Title
Community-Based Climate Adaptation Planning: Case Study of Oakland, California

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Publication Date
2012-02-01

Public Interest Energy Research (PIER) Program

White Paper

COMMUNITY-BASED CLIMATE ADAPTATION PLANNING: CASE STUDY OF OAKLAND, CALIFORNIA

A White Paper from the California Energy Commission's California Climate Change Center

Prepared for: California Energy Commission

Prepared by: Pacific Institute

FEBRUARY 2012

CEC-500-2012-XXX

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ACKNOWLEDGEMENTS

Major funds for this paper were made through the California Energy Commission's Public Interest Energy Research (PIER) Program.

Many individuals, organizations, and agencies helped make this work possible by providing data, information, and input and review of the final paper. First, we would like to deeply thank members of the Oakland Climate Action Coalition (OCAC), especially members of the Oakland Climate Action Coalition's Resilience and Adaptation Subcommittee who helped to plan coalition engagement with this research project: Brian Beveridge and Margaret Gordon of the West Oakland Environmental Indicators Project , Emily Kirsch and Colin Miller of Ella Baker Center, Nile Malloy of Communities for a Better Environment, and Armando Nieto of California Food and Justice Coalition.

We also extend our heartfelt appreciation to the following OCAC coalition members and colleagues who generously reviewed and shared their insights on draft research methods and results from this project: Dionne Andrews, Nehanda Imara, Anna Yun Lee, and Laneisha Tate (Communities for a Better Environment); Lotta Chan and Victoria Endsley (California Food and Justice Coalition); Ellen Choy (Mandela Marketplace); Robbie Clark (Causa Justa/Just Cause); Gopal Dayaneni and Mateo Nube (Movement Generation); Duane De Witt and Matthew Fidanque (West Oakland Environmental Indicators Project); Jamie Fine (Environmental Defense Fund); Vivian Huang, Mari Rose Taruc, Mei-ying Williams, and Miya Yoshitani (Asian Pacific Environmental Network); Zaigham Kabir (Center for Progressive Action); Ellen Kersten (University of California, Berkeley); Alice Kostin and Beth Weinberger (Kehilla Community Synagogue); David Jaber (InNative Consulting); Aaron Lehmer and Kirsten Schwind (Bay Localize); Frank Lopez (Urban Habitat); Donal Mahon (The International Longshore and Warehouse Union Local Six); Lauren Palumbi and Suzanne Pegas (Oakland Museum of California); Joél Ramos (Transform); Levana Saxon (Practicing Freedom); Rebecca Tumposky (Health for Oakland's People and Environmental Collaborative); Al Weinrub (Local Clean Energy Alliance); Ryan Briscoe Young (Greenlining Institute).

PREFACE

The California Energy Commission's Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

In 2003, the California Energy Commission's PIER Program established the California Climate Change Center to document climate change research relevant to the states. This center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's Climate Change Research Plan are: monitoring, analysis, and modeling of climate; improved methods to estimate greenhouse gas emissions; analysis of options to reduce greenhouse gas emissions; and impacts and adaptation studies.

For more information on the PIER Program, please visit the Energy Commission's website http://www.energy.ca.gov/research/index.html or contract the Energy Commission at (916) 327-1551.

ABSTRACT

There is growing recognition that some degree of climate change is now unavoidable and all regions, sectors, and people are vulnerable to climate change impacts to varying degrees. In response, a variety of stakeholders, from local governments to social justice groups and corporations, are beginning to think about adaptation strategies to help reduce their risk.

Adaptation planning it still in its infancy and local governments are struggling with how to navigate the planning process. A handful of communities in the United States have embarked on planning efforts and have engaged the local community in some manner. Here, we provide a detailed analysis of climate impacts, vulnerabilities, and adaptation options in a major economic center: Oakland, California. The goal of this study is to inform the development of a comprehensive and equitable climate adaptation plan effort. This research project engages active members of the Oakland Climate Action Coalition, including community-based organizations and resident leaders, in analyzing both the impacts of, and social vulnerabilities to, climate change. Further, it enumerates adaptation strategies that can be implemented at the local level, discusses their advantages and disadvantages, and identifies social equity concerns. Finally, it identifies trends and best practices in climate adaptation planning processes, focusing specifically on their efficacy in engaging the broader community and in addressing the needs of all residents, especially the most vulnerable. This paper is meant to serve as a tool for both city planners and community members everywhere, as they work in tandem to develop more equitable and resilient cities for the climate of the future.

Keywords: climate change, adaptation, resilience, Oakland, social vulnerability, economic vulnerability, socio-economic vulnerability, California, sea level rise, wildfire, extreme heat, air quality, water, energy, electricity, environmental justice, climate justice, climate action planning

Please use the following citation for this paper:

Garzón, Catalina, Heather Cooley, Matthew Heberger, Eli Moore, Lucy Allen, Eyal Matalon, Anna Doty, and the Oakland Climate Action Coalition. (Pacific Institute). 2012. ***Community-Based Climate Adaptation Planning: Case Study of Oakland, California***. California Energy Commission. Publication number: CEC-500-2012-XXX.

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Section 1: Introduction

The numerous and complex effects of climate change, already beginning to be felt globally, will grow significantly in the coming decades. From rising seas to increases in unpredictable weather events, increased air pollution and wildfires, and changes in water supply, climate change will have impacts on our economy, society, and environment. In response, local, state, and federal governments are beginning to take action through the development of action plans and regulatory initiatives to prevent climate change from exacting its worst toll (mitigation) and to prepare for its unavoidable impacts (adaptation). As communities become aware of distinct vulnerabilities to environmental hazards, they need information about the types of policies and plans to put into place.

Here, we provide a detailed analysis of climate impacts, vulnerabilities, and adaptation options in a major economic center: Oakland, California. Due in part to its location, Oakland is vulnerable to a number of climate impacts, such as flooding and wildfires. Climate impacts will be felt by a number of sectors, such as the Port of Oakland and other major transportation infrastructure, residential neighborhoods, local wetlands, and water supplies. Furthermore, Oakland is a large and diverse community. Certain communities and populations share characteristics that make them more vulnerable to adverse effects of climate change. Such groups might be more susceptible to harm from exposure to a hazard, directly affecting their ability to prepare for, respond to, and recover (Cutter 2009).

In 2011, the City of Oakland released its Energy and Climate Action Plan (ECAP), which set more aggressive greenhouse gas emission targets than those issued by the state (36 percent reduction in greenhouse gas emissions from 2005 levels by 2020) and identified a range of policies and programs to meet these targets. Over 30 community, environmental, labor, and other organizations joined forces to establish the Oakland Climate Action Coalition (OCAC). The goal of OCAC is to include community priorities in the city's climate action plan, and ensure that the plan is effective and equitable. Climate *mitigation* (reducing greenhouse gas emissions) has been the primary focus of the City's climate action plan. Like most of the city plans from across the United States that we reviewed, Oakland's ECAP includes little information on climate *adaptation*, or how the city should prepare for the impacts of climate change. City staff, however, recognizes the need for the development of a comprehensive city-wide adaptation plan.

The goal of this study was to inform the development of a comprehensive and equitable climate adaptation plan for the City of Oakland. Pacific Institute staff conducted a range of analyses to estimate both the impacts of and vulnerabilities to climate change. We consulted with active members of the OCAC, including community-based organizations and resident leaders, through a series of meetings and numerous discussions. Further, we identified adaptation strategies that can be implemented at the local level, discussed their advantages and disadvantages, and noted social equity concerns associated with them. Finally, we discussed best practices in climate adaptation planning processes. In particular, we focused on the need to

involve the wider community in adaptation planning, in order that plans and programs will address the needs of all residents, especially the most vulnerable. This analysis was meant to serve as a tool for both city planners and community members everywhere as they work to develop more equitable and resilient cities for the climate of the future.

Section 2: Approach

2.1 Community Engagement in the Oakland Climate Study

This effort represented a community-engaged research project. Community-engaged research is defined as an approach to the research process that integrates the technical expertise of researchers with the experiential knowledge of non-academically trained community partners who are directly affected by the issue being studied (Minkler and Wallerstein 2008). The authors use the term *community-engaged research* instead of the term *participatory research* to draw a distinction between the approach used in this study and participatory research projects that directly involve impacted community members in collecting and analyzing data. This study, however, used participatory process tools to engage OCAC member organizations based in vulnerable communities in decision-making related to the research, including how to structure engagement in the research process.[1] Data was collected and analyzed by Pacific Institute researchers, who then shared draft research methods and results with coalition partners and integrated their feedback into final research products.

Engaging community stakeholders can benefit the quality of the research process in a number of ways, as documented by Minkler and Baden (2008). Community participation in the research process can improve research design by refining research questions, methods, and instruments for greater accuracy and relevance. Involving community members in data collection, such as in administering surveys, can increase recruitment and response rates in research studies. The participation of the affected community in data analysis and interpretation can also enhance the interpretive validity of research findings. Lastly, engaging the affected community in disseminating research findings can lead to more widespread application and use of findings to improve the conditions being researched.

This study applied key principles of community-based participatory research to the research process, including recognizing community as a unit of identity, valuing priorities identified by the community, and sharing knowledge gained with all partners (Israel et al. 2008). According to Israel et al., "communities of identity may be centered on a defined geographic neighborhood or be made up of members of a geographically dispersed group with a sense of common identity" (2008: 49). This study engaged a city-wide policy advocacy coalition of community-based, labor, and environmental organizations that formed in 2009 to advance social equity within the City of Oakland's municipal climate action planning process. Member organizations of the OCAC included community groups based in neighborhoods with large concentrations of low-income residents, the elderly, those with pre-existing medical conditions, and other vulnerable populations, such as West Oakland, Oakland Chinatown, and East Oakland. For this study, we mostly worked with staff and representatives of OCAC member organizations who work with community residents, rather than with the residents themselves. However, Pacific Institute staff presented information on climate change and its local impacts at several community workshops. This approach was consistent with a standard practice in community-

[1] OCAC member organizations are identified in the acknowledgements of this paper.

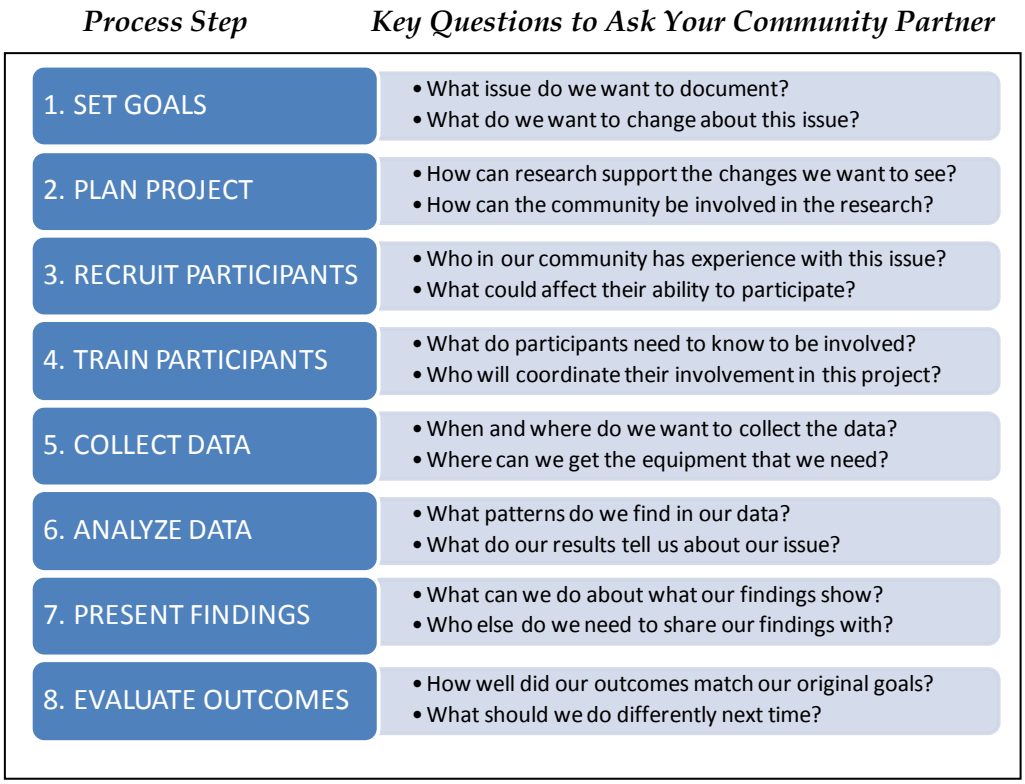
based research of engaging a community-based organization or coalition as the primary partner in a research process (Stoecker 2008).

Figure 1 lists the basic steps in a community-based research process and outlines key questions that researchers use to engage community partners in shared decision-making at each step in the process. This framework was developed by the Pacific Institute's Community Strategies for Sustainability and Justice Program through a series of community- and coalition-based research partnerships coordinated by program staff over the past 15 years. The Institute applied this framework to inform the process used to engage OCAC coalition partners in this study. Though capacity-building trainings were not a formal component of the study (step 4), OCAC engagement in the research process deepened an understanding of climate change impacts, vulnerabilities, and the need for appropriate adaptation strategies on the part of both researchers and coalition partners. This kind of co-learning, defined as a reciprocal transfer of knowledge and skills that enhances the capacity of all partners involved, is a key outcome of community-based research (Israel et al. 2008).

The study drew on the OCAC's existing coalition structure and collaborative process to engage coalition members in the research process. This structure consisted of a steering committee that met monthly, subcommittees on priority areas of coalition work as determined by the steering committee, and a general membership body that met every other month. OCAC subcommittees were co-chaired by a community-based member organization and a nonprofit intermediary group with staff capacity to support coalition-related activities.

In February 2010, Pacific Institute was asked to co-chair the OCAC's Resilience and Adaptation Subcommittee with the West Oakland Environmental Indicators Project, a community-based environmental justice organization. In this role, Pacific Institute staff facilitated monthly subcommittee meetings and supported subcommittee work by drafting meeting notes, comment letters, talking points, and other documentation of meeting outcomes to inform coalition work on the City of Oakland's Energy and Climate Action Plan process. In July 2011, the Institute was asked to join the OCAC Steering Committee due to its role as co-chair of the Resilience and Adaptation Subcommittee.

