with local and regional partners to provide robust trail and park maintenance to prevent and respond to damage from the effects of climate change. For example, park management agencies can strengthen and stabilize park buildings and trails to prevent future damage. Additionally, park resilience can be furthered with overlapping green infrastructure and stormwater measures such as detention/retention ponds and basins and decreasing impermeable surfaces to naturally capture and treat stormwater flows.

Relevant Hazards: Temperature/extreme heat, flooding, extreme precipitation, and wildfire.

MH-15. Identify Alternative Activities in Climate Sensitive Recreation Areas.

Coordinate with owners of winter recreation areas and water recreation areas to support additional recreational activities that are less dependent on snowpack and water levels. For example, alternative forms of recreation could include biking and hiking trails on skiing mountains during the summer season, or ropes courses and other alternative recreational activities at water recreation sites.

Relevant Hazards: Temperature/extreme heat, drought, and decrease in snowpack.

MH-16. Identify At-Risk Transportation Corridors.

Coordinate with community members, transportation agencies, and private entities to identify local and regional transportation, transit, and active transportation corridors that are at-risk from the effects of climate change. Prioritize further climate risk reduction actions for these routes.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, and extreme precipitation.

MH-17. Identify Alternative Routes for Transit Service.

Coordinate with regional transit providers to identify and communicate to the public alternative routes and stops and other redundancies in the transportation network if normal infrastructure is damaged or closed because of extreme events.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, and extreme precipitation.

MH-18. Maintain Soil Health.

Maintain and improve soil health. For example, increase soil organic matter to improve soils' water-holding capacity, soil structure, and water infiltration, and to reduce erosion (use cover crops and mixes, native grasses, crop or livestock residues, compost, mulch, biochar, or other organic amendments).

Relevant Hazards: Temperature/extreme heat, drought, and decrease in snowpack.

Climate Risk Reduction Measures

MH-19. Stabilize Burned Slopes in Key Areas.

Stabilize burned slopes located above developed areas, important infrastructure, or key transportation corridors as soon as possible after a wildfire event.

Relevant Hazards: Extreme precipitation and wildfire.

MH-20. Improve Medical Facility Preparedness.

Work with local medical providers and hospitals to ensure that medical facilities are prepared to meet any increased demand because of hazardous events. For example, this could be stocking up on specific medical supplies for local emergencies or working with emergency management agencies to have medical professionals and supplies at emergency shelter locations. Training could also be provided to medical staff to help improve recognition of new and emerging diseases in expanded geographies.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-21. Ensure Homeless Services' Availability in Hazardous Conditions.

Coordinate with local homeless services to ensure that emergency shelters are available during extreme heat events, poor air quality events, severe weather events, and other highly hazardous conditions. Ensure that people experiencing homelessness are made aware of these resources. Work with social care organizations to distribute necessities.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-22. Improve Poor Drainage.

Identify and remedy poor drainage areas to reduce disease risk from stagnant water.

Relevant Hazards: Flooding and temperature/extreme heat.

MH-23. Landscape with Climate Considerations.

Encourage landscaping projects to use plants that will continue to be viable in the area under long-term climate conditions. For example, update landscape ordinances and other applicable standards to include plants that are resistant to drought and extreme heat.

Relevant Hazards: Temperature/extreme heat, drought, and decrease in snowpack.

MH-24. Develop Climate Emergency/Business Resilience Plan.

For large commercial developments, develop a climate emergency/business resilience plan.

Relevant Hazards: Flooding, extreme precipitation, and wildfire.

MH-25. Revise Emergency Plans.

Revise emergency management plans, programs, and activities to account for changing hazard profiles and their consequences.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-26. Integrate Climate Change Considerations into Public Safety and Emergency Planning.

Integrate climate change risk reduction considerations into general plan Safety Elements, Local Hazard Mitigation Plans, public safety document, and all phases of emergency planning. A potential resource for implementing this measure is the Coastal Plan Alignment Compass (OPR n.d.).

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

Climate Risk Reduction Measures

MH-27. Provide Greater Affordable Housing Options.

Facilitate affordable housing options outside of hazardous zones for all residents.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-28. Transition to Climate-Smart Energy.

Transition to climate-smart sources of energy. For example, move away from vulnerable sources like hydroelectric, refineries and seaports, centralized power generation facilities that rely on long-range transmission infrastructure; move toward renewable and decentralized energy sources with storage capacity for variations in daily/seasonal demands.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, and wildfire.