Figure 1: Basic Steps in a Community-Based Research Process



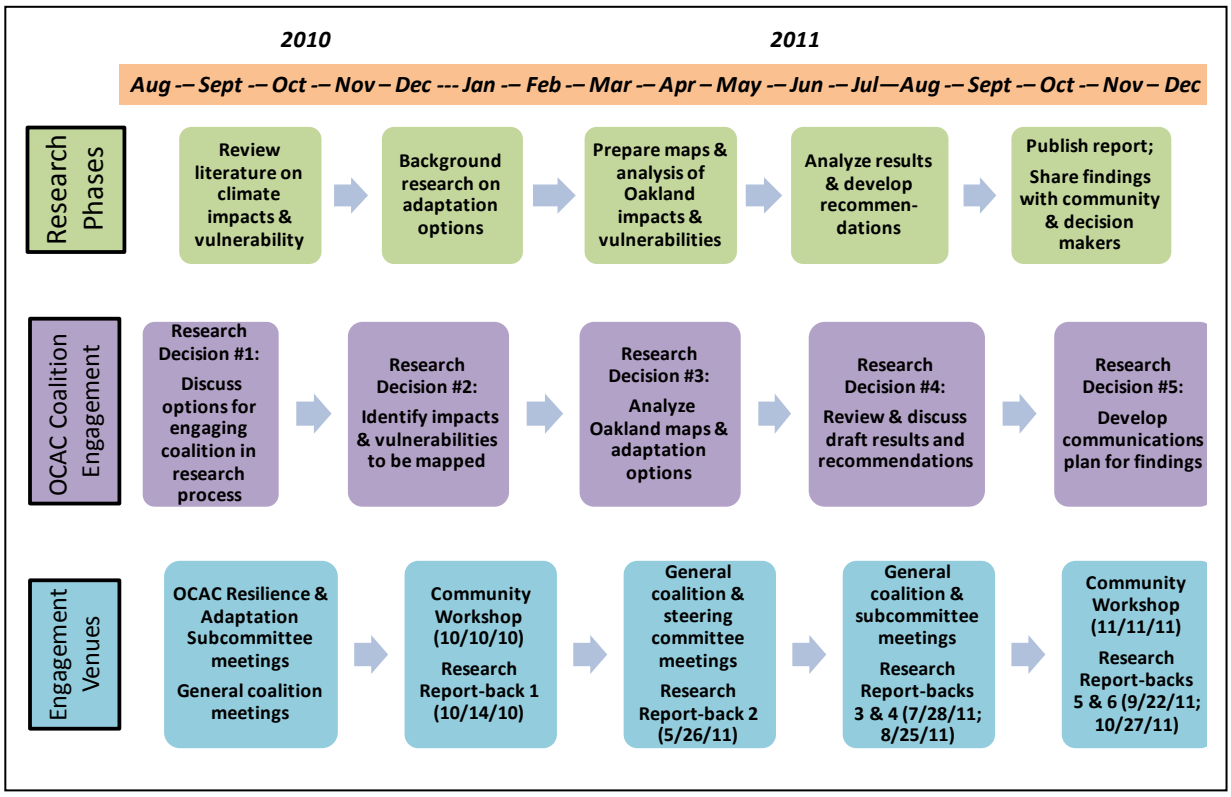
At the request of the OCAC Steering Committee, the OCAC Adaptation Subcommittee held a community workshop on adaptation at the *Oakland Day of Action for Climate Solutions*, an event at a local community college in October 2010. This event was sponsored by coalition member organizations. Pacific Institute researchers worked with community leaders at the West Oakland Environmental Indicators Project to develop popular education materials and interactive activities for the workshop based on the Pacific Institute's initial research on vulnerability factors to climate change impacts. Over 30 community members attended the workshop, where they matched factors that could affect vulnerability to potential local impacts of climate change and shared how they had responded to past extreme heat events, floods, and poor air quality. Participants then worked in small groups to brainstorm ways to better protect and prepare their communities should these kinds of impacts get worse or more frequent.

The Pacific Institute's active involvement in coalition activities helped to build and maintain trusting working relationships with OCAC member organizations, which is integral to a successful community-engaged research process (Israel et al. 2008). Resource constraints prevented Pacific Institute from directly compensating member organizations for the time they spent contributing to the study, as community engagement was considered outside the scope of fundable activities by the study funder. However, the Pacific Institute's commitment to supporting the work of the OCAC Resilience and Adaptation Subcommittee through staff time and other in-kind contributions helped establish the sense of reciprocity and mutual benefit

needed to sustain the engagement of OCAC coalition members throughout the research process.

Community engagement in this study took place from May 2010 to November 2011 through consultation with OCAC coalition partners at key points in the research decision-making process, as shown in Figure 2. These decisions included the types of climate impacts and vulnerability factors to be considered, the methods that should be used to map social vulnerability to local climate impacts, the interpretation of research results, and how to share the results with key audiences. Several venues were used to engage coalition partners in the research process, including general coalition meetings, OCAC Steering Committee meetings, OCAC Resilience and Adaptation Subcommittee meetings, community workshops, and research report-backs. Formats for engagement included brief updates on the research process, agenda items for discussion, PowerPoint presentations followed by facilitated question and answer sessions, small group discussions, and interactive workshop activities.

Figure 2: Community Partner Engagement in Oakland Climate Study



In June 2010, Pacific Institute shared a tentative timeline for the study with the OCAC steering committee and discussed options for engaging coalition members in the research process. Institute staff also held one-on-one meetings with member organizations to discuss how the proposed study related to their ongoing and planned organizational and coalition work on climate change issues in Oakland. The outcomes of these meetings indicated that OCAC member organizations were interested in being involved in the study but had limited capacity

to do so given their existing commitments with coalition activities and the lack of funding available to resource their involvement in the study. Based on these meetings, structures for community engagement in the study were designed to maximize overlap with existing coalition structures, rather than creating a separate decision-making body like a project planning team to guide the study.

A series of joint sessions between Pacific Institute researchers and interested OCAC members, called "research report-backs," were the primary structure used to engage the OCAC in the research process. These research report-back sessions consisted of a brief presentation by Pacific Institute staff on draft research methods and products followed by a facilitated discussion about their implications for OCAC members' work on local climate change issues. To maximize participation, the report-backs were held after regularly scheduled coalition meetings and lunch was provided. To engage coalition partners in planning these sessions, draft report-back agendas and materials were reviewed and discussed at OCAC Resilience and Adaptation Subcommittee meetings prior to each session and revised based on subcommittee feedback. The number of participants at each report-back session ranged from 7 to 22 participants and represented a variety of OCAC member organizations, including community-based organizations, environmental advocacy nonprofits, labor organizations, and faith-based institutions.

In total, six report-back sessions were held between October 2010 and November 2011 to share draft research methods and products with coalition members. The report-back sessions were scheduled as soon as possible once preliminary research results or draft products were available, in order to engage coalition partners in "real-time" decision-making to inform upcoming phases of the research process. The first report-back session in October 2010 discussed the potential climate impacts that would be evaluated in the study and the results of an academic literature review on vulnerability factors to climate impacts that would inform subsequent phases of the research process. The second session in May 2011 discussed the draft methods researchers were proposing to use for the vulnerability analysis. The time lag between the first and second report-back sessions was largely attributable to delays in acquiring and formatting the data sets needed for the mapping and analysis phases of the research.

At the third report-back in July 2011, Pacific Institute researchers shared draft maps of coastal flooding and extreme heat impacts in Oakland and discussed which potential adaptation measures could be put in place to prepare and protect vulnerable communities from those impacts. The fourth report-back session in August 2011 discussed draft maps of local air quality and wildfire risk impacts, as well as maps of vulnerability factors to climate change impacts, such as access to air conditioning and percentage of adults 65 and over living alone.

The fifth report-back session in September 2011 focused on sharing the results of Pacific Institute research on adaptation planning processes in other U.S. cities and potential adaptation measures that could be put in place through these processes to protect vulnerable communities from climate change impacts. At the sixth and final report-back session in October 2011, Pacific Institute researchers shared draft conclusions and recommendations to be included in a report

on the research, and developed a dissemination plan with OCAC members to share these recommendations with community stakeholders and decision-makers.

Lastly, Pacific Institute co-convened a final community workshop on equity and resilience on November 11, 2011 with other member organizations of the Oakland Climate Action Coalition. Pacific Institute researchers presented background information on local climate change impacts and adaptation options for vulnerable communities in Oakland. Over 100 participants attended the workshop, which featured speakers and discussions on how to build and sustain a movement for resilient and just communities in the San Francisco Bay Area. At the workshop, participants brainstormed impacts of concern and potential policy solutions at breakout sessions focusing on a range of climate impacts including those examined in this study.

2.2 Climate Impacts and Vulnerabilities

Climate risk is a function of exposure to the hazard and vulnerability. The primary objective of the research project was to identify geographic areas within Oakland with heightened risk to projected climate impacts, as a guide to policymakers and affected communities on where to focus climate adaptation efforts. The methodology we employed in this analysis involved three steps: (1) develop or obtain geographic data on the extent and severity of projected physical impacts of climate change to determine exposure to these impacts; (2) gather data on indicators of social vulnerability that relate to these impacts at an appropriate geographic scale; and (3) overlay vulnerability and exposure layers to produce a composite of exposure and vulnerability. The areas of overlap indicated those areas with heightened risk of being impacted by these climate changes as a result of exposure and social vulnerability.

Detailed maps of climate impacts and social vulnerabilities to these impacts in California were developed and described in Cooley et al. (2012). For this analysis, we used these maps but looked in detail at the climate impacts and social vulnerabilities in Oakland, California. Climate impacts evaluated include extreme heat, wildfires, coastal flooding due to sea-level rise, and particulate matter (PM) concentrations. Additionally, community stakeholders identified future food, water, and electricity prices as a key concern. The future prices of these commodities depend on many factors other than climate. While some analysis has been done on the effect of climate on these prices, it is often qualitative or the range of the results is too large to be useful. Given these limitations, we provided the group with a summary of the existing research on these impacts and identified potential implications for vulnerable communities.

All climate impacts except air quality in this study were evaluated under the Intergovernmental Panel on Climate Change (IPCC) A2 and B1 greenhouse gas emissions scenarios, which correspond to medium and medium-high greenhouse gas emission scenarios, respectively (see Section 2.2.1 for a description of the scenarios). Reported data represent averages over the following time periods: historic (1971–2000), early century (2010–2039), midcentury (2040–2069), and end of century (2070–2099). Such data were not available for air quality. For the air quality data, we relied on data from a modeling study covering current conditions (2000–2006) and mid-century (2047–2053) under a "business-as-usual" greenhouse gas emissions scenario and an extrapolation of current pollutant emissions.

2.1.1 IPCC Climate Change Scenarios

The impacts of climate change will ultimately depend on future greenhouse gas concentrations. Future greenhouse gas emissions remain uncertain and are influenced by a variety of demographic, socio-economic, and technological factors. Scenarios can be a useful tool for examining how changes in these driving factors affect greenhouse gas concentrations. These scenarios can be useful for evaluating impacts associated with climate change as well as assessing adaptation and mitigation activities. The Special Report on Emissions Scenarios (SRES) outlines four storylines that differ according to demographics, social, economic, environmental, and technological factors and lead to different levels of greenhouse gas emissions. Each storyline has a number of different scenarios, referred to as a family. A total of 40 scenarios have been developed.

The four storylines are described below:

The A1 storyline is characterized by "a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income" (IPCC 2000). The A1 family is further divided into three subgroups that are differentiated according to energy source: fossil intensive (A1FI), non-fossil sources (A1T), and a mix of fossil and non-fossil sources (A1B).

The A2 storyline is characterized by "self-reliance and preservation of local identities" (IPCC 2000). Population is expected to continuously increase, but economic growth and technological development are expected to be slow.

The B1 storyline has the same population projections as the A1 storyline but "rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies" (IPCC 2000).

The B2 storyline is characterized by "a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines" (IPCC 2000).

2.2.2. Vulnerability to Climate Change

To compare overall vulnerability to climate change among areas within the state, we used a vulnerability index that combines the many vulnerability factors into one score. The methodology for the index was based on the Social Vulnerability Index (SoVI) (Cutter et al. 2003), developed to assess social vulnerability to hazards. Cutter's original formulation of SoVI included 32 factors that the literature suggests contributes to a community's ability to prepare for, respond to, and recover from hazards (Cutter et al 2003). The SoVI index quantifies social vulnerability using available data, mostly from the US Census, including income, race, unemployment, and others. We developed a custom index that differs from SoVI in that it solely includes indicators specific to climate change impacts, such as air conditioner ownership, childhood obesity, percent tree cover, pre-term births, number of outdoor workers, and others.

Project partners provided input on the index, the possible data sources for that index, and its application. The final index consisted of 19 vulnerability factors. The social vulnerability index was compiled at the census tract level. For much of the data, census tracts were the smallest geographic boundary at which the data was aggregated. Each of the 19 variables was measured and reported in its own units (e.g. number of low-income residents, or percent impervious cover). In order to add these variables together, they were transformed to standard units using z-score standardization, as employed in Cutter et al. (2003). The cardinality was then adjusted to ensure that the sign of the factor represents the way the factor influences vulnerability. For example, a high percentage of low-income residents indicate higher vulnerability; so this variable has a cardinality of +1. By contrast, a higher percentage of high-school graduates indicate lower vulnerability, so this variable has a cardinality of -1. Once all of the variables were transformed, the component z-scores were averaged to generate a vulnerability score for each of the census tracts in Oakland (HVRI 2011). Higher numbers indicated greater social vulnerability, indicating that residents in the tract will be less likely to be able to cope with a climate-related disturbance like heat stress, a flood, or a wildfire.

To compare social vulnerability across Oakland, the index scores were grouped into terciles, with scores below the 33rd percentile considered "Low Vulnerability," those between the 33rd and 66th percentile considered "Medium Vulnerability," and the higher tercile comprising "High Vulnerability." This grouping is arbitrary. Communities that are considering this approach may want to use quartiles or quintiles to look at the data at a finer resolution. It is important to note that there may be highly vulnerable people within a low vulnerability tract.

It should be noted that we used the census tract boundaries from the 2000 Decennial Census, rather than the more recent 2010 census boundaries. Much of the data we used was collected from 2005- 2009 and was aggregated with the year-2000 census tract boundaries. It will be several years before American Community Survey data, which is grouped according to the 2010 Census boundaries, become available. See Cooley et al. (2011) for additional information about the data sources and methods for developing the index.

In addition to a single vulnerability index, maps for each vulnerability factor are available at www.pacinst.org and can be accessed by agencies, community groups, and individuals to help inform climate adaptation efforts. It is important to note that some indicators of vulnerability are not intended to measure progress toward more resilient communities, e.g., race and age characteristics of a community will not change through efforts to build resilience. Thus, these indicators will not be useful in measuring the effect of these efforts. Separate indicators will likely be needed to track climate planning and action processes.

Table 1 shows the vulnerability factors, the indicator used to represent that vulnerability, and the data sources used in the analysis. Ideally, our social vulnerability index would have included more than 19 factors, but we were limited due to the availability of data on various vulnerability factors. For example, some social characteristics, such as the level of community organization in an area, will have a significant effect on the population's ability to respond to and recover from climate change. Yet an indicator for this factor was not included in our analysis because reliable data at the appropriate scale were not available.

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Table 1. Factors Included in the Vulnerability Index and their Data Sources

Vulnerability Factor	Indicator	Data Source
Households with air conditioning	Households with an air conditioning unit	Roberts 2011a
Population over 25 with a diploma	People over age 25 who have a high school diploma	U.S. Census, American Community Survey (2005-9)
Born outside the U.S.	People who were born outside the United States	U.S. Census, American Community Survey (2005-9)
Impervious areas	Land in the area that has an impervious surface (e.g. sidewalk or roof)	EPA 2001
Residents living in institutions	Population living in “group quarters”, including institutions like correctional facilities, nursing homes, and mental hospitals, college dormitories, military barracks, group homes, missions, and shelters.	U.S. Census, American Community Survey (2005-9)
Households with limited English	Population 5 years and over who answered that they speak English less than "very well"	U.S. Census, American Community Survey (2005-9)
Households with no vehicle	Percentage of households with no vehicle available	U.S. Census, American Community Survey (2005-9)
People of color	People identifying as any other race or ethnicity besides white.	U.S. Census, American Community Survey (2005-9)
Households in poverty	Households with an income that is below 200% of the official federal poverty level	U.S. Census, American Community Survey (2005-9)
Pre-term births	Infants that were born before completing 37 weeks (about 8.5 months) of pregnancy	Roberts 2011b
Renter-occupied households	Percent of households where people are renting	U.S. Census, American Community Survey (2005-9)
Over 65 and living alone	Percent of households occupied by someone over age 65 who lives alone	U.S. Census, American Community Survey (2005-9)
Tree canopy cover	Land covered by tree canopy	Calculated by Jessdale et al. using data from Nat'l Land Cover Dataset, 2001
Under age 18	Population under age 18	U.S. Census, American Community Survey (2005-9)
Unemployment	Population 16 years and over able to work who are unemployed	U.S. Census, American Community Survey (2005-9)
Have jobs working outdoors	Percent of workers who work in agriculture, forestry, mining, or construction	U.S. Census, American Community Survey (2005-9)
Pregnancy	Percentage of women 15 to 50 years old who had a birth in the past 12 months	U.S. Census, American Community Survey (2005-9)
Food access	Access to full-service supermarkets according to Low Access Area measurement tool	The Reinvestment Fund 2010
Youth fitness	Fraction of children that are overweight or obese in tract (i.e. fraction over 85th percentile for age and gender based on the CDC growth curves.	Ortega Hinojosa 2011

2.3 Adaptation Strategies and Planning Processes

During the research report-backs, community partners indicated an interest in understanding specific adaptation strategies available to reduce vulnerability to climate change impacts and/or build community resilience. Given this interest, we reviewed the literature, surveyed existing adaptation efforts around the world, and consulted with community-based organizations and other OCAC member organizations engaged in this research project to develop a list of adaptation strategies. Through a review of these strategies, it became apparent that issues around equity were not reflected in many of these strategies. We therefore compiled a list of adaptation strategies and described equity concerns and potential policy solutions to address those concerns. For the purposes of this study, equity was defined as the fair and just distribution of financial and institutional resources to address climate change impacts across communities that either contribute to and/or stand to be adversely affected by those impacts, and the commitment to include those communities most vulnerable to being adversely impacted by climate change in the development, prioritization, and implementation of climate mitigation and adaptation policies, programs, and services.

Community partners also indicated an interest in better understanding approaches used in adaptation planning processes more broadly, specifically related to how community engagement was integrated into these processes. To address this interest, the research team reviewed climate action plans and associated documents developed by the 25 largest U.S. cities and smaller cities that pioneered the climate adaption planning process. The research team also conducted a series of interviews with city planners and community leaders across the country. Through this review, the research team identified trends and best practices in climate adaptation planning processes, focusing specifically on their efficacy in engagement of the wider community and in addressing the needs of all residents, especially the most vulnerable. Though not exhaustive, this analysis was meant to serve as a tool for both city planners and community members everywhere, as they work in tandem to develop more equitable and resilient cities for the climate of the future.

Section 3: Results and Discussion

3.1 Impacts and Socio-Economic Vulnerabilities in Oakland, California

Maps and other visual aids were prepared to provide community partners with a visual representation of projected climate impacts for Oakland and the social vulnerability to these impacts. In many cases, project partners' reaction to the data allowed us to refine how it is presented. In the following sections, we provide an overview of the materials presented and the input we received from the project partners.

3.1.1 Social Vulnerability to Climate Change

Social vulnerability to climate impacts is shaped by a variety of factors, including income, race, health, age, etc. For this analysis, we used a single vulnerability index to compile data on a variety of vulnerability factors. Vulnerability indices, however, have a number of limitations. In particular, data might not be available for some vulnerability factors. Additionally, some vulnerability factors are unique to particular climate impacts. For example, asthma increases vulnerability to extreme heat but not necessarily flooding. Despite their limitations, vulnerability indices can be powerful tools for better understanding overall risk and for targeting adaptation strategies.

At the first report-back session, held in October 2010, Pacific Institute and project partners discussed the potential climate impacts that would be evaluated in the study and the results of an academic literature review on vulnerability factors to climate impacts. Project partners indicated a strong interest in an analysis of the impacts of climate change on water, food, and electricity prices. Pacific Institute researchers had initially not planned to include this because of a lack of quantitative information on the impacts of climate change on commodity prices. Based on input from the project partners, however, the analysis was expanded to include lengthy discussion about the potential impacts of climate change on water, food, and electricity prices and some of the equity implications of these impacts. The analysis also included a discussion of strategies to help minimize impacts on vulnerable communities, such as ways to modify rebate programs to benefit those on fixed- or low-incomes.

Additionally, Pacific Institute researchers expanded the list of vulnerability factors to include those characteristics or qualities raised by OCAC members. For example, vulnerability factors for extreme heat were expanded to include those who work outdoors and households that lack access to a vehicle. Vulnerability factors for air quality impacts were also expanded to include those with respiratory disease and other health conditions that involve sensitivities to poor air quality. OCAC members noted that strong kinship ties and social networks make some people less vulnerable because they provide a safety net to fall back on in times of need.

At the second and fourth report-back sessions, held in May 2011 and August 2011, respectively, Pacific Institute researchers and community partners discussed the draft methods for the vulnerability analysis, including the vulnerability index and data sources for that index (Table

1). Project partners reviewed the data to determine whether it accurately reflected conditions in their communities. In most cases, the project partners agreed that the data were accurate. However, in three census tracts, project partners indicated that the data was not accurate. Pacific Institute researchers reviewed the data and upon further analysis found that these data did not change the overall vulnerability of the census tracts.

Table 2 shows the results of the vulnerability analysis. Of the 407,000 Oakland residents, about 23 percent resided in census tracts with a low social vulnerability. Fifty-six percent of the population, however, resided in census tracts with a high social vulnerability. Although the indices were divided into terciles, such that one-third of the census tracts were in each vulnerability category, e.g., high, medium, and low, census tracts with high vulnerability were more densely populated. Thus, a large proportion of the total population was classified as high vulnerability. The social vulnerability data showed a distinct geographic pattern. Areas of high vulnerability were largely concentrated in the southern and eastern portions of Oakland. Areas with a low vulnerability, by contrast, were typically found east of Highway 580 (Figure 3).

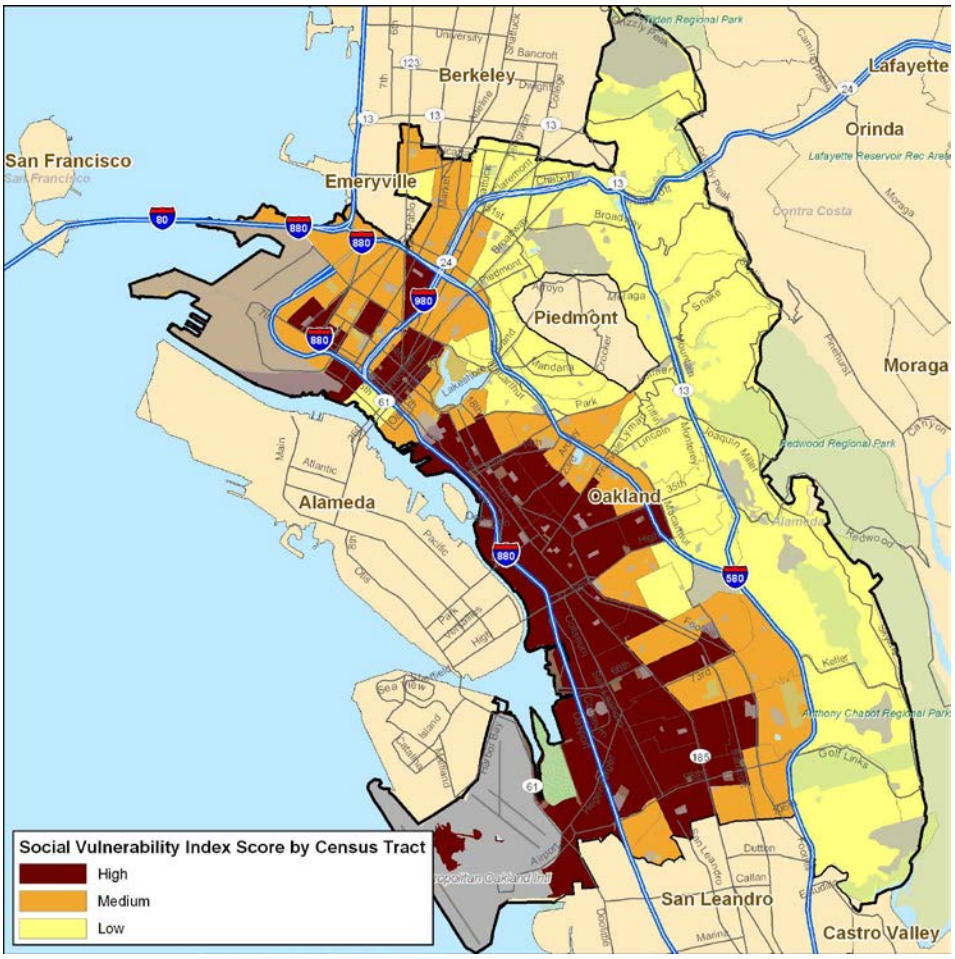
Table 2. Number of Oakland Residents Living in Low, Medium, and High Social Vulnerability Tracts

Level of Social Vulnerability	Population
Low	106,000
Medium	71,900
High	230,000
Total	**407,000**

Note: Results rounded to three significant figures. Population estimates reflect the number of people living in census tracts with a low, medium, and high social vulnerability.

A major discussion topic at the report-back sessions was the framing of climate change vulnerability and adaptation. Specifically, OCAC members discussed shifting from a negative to a more positive framing that could help to empower people and provide a more fruitful discussion for ways to enhance resilience. Climate change work has traditionally emphasized vulnerability and has used a deficit-based approach to assess the ability of communities to adapt to climate change. However, "vulnerable" populations might possess a broad range of skills or qualities that make them more resilient to climate impacts. For example, those who have access to grocery stores but are also able to rely on local food production may be better able to weather disruptions in food systems. Likewise, those who have struggled to make ends meet with limited material resources under current socio-economic conditions may be better able to cope during disaster.

Figure 3: Social Vulnerability to Climate Change Ranking



Note: Ranks are shown for all census tracts in Oakland.

3.1.2 Coastal Flooding Associated with Sea Level Rise

Data on coastal flooding associated with sea-level rise were based on flood hazard maps from Heberger et al. 2009. These flood hazard maps showed the areas that will be within the 100-year flood zone with a 1.0 meter and a 1.4 meter rise in sea levels, projected to occur by the end of the century under the B1 and A2 scenarios, respectively. Note that data on the location and conditions of coastal protection structures were not available, and thus, some of the areas shown as at risk of a 100-year flood might be protected by levees, seawalls, or other structures. New maps that include these protection structures are under development by other researchers.

Approximately 3,080 and 5,200 Oakland residents lived in areas within the 100-year flood zone with a 1.0 and 1.4 meter rise in sea levels, respectively (Table 3, Figures 4 and 5). Of these residents, nearly 90 percent lived in census tracts that have a high social vulnerability. About 10 percent of the population lived in census tracts with a medium vulnerability and a very small number of people lived in census tracts with a low vulnerability.

Table 3. Social Vulnerability of Population in Areas within Projected 100-year Flood Plain with Projected Sea Level Rise

	Population at risk of inundation	
Level of social vulnerability in area	1.0 m rise	1.4 m rise
Low	0	12
Medium	366	567
High	2,710	4,650
Total	3,080	5,230

Note. Numbers rounded to three significant figures. Population estimates reflect the number of people living in census tracts with a low, medium, and high social vulnerability.

Project partners expressed great interest in coastal flooding maps and data. This was attributable to a number of factors, including the disproportionate impact of coastal flooding on areas of high vulnerability, the high resolution of available data to provide detail on the extent of the impact, development pressures in low-lying areas along the shoreline, and land use planning efforts underway in these areas. Project partners pointed out that portions of flood-prone areas in the East and West Oakland neighborhoods lie within designated redevelopment zones or large redevelopment projects such as the Oakland Army Base re-use project adjacent to the Port of Oakland. Partners also pointed out that land at high risk of flooding overlaps with a Priority Development Area where regional agencies intend to incentivize infill development as part of the implementation of state climate legislation SB 375 in the Bay Area. Partners raised the need for local and regional agencies to better account for floods in these low-lying areas in making decisions about appropriate land uses to site in these areas. For example, siting additional housing stock in flood-prone areas without requiring necessary mitigation measures could place more vulnerable residents at risk.