MH-29. Identify Climate Hazard Overlay Zones.

Identify and establish climate hazard overlay zones for consideration during zoning and development of general and project site plans. Users can start by looking at hazard zone maps in existing general plans, as these maps have already been developed due to regulatory requirements. Available resources to identify climate hazard zones include the *Adaptation Planning Guide*, OPR's General Plan Guidelines, Cal-Adapt, the *Ocean Protection Council's 2018 Sea-Level Rise Guidance*, and the Integrated Climate Adaptation and Resilience Program Adaptation Clearinghouse.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, and wildfire.

MH-30. Establish Community Resilience Hubs.

Establish resilience hub locations in neighborhoods throughout the community. For example, develop existing community centers into cooling/clean air centers.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, wildfire, and air quality degradation.

MH-31. Improve Transportation Maintenance.

Update transportation maintenance protocols to incorporate climate vulnerabilities.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, and wildfire.

MH-32. Establish Urban Tree Management Plan.

Establish policies and management plans to develop urban forests and incentivize the use of best practices for the long-term maintenance and preservation of urban trees.

Relevant Hazards: Temperature/extreme heat, flooding, extreme precipitation, wildfire, and air quality degradation.

MH-33. Implement Park and Natural Resources Protection.

Develop coastal management plan to protect park infrastructure and natural resources. For example, the plan could include protecting existing open space adjacent to the coast, restoring dune habitat to increase the resilience of beaches, using soft or natural solutions for protecting structures facing flooding or inundation, require mitigation for impacts to public access, and the retrofitting or relocation of recreation and visitor-serving facilities. Develop equivalent plans for parks at risk of wildfire or inland flooding.

Relevant Hazards: Sea level rise, wildfire, and flooding.

MH-34. Implement Integrated Watershed Management.

Reduce flood and drought risk through integrated watershed management. For example, a healthy watershed maintains wetland areas as flood mitigation and maintains undeveloped natural areas, promoting soil health to blunt flood impacts and to assure greater resilience to drought.

Relevant Hazards: Flooding and drought.

Climate Risk Reduction Measures

MH-35. Increase Parks in Underserved Communities.

Increase access for underserved populations to parks, which can provide relief against extreme heat and flooding. Identify park-poor communities and ensure that new urban parks and trail systems are within walking distance to high-density infill, homes, and offices.

Relevant Hazards: Flooding and temperature/extreme heat.

MH-36. Decentralize and Localize Energy Production and Storage.

Increase local, decentralized renewable energy production and energy storage capacity to improve energy independence. For example, remove reliance on long-range transmission electricity infrastructure that may start wildfires by installing micro-grids, local renewable energy generation, and battery storage. Create municipal energy utilities and/ or form electric co-ops between rural jurisdictions for more local control over infrastructure and energy supply.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-37. Develop Climate Hazard Notification System.

Develop a notification system for natural hazards that provides early warnings and evacuation notifications. Ensure that the system can be deployed across multiple scales, is responsive to community needs, and reaches vulnerable populations.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-38. Integrate Climate into Health Programs.

Integrate climate change and health equity into traditional public health programs and core functions.

Relevant Hazards: Sea level rise, flooding, temperature/extreme heat, extreme precipitation, wildfire, drought, decrease in snowpack, and air quality degradation.

MH-39. Implement Pervious and Climate-Smart Surfaces.

Encourage and incentivize the use of pervious and climate-smart landscaped surfaces to reduce the urban heat island effect, catch stormwater, and lower overall water use.

Relevant Hazards: Flooding, temperature/extreme heat, and drought.

MH-40. Address Energy/Water Efficiency Funding Barriers.

Address programmatic, funding, and financing barriers for energy/water efficiency retrofits for low-income households and small businesses. Coordinate with local and tribal governments to provide low-income and disadvantaged community energy efficiency and demand response services.

Relevant Hazards: Temperature/extreme heat, drought, and decrease in snowpack.

MH-41. Expand Urban Greening/Agriculture.

Collaborate with community-based organizations to develop or expand urban greening and urban agriculture programs. For example, urban greening can include adding trees, parks, green infrastructure, and other green elements to a neighborhood. Urban agriculture includes community gardens or small farms within urban areas of a community.

Relevant Hazards: Flooding, temperature/extreme heat, and air quality degradation.

MH-42. Provide Vaccinations for Changed Transmission Vectors.

Ensure that free or reduced-cost vaccinations for vector-borne diseases are widely available.