Figure 4: Projected 1.0 m Rise in Sea Levels and Social Vulnerability

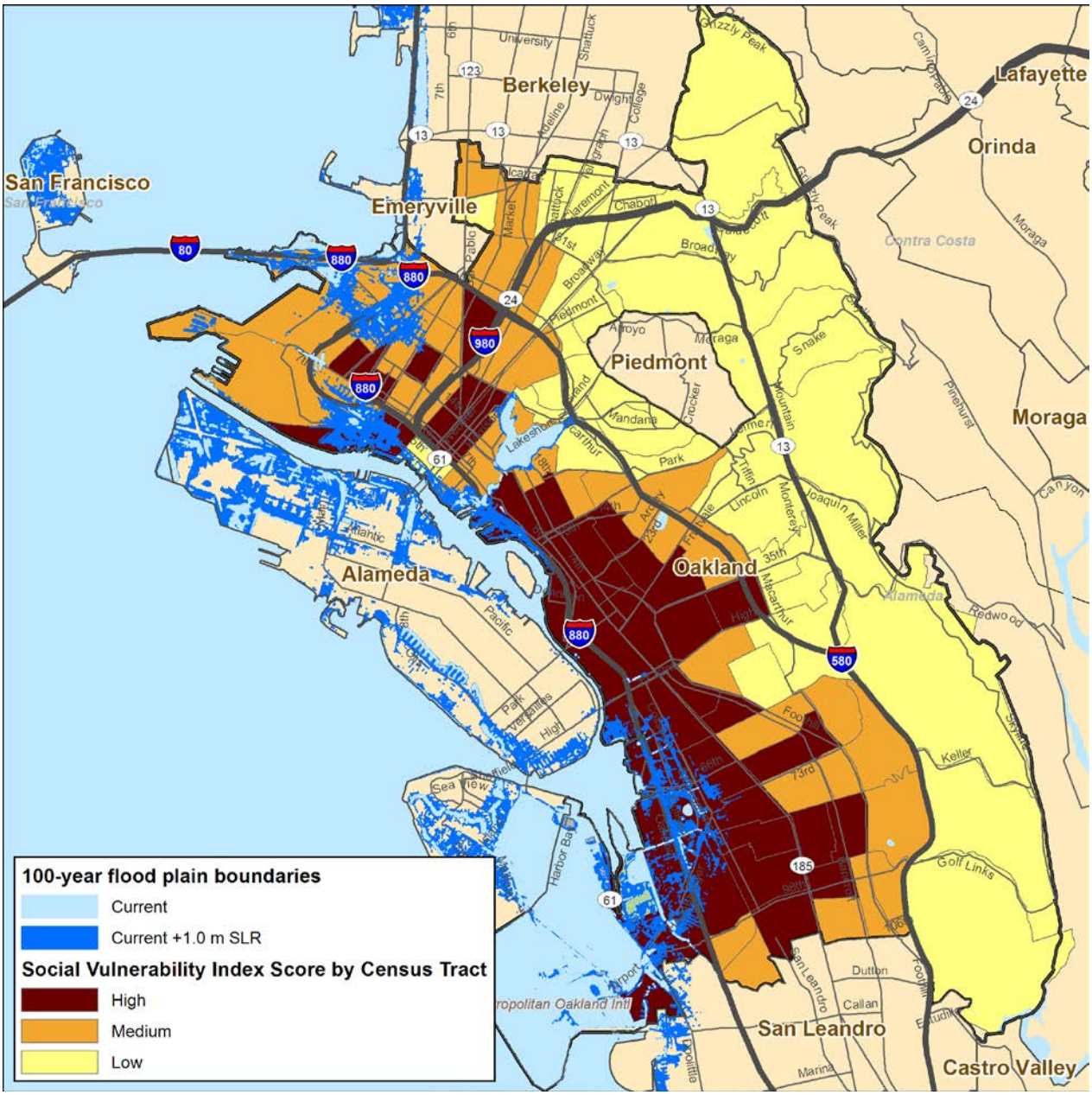
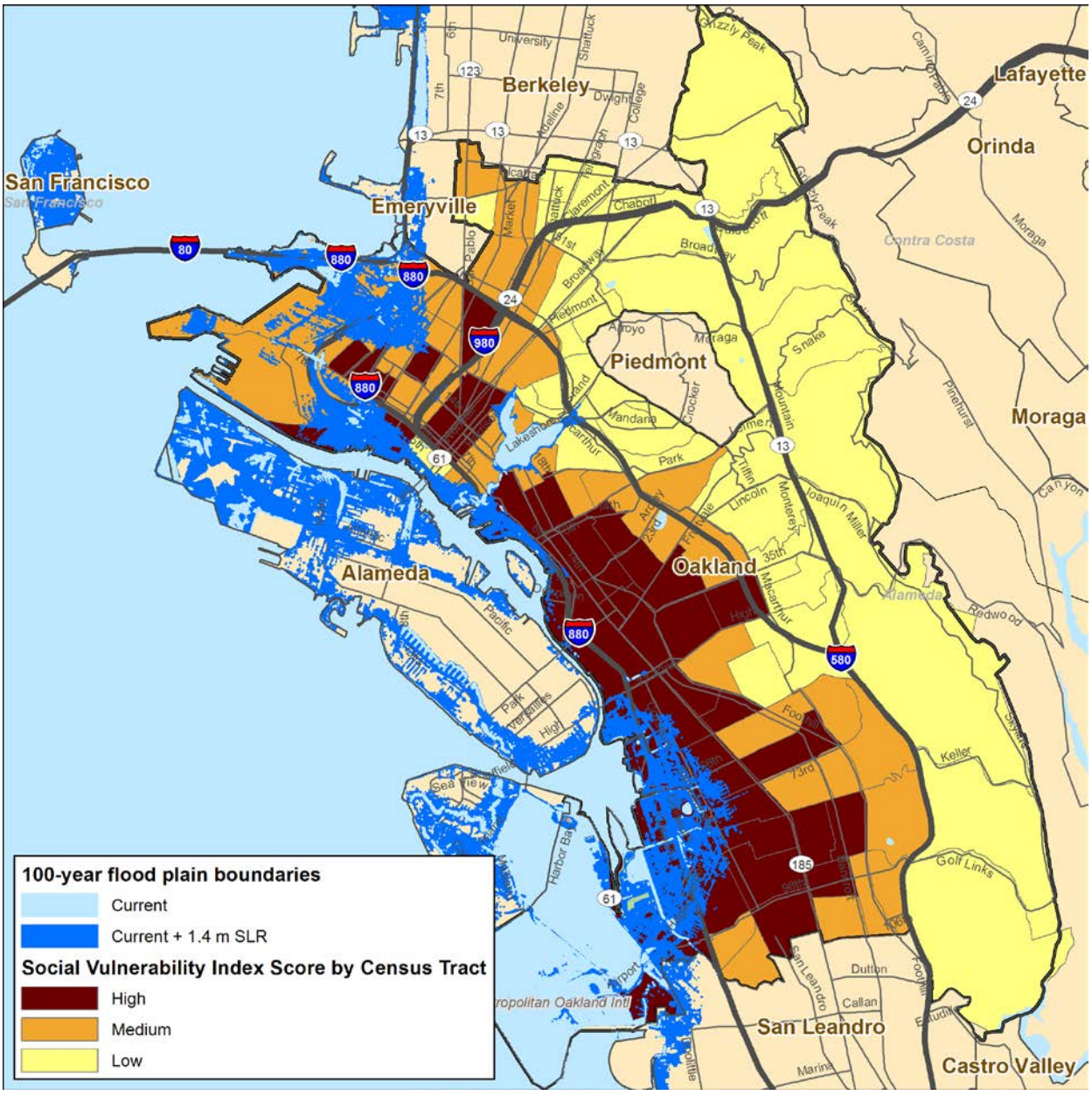


Figure 5: Projected 1.4 m Rise in Sea Levels and Social Vulnerability

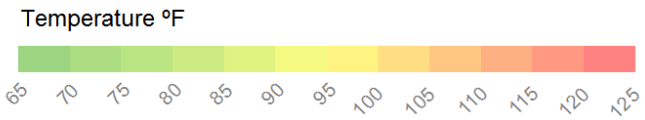


3.1.3 Extreme Heat

Temperatures in Oakland are relatively mild. Figure 6 shows the historic (1971–2000) daily maximum temperature that is exceeded 5 percent of the time during the summer period (May 1 to October 31), which we refer to as the local high-heat threshold. Over the historic period (1971–200), the local high-heat threshold in the northeastern part of Oakland was 87.2°F. Temperatures were slightly cooler in the southwest part of Oakland, where the historic local high-heat threshold was 84.5°F. Temperatures were even cooler in the northwest part of Oakland, where the local high-heat threshold was 81.7°F over the historic period. Note that

these temperatures were averaged over relatively large grid cells and that there was significant variation within a single cell. For example, grids along the coast include areas over water, which tended to be cooler than over land. Thus the temperatures for the inland portions of the grid would likely be considerably higher than the average for the entire grid. Likewise, areas with significant paved areas were likely to be warmer than the average over a large grid.

Figure 6: Daily Maximum Temperature Exceeded 5% of the Time, 1971–2000



Note: Averaged from 4 downscaled climate models

Climate change is projected to dramatically increase the frequency of extreme heat events in Oakland. By definition, the daily maximum temperature exceeds the local high-heat thresholds shown in Figure 6 for 7.6 days during the period from May 1 to October 31 each year (153 days during this period x 5 percent). By mid-century (2040–2069), the daily maximum temperature is projected to exceed the local high-heat threshold for 15.4 days and 17.2 days under the B1 and A2 scenarios, respectively (Table 4). By the end of century (2070–2099), the daily maximum temperature is projected to exceed the local high-heat threshold for 18.6 days and 29.4 days under the B1 and A2 scenarios, respectively. In both scenarios, temperatures are projected to be warmer in the areas in East Oakland, which lies inland and to the south.

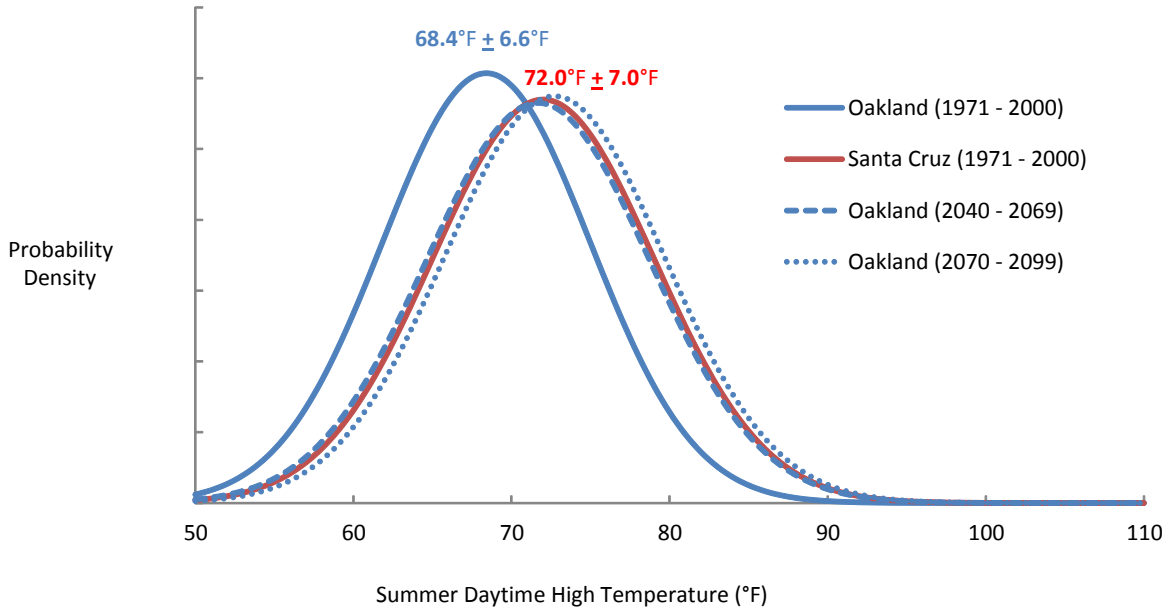
Table 4: Annual Average Number of Days Exceeding the 95th Percentile Summertime (May 1–October 31) High-Heat Threshold for Oakland, California

Time Period	B1	A2
1971–2000	7.6	7.6
2010–2039	11.7	12.2
2040–2069	15.4	17.2
2070–2099	18.6	29.4

Note: These estimates represent an average of 4 downscaled climate models.

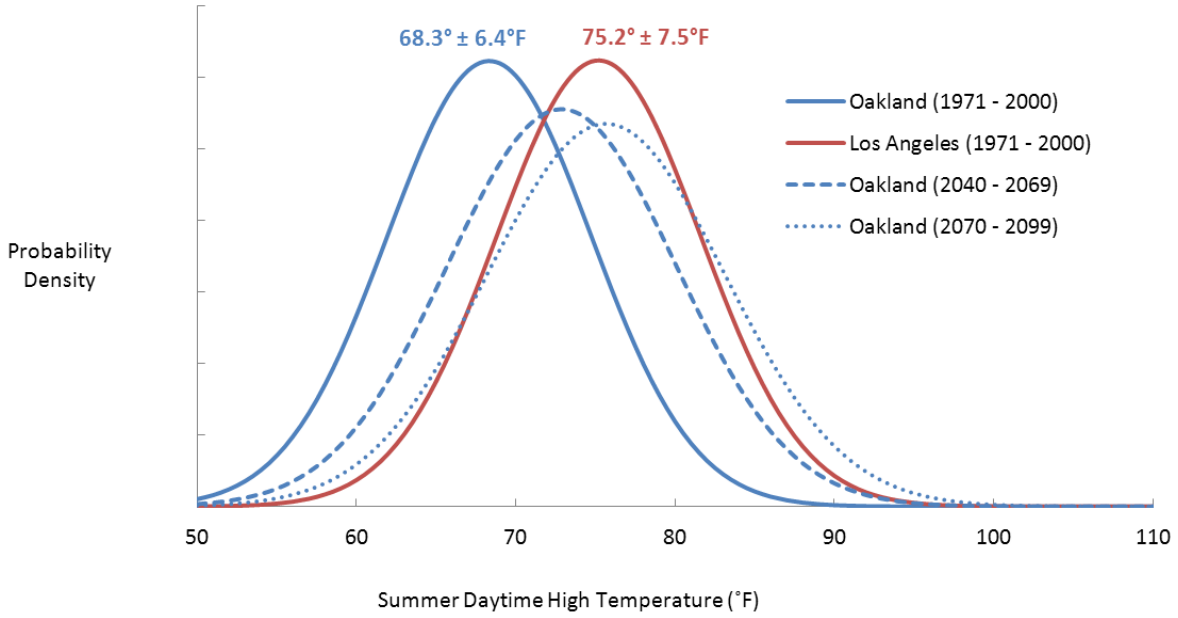
Evaluating increases in the number of extreme heat events is critical for developing adequate emergency preparedness and response strategies. This information, however, was difficult for most people to grasp conceptually. Community stakeholders suggested identifying a California city that has similar temperature characteristics today as is projected for Oakland, i.e., a future temperature analog. In order to answer this question, we looked at the distribution of summertime (May 1 to October 31) high temperatures for a few dozen cities in California, both now and in the (simulated) future. Under the B1 scenario, the distribution of daily maximum temperatures in Oakland for the period 2070–2099 closely resembled the distribution for Santa Cruz for the baseline period of 1971–2000, as shown in Figure 7. Under the A2 scenario, the distribution of daily maximum temperatures in Oakland for the period 2070–2099 closely resembled the distribution for Los Angeles for the baseline period of 1971–2000, as shown in Figure 8.

Figure 7: Distribution of Summertime (May 1–Oct 31) Daily Maximum Temperatures for Oakland in the Historical Period (1971–2000) and for Future Periods under the B1 Emissions Scenario



Note: Statistics were tabulated from general circulation model (GCM) output downscaled by Scripps Institution of Oceanography (SIO) averaged for four different climate models. For comparison, the historical distribution is shown for Santa Cruz, California, a coastal city 100 km (60 miles) south of Oakland.

Figure 8: Distribution of summertime (May 1–Oct 31) Daily Maximum Temperatures for Oakland in the Historical Period (1971–2000) and For Future Periods under the A2 Emissions Scenario

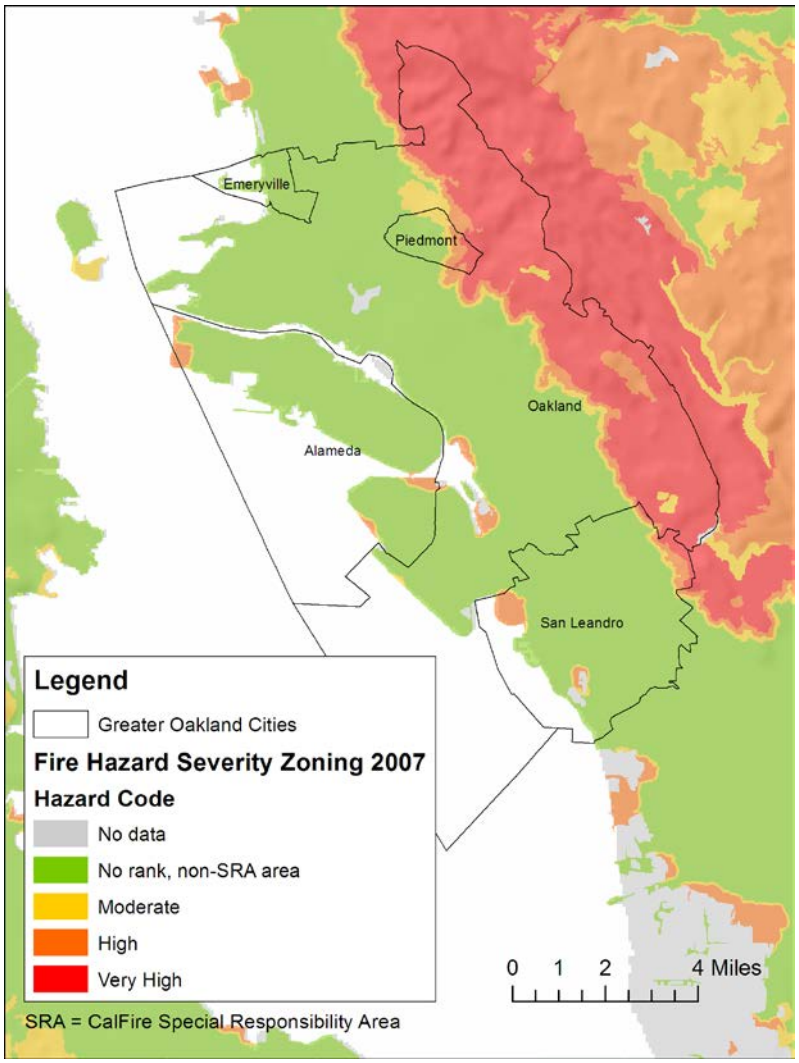


Note: Statistics were tabulated from GCM output downscaled by SIO, averaged for four different climate models. For comparison, the historical distribution is shown for Los Angeles, 430 km (270 miles) south of Oakland.

3.1.4 Wildfire Risk

Much of Oakland, especially the urbanized areas, has a low fire risk. Large portions of the Oakland hills, however, are at very high risk of wildfire (Figure 9). This risk was apparent in the Oakland Firestorm of 1991, which burned 1,520 acres, destroying 3,354 single-family dwellings and 456 apartment units and resulting in an estimated loss of more than $1.5 billion. Additionally, 25 people lost their lives in the fire and 150 people were injured. According to the Federal Emergency Management Agency, wind "threatened to drive the fire across the entire city of Oakland" (FEMA 1991). In addition to direct losses, fires produce significant local air quality concerns in surrounding areas.

Figure 9: CalFire Fire Hazard Severity Zones in the Oakland Area



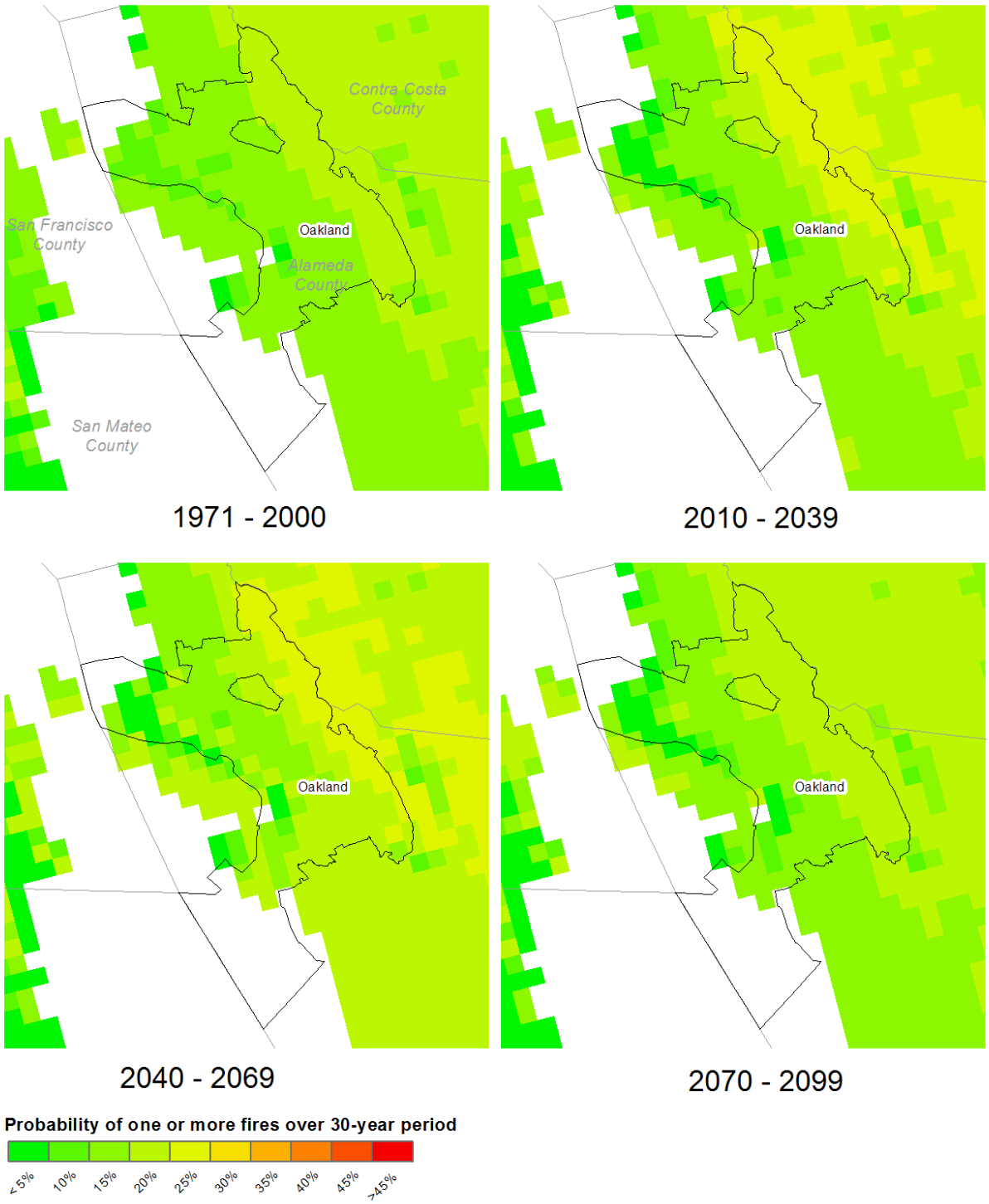
Figures 10 and 11 show the probability of one or more fires over a 30-year period under historic conditions and as modeled for the B1 and A2 scenarios. The probability of a fire was projected to be higher in the Oakland hills along the eastern edge of the city. Under the B1 and A2 scenarios, the fire risk was projected to increase throughout Oakland through mid-century (Figure 12). Larger increases were projected for the A2 scenario compared to the B1 scenario. By late century, however, fire probability was projected to decline along the Oakland hills relative to early- and mid-century although it was still higher than under historic conditions. The reduction in fire risk suggested reduced vegetation under heat and water stressed environments (Krawchuk pers. Comm.). Note that these data made no projections about the severity of the fire.

Under both the A2 and B1 scenarios, the areas with the greatest likelihood of wildfire tended to be the areas with low social vulnerability. Generally areas with high social vulnerability were highly urbanized with low fire probability. Large fires in the Oakland hills, however, could

create air quality impacts throughout Oakland and depending on conditions, spread into areas not immediately adjacent to open space.

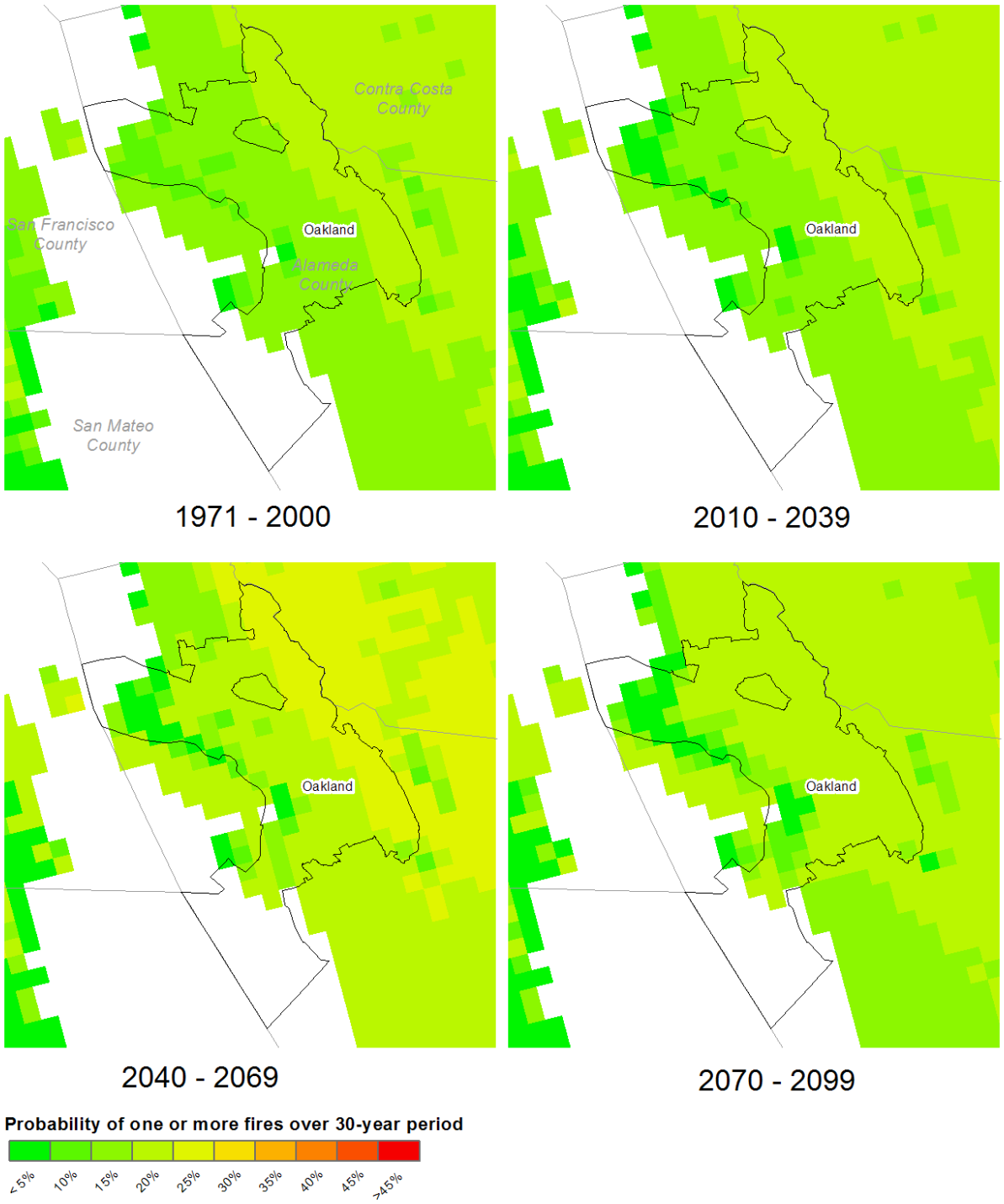
Project partners expressed relative disinterest in the wildfire risk maps and data when compared to the other impacts. Partners pointed to the low social vulnerability in areas of high wildfire probability in the Oakland hills as one reason for this disinterest. Partners raised the need to better communicate the implications of wildfire for vulnerable communities in areas adjacent to those with high wildfire probability because the spread of wildfire to adjacent areas could affect vulnerable populations. Vulnerable residents could still be affected if their place of employment is located in areas with high wildfire probability. Air quality could also be compromised throughout Oakland. Lastly, the allocation of limited financial resources towards wildfire management and response in the more affluent and politically well-represented areas could hamper efforts to address other impacts disproportionately concentrated in areas of high vulnerability, such as coastal flooding.