Relevant Hazards: Flooding and temperature/extreme heat.

Climate Risk Reduction Measures
Sea Level Rise and Coastal Flooding/Erosion
SLR-1. Implement Engineering Solutions. Build a seawall or offshore reefs to protect the project. Build levees to reduce flooding. Consider jetties and groins.
SLR-2: Raise Building Floor Elevations. Ensure buildings have raised finished floor elevations.
SLR-3. Implement Natural Coastline Infrastructure. Use natural shoreline protection methods, such as beach nourishment, living shorelines, and dune restoration, where feasible.
SLR-4. Strengthen Buildings Against Flood. Strengthen buildings against flooding using dry or wet floodproofing techniques.
SLR-5. Use Moveable Infrastructure. Incorporate modular components in the building design to allow the project to move away from coastal flooding and erosion zones.
SLR-6. Develop Adaptive Management Plan. Develop an adaptive management plan to address the long-term impacts of sea level rise. In the plan, include an assessment of local vulnerability, including infrastructure such as roads and water reclamation facilities, buildings in the inundation areas, and ecosystems. For example, adaptive management techniques can include flexible adaptation pathways. Adaptation pathways are a planning approach that address uncertainty by considering multiple possible futures and analyzing the robustness and flexibility of various options across those futures.
SLR-7. Require Consideration of Sea Level Rise for New Development. Require accounting of sea level rise in all applications for new development in shoreline areas. Ensure that all applications for new development account for projected sea level rise and provide adequate protection (e.g., setback, armoring). For example, require applications develop a vulnerability and risk reduction plan that uses the *Ocean Protection Council Sea-Level Rise Guidance*. Provide guidance for applicants in considering most suitable sea level rise scenarios in planning.
SLR-8. Develop Setbacks. Develop adequate setbacks for new development. For example, ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea level rise induced erosion) over the life of the structure, without the use of a shoreline protective device.
SLR-9. Develop Regional Sediment Management. Develop a regional sediment management program including strategies designed to allow the use of natural processes to solve engineering problems.
SLR-10. Sell off High-Risk Area Development Rights. Allow landowners in high-risk areas to sell their development rights. In conjunction, designate areas for increased density in a community for this.
SLR-11. Site Outside Coastal Hazard Zone. Select sites outside of coastal hazard zone or coordinate with long-term community managed retreat plans. Develop plans allowing for coastal inundation in defined areas.

Climate Risk Reduction Measures
SLR-12. Limit Basements in Flood Zones. Limit basements and first floor habitable space in flood zones and keep critical assets (such as major electrical infrastructure) on higher floors.
SLR-13. Provide Removal Options in Flood Zones. Analyze options for removal of the structure or critical assets connected to the structure when planning and designing new development in flood zones.
SLR-14. Coordinate with Regional Planning Efforts. Coordinate with regional agencies on developing policies and/or plans where project-level solutions alone may not be able to mitigate sea level rise risk.
SLR 15. Alert Public of Storm Surge Risks. Include signage to warn people about flooding during storms and king tides. Provide materials to visitors and communities on risks of storms and king tides.
Extreme Precipitation and Inland Flooding
EP-1. Incorporate Runoff Projections in Hydrologic Designs. Incorporate projected increases in runoff into site-specific hydrologic design. Account for uncertainty in future runoff due to potential changes in precipitation, where past data is not a reliable predictor of future events.
EP-2. Install Stormwater Outfall Pumps/Lift Station for Water Drainage. Install stormwater outfall pumps/lift stations to drain water from the system if outfalls were to become submerged.
EP-3. Install Stormwater Cistern/Retention Basin. Build or enhance stormwater cisterns or retention basins.
EP-4. Waterproof Operational Equipment. Protect mechanical, electrical, and other key operational equipment from flooding at critical facilities/locations by dry proofing or wet proofing facilities.
EP-5. Upgrade Wastewater Systems. Upgrade wastewater systems to accommodate projected changes in precipitation and flooding. For example, enhance wastewater system capacity to prepare for increased flows and strengthen facilities against extreme events.
EP-6. Site Outside Floodplain. Select site outside the floodplain. If not completely possible, keep most climate-sensitive elements of the project outside the floodplain.
EP-7. Maintain Stormwater Infrastructure on Key Routes. Conduct regular cleaning and maintenance of storm drains and other stormwater infrastructure assets along key roadways, especially in advance of the rainy season. Improve storm drain capacity in areas where ponding is regularly observed.