Figure 10: Modeled Fire Probability in the Vicinity of Oakland, California, under the B1 Scenario



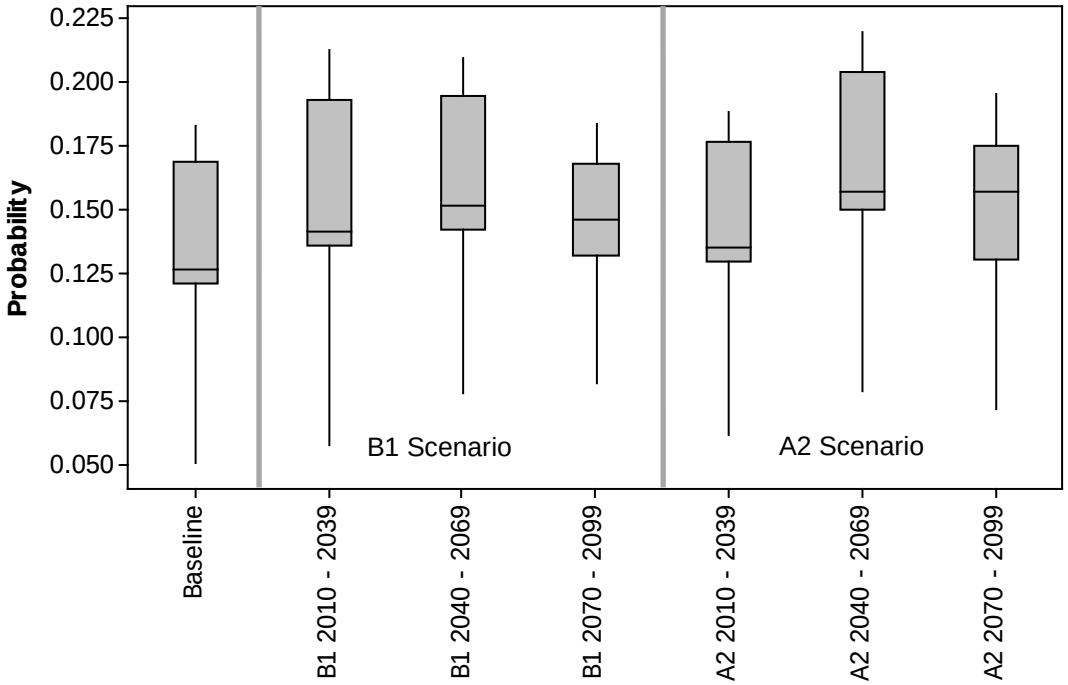
Note: Data from Krawchuk and Moritz 2012

Figure 11: Modeled Fire Probability in the Vicinity of Oakland, California, under the A2 Scenario



Note: Data from Krawchuk and Moritz 2012

Figure 12: Distributions of Probabilities of One or More Fires over a 30-year Period in Oakland by Time Period and Climate Scenario



3.1.5 Air Quality

Temperature and air quality are not always directly correlated. Increased temperatures can adversely impact air quality, but a number of other variables are important in determining the overall impact, such as wind speed and direction, which are more difficult to predict. The number of additional variables and the wide range of uncertainty associated with this modeling means that it may not be amenable to quantitative analysis. Here, we limited our discussion of climate change and air quality to particulate matter with a diameter < 2.5 μm ($PM_{2.5}$), for which researchers express the most confidence in their numerical models. There are a number of other air quality parameters that are important to human health, particularly ozone, for which reliable data are not as readily available.

Particulate matter is composed of soot, dust, liquid droplets, and other fine particles. Particles with a diameter < 2.5 μm ($PM_{2.5}$) are called respirable particulate matter and pose a greater health risk than larger particles because they are able to enter and stay in people's lungs (EPA 2002). Exposure to particulate matter is associated with a number of health problems related to the heart and lungs, including: decreased lung function; aggravated asthma; development of chronic bronchitis; heart disease; and lung cancer (EPA 2002). $PM_{2.5}$ is shown here in units of micrograms per cubic meter of air ($\mu g/m^3$). The federal average annual air quality standard for $PM_{2.5}$ is 15.0 $\mu g/m^3$, although California standards are slightly more rigorous at 12.0 $\mu g/m^3$ (ARB 2012). The 24-hour average concentration should not exceed 35 $\mu g/m^3$ under both federal and California laws (ARB 2012). It is of note that the World Health Organization's $PM_{2.5}$ guidelines

are even stricter than federal or even California law, at 10 μg/m^3 for annual average concentration and 25 μg/m^3 for 24-hour average concentration (WHO 2011). For those with health conditions that involve vulnerabilities to particulate matter, however, even these more rigorous standards might not adequately protect their health.

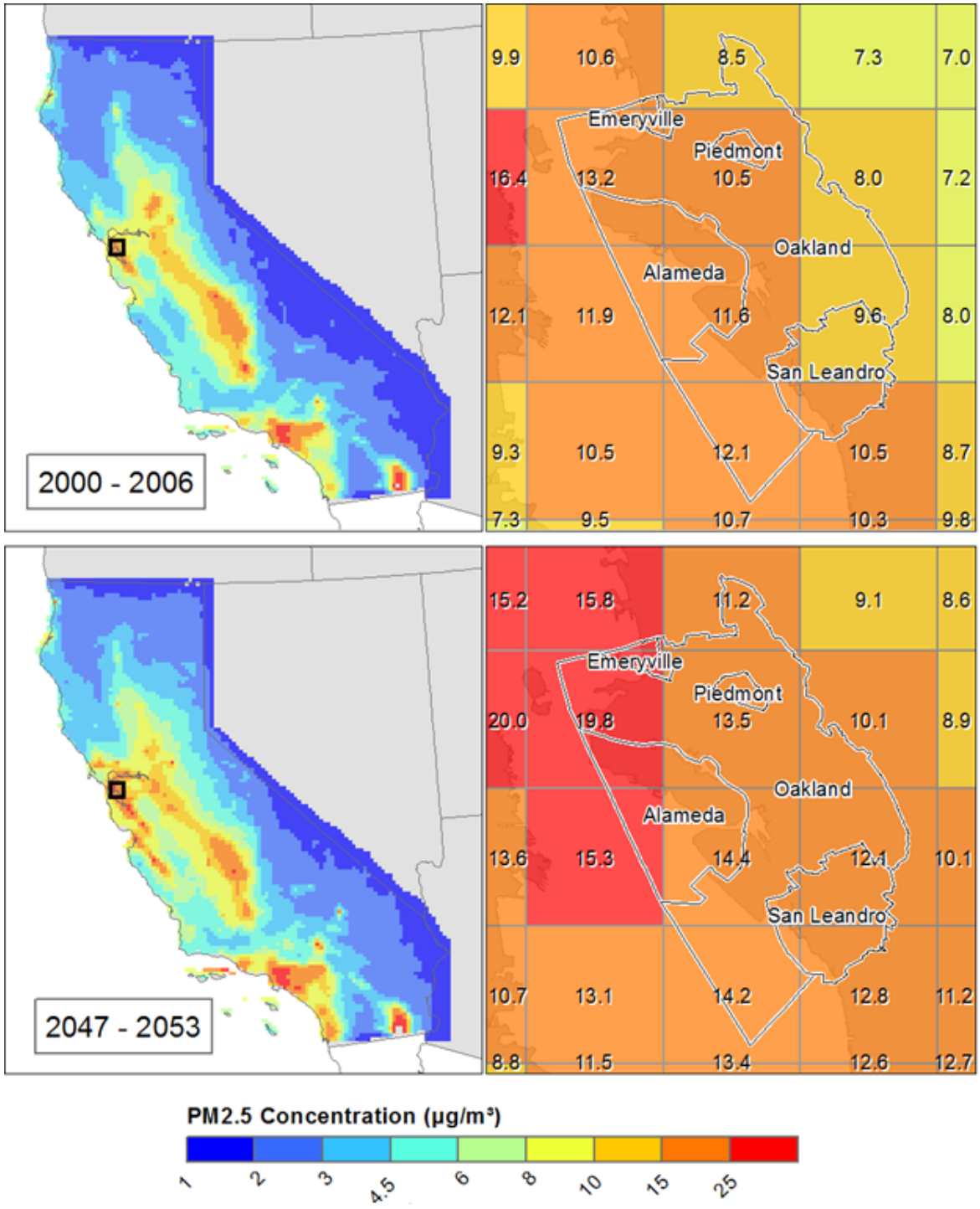
The air quality modeling was based on a projection of future emissions which extrapolates on current trends. The climate forcing was based on downscaled climate model output from NCAR PCM model under the b06.44 "business as usual" scenario. This scenario did not include emissions controls and did not correspond to the IPCC SRES scenarios (A2 and B1) used elsewhere in this report. The air-quality models were run for seven-year windows in order "to account for the effects of El Nino Southern Oscillation (ENSO) events and the intra-annual variability in the climate data that would have different implications in the final air quality results" (Kleeman et al. 2010, 143).

Figure 13 shows the modeled average annual $PM_{2.5}$ concentrations under historic conditions and at mid-century. By mid-century, large portions of Oakland were projected to exceed California's $PM_{2.5}$ air quality standards. The spatial resolution of the available air quality data was too coarse to perform a meaningful overlay of the impact and vulnerability data. However, the model results suggested that $PM_{2.5}$ concentrations are projected to increase throughout Oakland. The increase was slightly greater in the western parts of Oakland, where social vulnerability was high.

High ambient heat can exacerbate the human health impacts of air pollution. According to Luber and McGeehin (2008), a positive association has been found between high temperatures and ground-level ozone production. Studies suggest that ozone and high temperature also affect mortality synergistically, with heatwave mortality greatest on days with high particulate matter concentrations (Luber and McGeehin 2008). Other studies have found that high diesel particulate matter concentrations can aggravate asthma symptoms, and that chronic exposure in children is associated with reduced lung function that increases the risk of developing asthma and other respiratory illnesses (ARB 2012).

Project partners expressed strong interest in the air quality maps and data and raised a number of concerns about them. Partners questioned the accuracy of the baseline data on 2000-2006 particulate matter concentrations due to a perception that regulatory agencies collecting these data did not adequately capture the extent of particulate matter generated by mobile sources, in particular diesel-powered vehicles. This perception was based on the work of several community-based OCAC member organizations conducting diesel truck counts that yielded higher diesel emissions estimates than those provided by agency data. The relatively low resolution of available data sets was also an issue. Partners noted that that areas of high health risk due to toxic air contaminants, as designated by the Bay Area Air Quality Management District, did not appear as areas of high particulate matter concentration on the maps. There was a concern that these maps could undermine the ongoing work of OCAC member organizations to improve regulatory data collection on particulate matter concentrations in West Oakland, East Oakland, and other high vulnerability areas that the maps did not show to be areas with high $PM_{2.5}$ concentrations.

Figure 13: Modeled Particulate Matter Concentrations (µg/m³) in the Atmosphere around Oakland, California, Averaged over 2000–2006 (above) and 2047–2053 (below)



3.1.6 Water, Food, and Electricity Prices

The effect of climate change on the price of food, water, and electricity is a key concern for some communities, especially those with large numbers of people on low- or fixed-incomes. Climate change, however, is but one of many factors affecting the price of these essential services. Quantitative data on these impacts were not available because the magnitude of the impact is unknown, the uncertainty is too great, or sufficient analysis has not yet been done. Below, we qualitatively describe the potential impacts of climate change on water, food, and electricity prices.

3.1.6.1 Electricity Prices and Climate Change

California's electricity system is affected by a number of climate variables, and projected climate changes will have implications for electricity generation, transmission, and demand in the state. Coastal power plants are vulnerable to rising seas and increased storm frequency and intensity. Sea level rise is expected to put 30 coastal power plants, with a combined capacity of more than 10,000 megawatts, at risk of inundation from a 100-year flood event with a 1.4 m rise in sea levels (Heberger et al. 2009). Increased storm frequency or intensity due to climate change could also affect offshore water intake and discharge pipes in many coastal facilities, potentially forcing curtailment of power generation (Perez 2009). These impacts may increase power generation costs as a result of damage to coastal facilities and increased insurance costs.

Other forms of power generation are also vulnerable to projected climate impacts. For example, hydropower generation, which constitutes 20 percent of total electricity generation in California, will be affected by changes in the hydrological cycle, including reduced snowpack, greater winter flows, and lower summer flows. Facilities that rely on snowpack as an effective reservoir for spring and summer flows are at greater risk of reduced hydropower generation potential during the summer (Phinney et al. 2005). Case studies of two high-elevation hydropower systems estimated an average reduction in runoff, greater frequency of spills, and overall reduction in energy generation (Vicuña et al. 2009).

Electricity transmission and distribution are also at risk from a range of climate impacts. The forecasted increase in wildfires resulting from climate change could affect the transmission of electricity through fire-prone regions of the state (Perez 2009). For example, a massive fire in eastern Arizona in June 2011 threatened transmission lines that provide electricity to hundreds of thousands of people as far east as Texas. In California, major investor-owned utilities have already reported significant increases in wildfire insurance premiums as affecting their revenue requirements (CPUC 2010a). Additionally, the efficiency of thermal power plants and of transmission and distribution lines is expected to decline with higher ambient temperatures (Sathaye 2011). Thus, warmer temperatures and increased frequency and severity of wildfires due to climate change may cause transmission-related increases in costs and electricity rates.

The impacts of climate change on electricity generation and transmission are compounded by a projected rise in electricity demand throughout the state. Rising average and peak temperatures are projected to increase average electricity demand for commercial and residential air

conditioning (Franco and Sanstad 2007). Using historic billing and temperature data across the state, Auffhammer and Aroonruengsawat (2009) estimate that warmer temperatures may increase total electricity demand in California by up to 18 percent by the end of the century assuming a constant population. Increases in electricity demand will likely be even more pronounced during extreme heat events, which are estimated to increase in frequency under a number of climate change scenarios (Miller et al. 2007). In northern parts of the state, warmer temperatures will lower demand for space heating during the winter. Because California's households largely use natural gas for space heating, however, warmer winter temperatures will likely reduce natural gas demand rather than electricity demand (Aroonruengsawat and Auffhammer 2009).

There has been little research on the relationship between climate change and future electricity prices in California. Climate change, however, is only one of several factors affecting the supply and demand of electricity. Franco and Sanstad (2007) note that "demographic trends—including both increases in state population and changes in its spatial distribution—economic growth, developments in energy markets…and other policy decisions affecting the electric power system must be considered simultaneously." For example, economists estimate that AB32 compliance will increase electricity rates by 12 percent to 30 percent by 2020 (Weiss and Sarro 2009; Aroonruengsawat and Auffhammer 2009).

While climate may not be the dominant factor affecting future prices, rising electricity prices will have major implications for communities across California, especially those with large numbers of people on low- or fixed-incomes. While most California households spend 1 to 2 percent of their household income on electric bills, electricity expenditures for low-income households account for 8 percent of household income on average (Burtraw et al. 2009; Bernstein et al. 2000). As average and peak temperatures rise, low-income households and renters are more likely to experience high electricity costs due to poor housing conditions, such as inefficient heating and cooling systems and inadequate insulation (Bernstein et al. 2000). Current programs to improve energy efficiency through weatherization, however, do not reach most low-income households: only one of every seven low-income households in the United States eligible for the federal Low-Income Home Energy Assistance Program receives assistance (United States Department of Health and Human Services 2010). In California, nearly a quarter of eligible households were not enrolled in financial assistance programs provided by local utilities (Division of Ratepayer Advocates 2011), suggesting that outreach efforts must be expanded. Affordable electricity for indoor cooling is especially important for older residents, children, and people with medical conditions, which have higher risk of serious injury or death in the event of extreme heat (Knowlton et al. 2009; Schwartz 2005). Currently, however, only residents that rely on energy-intensive medical equipment are eligible for expanded baseline allowances for electricity use (CPUC 2010b).

3.1.6.2 Water Prices and Climate Change

The majority of utilities in California are publicly owned and set rates through a vote by a locally elected Board of Directors. Rate increases are politically unpopular, and consequently, utilities are reluctant to raise them. Despite pressures to keep rates low, however, utilities across California are beginning to raise rates. Between 2003 and 2006, for example, water rates in California increased by about 15 percent, adjusted for inflation (Black & Veatch 2006).

Additionally, temporary price increases have been used as a tool for reducing demand during a water supply constraint. During the 1987–1992 drought, for example, many urban water users were subject to significantly higher water rates, with several utilities using price increases as their main drought management strategy (Frederick and Schwarz 2000). The East Bay Municipal Utilities District increased its highest block rate nearly 500 percent between 1986 and 1991, achieving a 33 percent reduction in water use in 1991 (Pint 1999).

The upward trend in water rates overall and the willingness of utilities to institute considerable rate increases during water supply constraints suggest that water users will likely pay more for water in the coming decades. The Intergovernmental Panel on Climate Change projects that the cost of supplying water to residential users will increase under a number of climate change scenarios (Bates et al. 2008). Similarly, the Association of Municipal Water Agencies (2009) estimates that adapting to climate change impacts, including water supply reductions and increases in water demand, will increase costs to drinking water systems by $137–$274 billion through 2050 in the southwestern United States.[2] Ultimately, the impact of climate change on water rates will depend upon the mitigation and adaptation actions that are implemented by water agencies and the regulatory bodies that oversee them.

The financial burden of higher expenditures on water will be particularly burdensome for those on low- or fixed-incomes. According to the U.S .Environmental Protection Agency (2003), median household expenditures on water service should not exceed of 1.5 percent of median household income for any water system. The proportion of water users already spending in excess of this affordability threshold may be significant. Renters and those living in older homes are also vulnerable to water rate changes. According to Article XIIID of the California Constitution, water providers must notify all affected landowners of changes to water rates, who in turn have the power to veto the rate change through written public comments (Firestone 2009). Residential tenants are often not informed by their landlord of changes to water rates and, furthermore, do not have veto power. While changes in state and federal building and appliance codes have reduced indoor water use in new homes, residents living in homes built prior to code changes are more likely to be using old toilets and showerheads that use up to three times more water than newer models (ConSol 2010).

[2] This estimate does not include the impact of more intense precipitation events on water quality and additional treatment and monitoring costs for utilities that will be needed.

3.1.6.3 Food Prices and Climate Change

Climate change will directly affect agricultural production as a result of changes in temperature, precipitation, and extreme events. These changing climate conditions will produce secondary effects on the supply of and demand for water resources. Warmer temperatures may shift the geographic range and growing season of crops and affect the ranges and prevalence of pests, pathogens, and weeds (CCCC 2006). Changes in precipitation can affect soil erosion rates and soil moisture and the availability and reliability of water supplies for irrigation. Increasing atmospheric levels of CO_2 may enhance the growth of some crops, but this may be offset by higher levels of ground level ozone, which limits crop growth. Increases in the frequency and severity of heat waves and other extreme weather events could stress livestock and reduce crop yield and quality (Easterling et al. 2007).

The impacts of climate change on future food prices remain uncertain. Food prices are affected by a variety of factors, including population, income, diet preferences, energy prices, changes in technology, etc. Throughout much of the twentieth century, real agricultural prices have declined. The Food and Agriculture Organization of the United Nations, however, has linked recent spikes in food prices to extreme weather events, which will become more common as a result of climate change (FAO 2011). A 2010 report from the International Food Policy Research Institute found that real agricultural prices will increase from 31 percent for rice to 101 percent for maize by 2050 due to population and economic growth and climate change (Nelson et al. 2010). Likewise, a recent Oxfam analysis found that world market prices for agricultural products and processed foods will increase by 2030 and that climate change will exacerbate this trend (Willenbockel 2011).

Rising food costs will have significant implications for a large segment of the population that is already struggling to put food on the table. According to the USDA Economic Research Service, currently about 14 percent of California households, or more than 1.8 million households, are food-insecure or lack access to enough food to support an active, healthy life. Among other indicators of food insecurity, the majority of these households report not eating balanced meals, skipping meals, and losing weight because they do not have enough money for food. Among those with the highest rates of food insecurity are households with incomes below the poverty line, single-parent households, and non-white households (Nord et al. 2010).

Low-income households have less money to spend on food, yet food purchases account for an average of 21 percent of their income (USDA 2011). Additionally, studies have shown that food prices tend to be higher in low-income neighborhoods because large chain stores, which typically have lower food prices, are not located in these neighborhoods (Chung and Myers Jr. 1999; Kaufman et al. 1997). Neighborhoods served solely by small grocery stores also have far more limited access to healthier foods, such as whole-grain products, fresh fruits and vegetables, and low-fat meat and dairy. Where these items are available, they tend to be far more expensive, suggesting that the limited availability of healthy foods and their higher costs act as a deterrent to eating healthier among very low-income consumers (Jetter and Cassady 2006). Food deserts, or large geographic areas with limited access to healthy food and a high concentration of fringe food venues (such as fast food restaurants and convenience stores that

sell foods high in salt, fat, and sugar) have been getting increasing attention, and represent a major social vulnerability to the potential impacts of climate change on retail food prices (Ver Ploeg 2010).

3.2 Identifying Adaptation Strategies in Oakland, California

There is growing recognition that some degree of climate change is now unavoidable and all regions, sectors, and people are vulnerable to climate change impacts to varying degrees. In response, a variety of stakeholders, from local governments to social justice groups and corporations, are beginning to think about adaptation strategies to help reduce their risk. The IPCC defines adaptation as "initiatives and measures to reduce the vulnerability of natural and human systems against actual and expected climate change effects."

Through our review, we identified nearly 50 strategies for building community resilience and adapting to climate impacts associated with extreme heat, flooding, wildfire, poor air quality, and rising food, water, and electricity prices. These strategies were highly varied. Some, such as public education programs, could be implemented at a relatively low cost and be integrated into existing outreach campaigns. Others, such as limiting development in flood-prone areas, could be highly controversial and politically charged. Some, such as purchasing emergency supplies, could be implemented by the individual whereas others, like developing early-warning systems, require action on the part of local government.

Project partners noted that social equity concerns were often not fully acknowledged nor adequately addressed in identifying adaptation strategies. For example, a local government might open cooling centers in air-conditioned public buildings, such as community centers and libraries, to provide relief during extreme heat events. However, those without access to public transit or who do not own a vehicle might be at increased risk because they are unable to travel to cooler areas or community cooling centers (Shonkoff et al. 2009). Likewise, those with limited mobility might not be able to access these cooling centers. In a 1995 heat wave in Chicago, for example, being confined to bed was found to be the strongest risk factor for heat-related death (Semenza et al. 1996).

Through our review, we developed a series of policy solutions to address equity concerns associated with various adaptation strategies. For cooling centers, for example, local government could provide a free shuttle service from neighborhoods with identified vulnerable populations. Likewise, communities could establish neighborhood-level communication networks to inform residents of the location and directions to the nearest cooling center and coordinate transportation to these centers for limited-mobility residents during extreme heat events. Similarly, local agencies could collaborate with community-based groups to identify suitable locations for cooling centers, develop effective messaging to notify residents, conduct outreach, and plan appropriate activities for residents at centers.

As another example, rebates and incentives for water and energy efficiency improvements are commonly proposed as both adaptation and mitigation strategies. These programs, however,

also raise equity concerns.[3] Many water and energy utilities offer rebates and incentives to their customers to encourage them to buy more efficient appliances and fixtures. For example, East Bay Municipal Utilities District partnered with PG&E to provide a $100 rebate for the purchase and installation of a high-efficiency clothes washer to help offset the higher cost of the efficient machine compared to a less efficient model. For most rebate customers, the customer must purchase the device and then apply for the rebate, which can take weeks to arrive.

Those on low- or fixed-incomes, however, might not be able to cover the additional cost for the efficient device and thus may not be able to take advantage of the rebate program. There are a number of policies that can be implemented to help ensure that all residents are able to participate in these programs. For example, utilities can provide rebates at point-of-sale for the purchase of efficient fixtures and appliances. Additionally, utilities can develop direct install programs for low-income residents. Utilities can also develop zero-interest loan programs to help low-to-moderate income residents install efficiency measures.

A number of measures can also be put in place to engage vulnerable populations in emergency planning, preparedness, response, and recovery related to coastal flooding. Projections for future sea level rise and precipitation can be integrated into new and existing storm water and sewer infrastructure improvements. Vulnerable populations, such as housing for low-income residents, can be prioritized in infrastructure improvement programs like raising raise existing structures above flood level and financial assistance programs to repair flood-damaged homes.

Vulnerable populations can also participate in monitoring and advising projects to build seawalls to protect berths and runways from rising sea levels at Port and airport facilities, such as public notices and hearings, to ensure that they do not redirect climate change impacts to neighboring communities. Areas exposed to floods with concentrations of vulnerable populations can be prioritized for community-based emergency planning efforts in partnership with emergency response agencies.

Public transit and paratransit providers can be involved in in evacuation route planning to ensure access to transportation for residents with limited mobility. An early warning system for flooding can be established that provides warnings in multiple languages, through multiple culturally or economically appropriate and accessible information streams. Outreach efforts can also be tailored to vulnerable populations, such as conducting reverse 911 calls to the elderly and those at risk.

OCAC members also identified a range of resources and qualities in the communities in which they lived and worked that could help promote climate resilience, including vibrant social

[3] Water and energy efficiency improvements reduce total energy use and greenhouse gas emissions and are therefore classified as mitigation strategies. Because climate change reduces the availability and reliability of both water and energy supplies, efficiency improvements also reduce vulnerability to water and energy constraints and are therefore adaptation strategies.

networks, community infrastructure like churches and block associations, and the presence of residents with subsistence skills such as fishing and growing food. OCAC members identified strategies to build community resilience, such as building collaboration across neighborhoods and developing block-by-block emergency preparedness networks. They pointed out the importance of engaging community-based organizations in adaptation planning efforts, since community organizing could help build resiliency by strengthening social networks and leveraging these networks to connect residents to the resources and services they needed to cope with local climate change impacts.

Appendix A summarizes the adaptation strategies we identified, including their advantages, disadvantages, equity concerns, and policies available to ensure that these strategies address the needs of all members of a community, especially the most vulnerable. This list was not meant to be exhaustive but was intended to inform the adaptation planning process in Oakland and in communities elsewhere.

3.3 Community Engagement in Adaptation Planning Processes

As indicated above, there are a variety of strategies available for adapting to climate change. The determination of what strategies to pursue and when will be based on a variety of factors, including financial resources, community values, and institutional structures. Ultimately, these decisions will be made during the adaptation planning and implementation process. Below, we detail the trends and best practices in climate adaptation planning processes, focusing specifically on their efficacy in engagement of the wider community and in addressing the needs of all residents, especially the most vulnerable.

At the report-back sessions, OCAC coalition members also discussed approaches for engaging residents of vulnerable communities in local climate change issues. They pointed out that prevailing ways of talking about climate change by scientists and the media were too technical and future-oriented to seem relevant to people's everyday lives. OCAC members raised the need for emphasizing short-term actions that residents can take to build resiliency and adaptive capacity, such as identifying higher-level areas in the neighborhood in case of flooding or documenting who in the community had access to vehicles and boats in the event of an emergency evacuation. They also stressed the importance of popularizing technical information about local climate impacts and adaptation options to make it more accessible to community residents. For example, drawing on people's experiences with past events like heat waves and flooding can contextualize information about what climate change means in terms of increased frequency or intensity of these events and help convey the relevance of adaptation planning to their lives. OCAC members also suggested emphasizing direct benefits to quality of life, such as green job creation associated with expanding weatherization or retrofitting programs, in relaying the importance of public participation in adaptation planning.

The issue of adaptive capacity, particularly institutional capacity to respond to climate change impacts, was also raised by coalition partners. Though individual institutions had relevant programs that OCAC members were aware of, such as the Oakland Fire Department's Citizens

Organized in Response to Emergencies (CORE) Program or the Alameda County Department of Public Health's Emergency Medical Services Division, overall coalition members expressed the need for more structured interagency collaboration on adaptation planning in partnership with vulnerable communities. Coalition members also flagged the lack of awareness of available programs and resources on the part of residents in vulnerable communities due to limited outreach efforts on the part of agencies. OCAC members also expressed the need for local agencies, particularly emergency responders, to partner with community organizations to assess neighborhood-level capacity to respond to climate change impacts and leverage agency programs to build this capacity. Coalition partners felt that a community-based adaptation planning process would be an effective avenue in which to do this initial neighborhood resources inventory, needs assessment, and relationship-building with government institutions.