Climate Risk Reduction Measures
Wildfire
WF-1. Implement Fire-Safe Landscaping.
Implement fire-safe landscaping. A toolkit for fire-safe landscaping is available online (IBHS n.d.).
WF-2. Install Fire Suppression Systems and Improve Structural Strength.
Install fire suppression systems in high fire risk locations. Incorporate hardening and strengthening aspects into structure design and material selection, such as tile roofs and mesh in attic vents to prevent ember sparks.
WF-3. Strengthen Vulnerable Assets in High Wildfire Risk Areas.
Strengthen vulnerable assets in high wildfire risk areas. For example, replace wooden electricity distribution poles with steel poles.
WF-4. Educate on Wildfire Resistant Landscaping.
Provide information to homeowners about statutory vegetation management requirements (CAL FIRE 2019a) and promote defensible space to slow fire spread in forested and wildland-urban interface (WUI) areas. For example, send educational materials encouraging homeowners to create fire-resistant zones with stone walls, patios, decks and roadways. Similarly, promote the use of rock, mulch, flower beds and gardens as ground cover for bare spaces and as effective firebreaks. Additional resources are available from CAL FIRE (CAL FIRE 2019b).
WF-5. Site Outside WUI.
Direct site selection outside of the WUI, the zone where development meets wildland areas, including fire hazard severity zones as mapped by CAL FIRE. (Some Counties also have WUI maps.) If not able to site outside the WUI and/or fire hazard severity zones, implement other fire-safe management, such as creating defensible space or carrying out fuel management.
WF-6. Designate and Strengthen Wildfire Emergency Routes.
Identify and mark emergency routes or recommend additional roads in the wildland-urban interface in case of evacuations. Provide advanced public education on evacuation routes and deliver emergency evacuation orders and warnings. Make all notices and guidelines accessible in multiple languages. Ensure redundancy in evacuation routes.
WF-7. Develop Fire Risk Assessment for New Development.
Develop a fire risk assessment for all new development within fire hazard severity zones or the WUI.
WF-8. Implement Fuel Management.
Carry out fuel (i.e., live vegetation or dead biomass) removal/management techniques, such as fuel breaks, in the WUI and in the wildfire influence zone. Conduct controlled/prescribed burns to mitigate wildfire risk.
WF-9. Install Air Filters.
Encourage the installation of air filters to protect against indoor air quality impacts during wildfire smoke exposure events.
WF-10. Adopt WUI Building Standards.
Recommend in Local Responsibility Areas that households adopt WUI Building Standards and consider using WUI-approved construction materials if they are in High and Moderate Fire Hazard Severity Zones.
Temperature/Extreme Heat
EH-1. Install Green Infrastructure.
Install green infrastructure to increase shading and reduce heat impact. For example, green streets and pocket parks.

Climate Risk Reduction Measures
EH-2. Provide Heat Mitigation for Public Walkways and Transit Stops. Collaborate with public works departments and regional transit providers to increase shading and heat-mitigating materials on pedestrian walkways and transit stops. For example, build bus shelters or plant trees at bus stops to provide shade for waiting passengers.
EH-3. Install Heat-Reducing Roof. Install green roofs, cool roofs, or other high-albedo or heat reducing roofs.
EH-4. Enhance Building Envelope Efficiency. Improve building envelope efficiency to protect against extreme heat. For example, install well-sealed doors and windows or window treatments such as solar shades. May also include passive cooling design/architecture.
EH-5. Upgrade to Efficient Equipment/Infrastructure. Upgrade equipment and infrastructure to be more energy-efficient to minimize stress on the electrical grid.
EH-6. Install Refillable Water Stations. Install refillable water stations at parks, trailheads, community centers, and sport courts/fields with available water supplies to encourage proper hydration and protection against heat-related illnesses.
EH-7. Install Equipment Cooling System. Provide cooling systems for equipment sensitive to overheating.
EH-8. Use Alternative Pavement Surfaces. Use alternative pavement surfaces (to reduce rutting, cracking, heat impacts, etc.) when resurfacing roads, critical intersections, multi-use paths, and city parking lots.
EH-9. Expand Urban Tree Canopy. Develop or expand urban tree canopy to help cool urban environments.
EH-10. Install Covered Parking. Install a form of covered parking, such as trees or solar panels, that mitigates heat islands and reduces off-gassing from cars.
EH-11. Work with Schools to Reduce Heat Exposure. Provide education, partnership, and other support to local schools to reduce outdoor exposure during extreme heat events.
EH-12. Provide Backup Power for Cooling Centers. Ensure that facilities used as cooling centers are equipped with backup power supplies, including onsite renewable energy generation and energy storage systems as feasible.
EH-13. Develop Heat Emergency Plan. Adopt or update heat emergency plan. Ensure that the needs of vulnerable and remote populations are accounted for in the plan.
EH-14. Develop Low-Income Energy Programs. Work to coordinate energy-related programs that target low-income communities with broader climate risk reduction efforts.

Climate Risk Reduction Measures
EH-15. Provide Low-Income Air Conditioning.
Provide reduced-cost, energy-efficient air conditioning systems to low-income households.
EH-16. Establish a Shuttle System to Cooling Centers.
Establish a shuttle system to operate during extreme heat events with specific pickup points and provide access to local cooling centers for persons who are unable to drive or lack access to a vehicle.
Drought
D-1. Install Water Efficient Appliances.
Install water-efficient appliances, such as water-efficient faucets and pipe fixtures.
D-2. Install Water Reuse Infrastructure.
Install infrastructure that encourages water reuse, such as greywater appliances and stormwater capture.
D-3. Install Drought Resistant Landscaping.
Install pervious and landscaped surfaces to reduce heat island effects and improve groundwater recharge. Installation may include the use of native, arid ecosystem plants as well as water-smart technologies, such as drip irrigation.
D-4. Educate on Water Conservation.
Educate the public on and encourage water conservation behavior. For example, running education campaigns or having information available at a community center.
D-5. Outreach to Educate About Recycled Water Safety.
Initiate public outreach to encourage acceptance of recycled potable water sources.
D-6. Build Alternatives Forms of Water Recreation.
Work with owners of water recreation sites to begin installing alternative forms of recreation that are less dependent on water levels.
D-7. Diversify Water Supply Sources.
Diversify water supply sources to have backup sources during drought when some water supplies (e.g., surface water) may be scarce to ensure all communities have access to water. For example, increase sourcing from groundwater or local recycled water.
D-8. Develop Groundwater Sustainability Plan.
Work with local water utilities, agencies, and stakeholders to comply with or develop a groundwater sustainability plan.
D-9. Implement Local Water Recycling.
Implement local water recycling, either decentralized at residential/commercial facilities, or centralized at larger community facilities.

References

Bedsworth, L., D. Cayan, G. Franco, L. Fisher, S. Ziaja. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. Statewide Summary Report. *California's Fourth Climate Change Assessment*. Publication number: SUMCCCA4-2018-013.

CAL FIRE. 2019a. *More from Cal Fire*. Available: https://www.readyforwildfire.org/more/fire-safety-laws/. Accessed: May 2021.

CAL FIRE. 2019b. *Prepare for Wildfire*. Available: https://www.readyforwildfire.org/prepare-for-wildfire/get-ready/fire-resistant-landscaping/. Accessed: May 2021.

California Air Resources Board (CARB). No Date. *California Climate Investments Co-benefit Assessment Methodologies*. Available: https://ww2.arb.ca.gov/resources/documents/cci-methodologies. Accessed: May 2021.

California Department of Transportation (Caltrans). 2020. *2019 Climate Change Vulnerability Assessments*. Available: https://dot.ca.gov/programs/transportation-planning/2019-climate-change-vulnerability-assessments. Accessed: January 2021.

California Governor's Office of Planning and Research (OPR). No Date. *Topics: Plan Alignment*. Available: https://resilientca.org/topics/plan-alignment/?orgtypes=federal. Accessed: May 2021.

California Governor's Office of Emergency Services (Cal OES). 2020. California Adaptation Planning Guide. June. Available: https://www.caloes.ca.gov/HazardMitigationSite/Documents/CA-Adaptation-Planning-Guide-FINAL-June-2020-Accessible.pdf. Accessed: July 2021.

Deas, M., Grannis, J., Hoverter, S., & DeWeese, J. 2017. *Opportunities for Equitable Adaptation in Cities (Rep.)*. Washington DC: Georgetown Climate Center. Available: https://www.georgetownclimate.org/files/report/GCC-Opportunities_for_Equitable_Adaptation-Feb_2017.pdf. Accessed: January 2021.

Insurance Institute for Business & Home Safety (IBHS). No Date. *Wildfire Ready*. Available: https://disastersafety.org/wildfire/wildfire-ready/. Accessed: May 2021.