3.3.1 Trends in Adaptation Planning

Communities across the nation are beginning to address the myriad of challenges that climate change poses. For this analysis, the research team reviewed climate action plans and associated documents developed by the 25 largest U.S. cities and smaller cities that pioneered the climate adaption planning process. [4] The research team also interviewed city planners and community leaders across the country. Of the 25 largest cities, 20 had developed comprehensive climate action plans (Table 5). Of these 20, however, only seven integrated climate adaptation measures into their action plans. An additional five addressed adaptation in supplementary documents, separate adaptation plans, or department specific adaptation plans.

Only 7 of the 12 cities that include elements of adaptation planning in their climate action efforts explicitly identify vulnerable populations as a priority in developing and implementing adaptation measures. In addition, explicit references to vulnerable populations was typically limited to low-income individuals and families and were generally considered only to the extent that their limited resources present a barrier to achieving city-wide mitigation goals. As a result, measures addressing vulnerable populations were generally based on financial assistance or programmatic support for low-income households. There was little consideration given to measures that would reduce vulnerability or increase resilience to potential climate hazards.

Table 5. Review of Adaptation Planning Efforts in the 25 Largest U.S. Cities

City or County	Climate Action/ Emissions Reduction Plan	Included adaptation measures in Climate Action Plan or in Supplementary Documents	Mentioned Vulnerability	Discussed Vulnerability Outside of Public Health	Included Discussion of Emergency Preparedness as Part of Adaptation and Vulnerability
New York, NY	X	X	X	X	X
Los Angeles, CA	X	X			
Chicago, IL	X	X	X	X	X

[4] Other cities evaluated included Miami-Dade County, Florida; Chula Vista, California; Portland, Oregon; Oakland, California; Keene, New Hampshire; Homer, Alaska; Berkeley, California; and Pinole, California.

City or County	Climate Action/ Emissions Reduction Plan	Included adaptation measures in Climate Action Plan or in Supplementary Documents	Mentioned Vulnerability	Discussed Vulnerability Outside of Public Health	Included Discussion of Emergency Preparedness as Part of Adaptation and Vulnerability
Houston, TX	X	X	X		X
Phoenix, AZ	X	X			
Philadelphia, PA	X	X			
San Antonio, TX	X				
San Diego, CA	X	X	X	X	
Dallas, TX	X				
San Jose, CA	X				
Detroit, MI	X				
San Francisco, CA	X	X	X		
Jacksonville, FL					
Indianapolis, IN					
Austin, TX	X	X			X
Columbus, OH	X				
Fort Worth, TX					
Charlotte, NC	X				
Memphis, TN					
Boston, MA	X	X	X	X	X
Baltimore, MD					
El Paso, TX	X				
Seattle, WA	X	X	X	X	X
Denver, CO	X	X			
Nashville, TN	X				

Among the 12 cities that had developed adaptation plans or identified opportunities for adaptation, there was a significant variation in their consideration of different forms of vulnerability to climate impacts. Virtually all developed adaptation plans that considered the social risks of climate change impacts to be associated most closely with public health and their adaptation recommendations were developed accordingly. This generally included measures to cope with extreme heat, reductions in air quality, and in some cases, changing disease patterns. However, only half of city climate adaptation plans stated an intention to integrate climate impacts into emergency preparedness and response planning. Beyond public health and safety measures, fewer than half of the adaptation plans discussed a more comprehensive view of vulnerability addressing not only public health, but also economic and social impacts. It is of note that the plans that integrated socio-economic impacts and emergency preparedness also tended to be those that explicitly considered especially or disproportionately vulnerable populations in their adaptation planning process.

3.3.2 Community Engagement Models in Adaptation Planning Processes

Community engagement can serve as both a means and an end, as engaging numerous government agencies, industries, local businesses, faith-based organizations, environmental

groups, and citizen organizations contributes to a more robust and inclusive adaption planning process as well as more equitable and effective adaptive action (National Research Council 2011). Among the plans reviewed, community outreach and engagement were generally accepted as crucial elements of successful climate action. However, the process used and degree of community engagement varied. In many cases, community engagement largely served as a platform for soliciting community feedback on a draft report. These community outreach and education efforts generally sought to promote citizen buy-in and individual behavior change, rather than provide open forums and mechanisms for gathering community concerns. They also tended to focus on mitigation goals and strategies. Furthermore, few cities had developed tools or processes to facilitate the inclusion of historically under-represented communities in outreach efforts. Through our research, we found examples of stakeholder and community engagement during each of three stages of the adaptation planning process: research, planning, and implementation. Below, we provide examples and best practices for community engagement in each of these phases.

3.3.2.1 Research

The research stage of the climate adaptation planning process is centered on a systematic review of projected climate impacts for the local area; the impacts of these changes on multiple sectors; and a comprehensive assessment of which populations or geographic areas are vulnerable to these impacts. The research stage might also focus specifically on community engagement in climate change issues, exploring best practices in integrating communities and non-governmental organizations into the climate planning process, and in resilience-focused private-public sector collaboration (National Research Council 2011).

Science-based assessments of potential climate impacts generally present few opportunities for stakeholder engagement. However, communities can be engaged in some aspects of assessing social and economic risks, vulnerability, and available communities and government services to help ensure the accuracy and efficacy of the research produced (ICLEI 2010; Institute for Sustainable Communities 2010; Parzen 2009). Numerous U.S. cities adopted participatory approaches to research on climate change issues. These models included multi-stakeholder appointed task forces, commissioned ethnographic research, and direct collaboration with community groups to develop adaptation and community engagement strategies.

For example, Miami-Dade County engaged stakeholders in research through the creation of a multi-committee advisory task force. Comprised of scientists from leading local institutions, including the University of Miami, the task force's Science Committee provided the county with scientific and technical information about climate change impacts; the efficacy and cost-effectiveness of mitigation and adaptation strategies; and the potential economic, social, and health impacts of climate change and adaptation strategies. Community members were not directly involved in the development of research priorities or products. However, the Science Committee drew on the knowledge and expertise of diverse stakeholders including local residents, students, and business people to help ensure that the research addressed the needs and concerns of vulnerable communities (Miami-Dade County 2011).

Several cities also conducted extensive participatory research to inform outreach, communications, and engagement strategies in the planning and implementation of climate adaptation measures. For example, the City of Los Angeles contracted with Occidental College's Urban & Environmental Policy Institute (UEPI) and the GreenLA Coalition, a coalition of over 60 diverse environmental and environmental justice organizations in the LA area, to recommend strategies for wider community engagement and public participation in local climate action (Matsuoka et al. 2008). To inform these recommendations, UEPI and GreenLA Coalition interviewed 159 Los Angeles residents, including business, labor, and religious leaders, students, community organizers, government workers, scientists and private equity managers about their concerns related to climate change (Matsuoka et al. 2008). In addition, the research team reviewed best practices in climate change public engagement strategies pioneered by cities across the U.S. and internationally (Matsuoka et al. 2008). Informed by this research, UEPI and GreenLA Coalition developed the Los Angeles Climate Action Campaign, which had a three-pronged approach for engagement, including mayoral summits, a communications campaign, and public engagement in climate policy (Matsuoka et al. 2008).

The City of Chicago also undertook extensive research efforts to inform their public engagement efforts in the implementation of adaptation measures. In 2008, the City commissioned the Field Museum's Environment, Culture and Conservation (ECCo), a local research institution specializing in participatory action research, to conduct rapid ethnographic inventories of Chicago's diverse communities (ECCo 2009). In collaboration with community partners, ECCo produced seven ethnographic assessments of different Chicago communities, identifying their assets, concerns, priorities, and culture surrounding climate change. This research then informed Chicago's strategies for communications and messaging, information and resource dissemination, and direct community participation by providing concrete recommendations for best practices in city engagement with each of these neighborhood or demographic communities (ECCo 2009).

3.3.2.2 Planning

Adaptation planning consists of developing, drafting, and vetting a plan to adapt to the impacts of climate change, as well as conducting public education, outreach, and engagement. These measures aim to build community buy-in and increase public awareness of climate change impacts in order to engage stakeholders in identifying both problems and solutions (Clean Air Partnership 2007).

In developing regional adaptation plans, collaboration with local community groups through a participatory research and planning process can help ensure that community needs and concerns are addressed. Cities that have prioritized stakeholder and community engagement in their climate action planning have deployed a diversity of strategies and models for integrating community needs and input into the adaptation planning process. Three basic models for stakeholder engagement have emerged in different city planning contexts, namely:

1. City-run public outreach: Community participation is solicited in forums such as public meetings, focus groups, opinion polls surveys, or online open comment periods;

outreach occurs after the city has developed an adaptation plan, which may or may not have included community input

2. City-appointed task force: Task forces typically consist of key stakeholders including civic, business, and community leaders, and are charged with developing recommendations for adaptation measures and in some cases with developing the community engagement strategy

3. Community-initiated coalitions: Community groups form a coalition to collaboratively develop responses, recommendations, or demands and leverage their unified voice to address the needs of the communities they serve. In some instances, a representative from the coalition is brought onto a city task force or serves as a primary advisor or representative for community issues in a city-driven public-outreach process. In other instances, the coalition organizes and takes direct action within the community to build resilience to climate change, either separately or in collaboration with city agencies.

These models were not rigid or mutually exclusive. Generally cities adopted multi-pronged or tiered approaches to stakeholder engagement that encompass at least one or more of these strategies.

In Miami-Dade County, for example, the Board of County Commissioners convened an advisory task force consisting of seven committees, each charged with identifying key issues and developing recommendations for climate change mitigation and adaptation within their focus area. Together, these committees were comprised of more than 150 individuals with a diversity of expertise, including representatives from government agencies, local academic institutions, businesses, community-based organizations, and environmental organizations as well as local citizens. The advisory task force also served as the primary platform for community engagement, with many members of the public serving on committees or attending joint and individual committee meetings that were open to the public.

Other cities have developed a tiered task force participation model, inviting leaders of key institutions to a steering committee that engages directly with city staff and an advisory group that reviews and provides advice and feedback on the work of the steering committee throughout the process (Matsuoka et al. 2008). In Boston, for example, the Climate Action Leadership Committee brought together 22 leaders and representatives from all of the city's major sectors, including the private sector, universities, and non-profits to develop mitigation and adaptation recommendations (Barr Foundation 2010). The City of Boston also developed a Community Advisory Committee to bring the larger Boston community into the planning process. Recognizing Boston's tradition of strong neighborhood identities, the Mayor opened a city-wide nomination process to identify local residents to serve as members of the Community Advisory committee. Ultimately the mayor selected 36 residents, representing each of Boston's neighborhoods, from a pool of over 70 nominees (Barr Foundation 2010). Throughout the planning process, the Community Advisory Committee reviewed and vetted climate mitigation and adaptation measures recommended by the Leadership Committee, as well as designed the community engagement strategy for their implementation.

In Los Angeles, the City utilized several platforms for community engagement through participation in the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC). LARC is a collaborative that brought together leaders from a diversity of sectors and developed the GreenLA coalition to facilitate the involvement of environmental groups and community stakeholders in setting climate policies. In monthly meetings with city staff, GreenLA provided input on the development of the city's climate action plan as well as its ongoing implementation.

3.3.2.3 Implementation

Implementing climate adaptation plans involves developing the structure of the adaptation plan, releasing the plan, prioritizing risks and actions, identifying funding sources, engaging crucial agencies and stakeholders to carry through adaptive measures, and establishing milestones and metrics to evaluate the efficacy of the climate adaptation effort. A variety of institutional mechanisms have been developed for the adaptation planning process to facilitate implementation. In general, city climate adaptation policy development took four basic forms:

1. A comprehensive adaptation plan
2. Integration of adaptation into city's existing strategic plan
3. Integration of adaptation into departmental or sector-specific plans
4. Integration of adaptation into specific city projects

For successful implementation of climate action, as with climate planning, the particular model or form was largely secondary to the process. For this reason, there were many unifying best practices and pitfalls in implementing adaptation plans. Perhaps the most common shortcoming was the immediate disbanding of advisory task forces and coalitions once the plan was developed. This lack of continuity and failure to create explicit and participatory structures within city governance for the development and facilitation of implementation strategies often resulted in poor or non-existent implementation of climate action plans. Furthermore, lack of resources, poor prioritization of actions, and failure to engage and capitalize on existing city activities led to inaction upon the completion of the planning process. However, through the development of more systematic structures for implementation, some major cities succeeded in integrating adaptive actions into city governance and committed themselves to the challenging process of building resilience in their communities.

A handful of cities have spearheaded a number of best practices in implementation, working to engage key stakeholders, agencies, and communities to prioritize risks and actions, identify funding sources, and establish milestones and metrics. In New York City, for example, Mayor Bloomberg created a new Office of Long-Term Planning and Sustainability (OLTPS) and hired expert staff whose sole responsibility was to coordinate implementation of PlaNYC, a comprehensive long-term plan for development and sustainability in New York City. The new OLTPS was charged with overseeing both short- and long-term performance management and reporting on the implementation of PlaNYC. As part of this effort, the OLTPS designed and utilized an intensive process of community engagement in the development of the plan,

incorporating input and feedback from the public throughout the planning process to ensure that once released, it could be implemented immediately.

To support the newly created OLTPS, the Mayor's office also established an advisory board to build public support for the plan and draw upon local knowledge and expertise in various planning areas. Comprised of experts with backgrounds in environmental justice, green infrastructure, environmental policy, real estate, business, labor, energy, urban planning, as well as community advocacy representatives, the Mayor's Sustainability Advisory Board served as the primary advisory body in supporting the development of recommendations in the plan and implementation strategies (ICLEI 2010).

New York City's efforts for implementation of PlaNYC also benefited from a community-initiated process of engagement, as community groups across the city formed the Campaign for New York's Future. Funded by over a dozen local foundations concerned with environmental and economic issues, this coalition emerged as the primary community advocate for the implementation of PlaNYC, building both public and political buy-in through educating the public about the benefits of its programs and lobbying the State Legislature on key issues (ICLEI 2010).

In other cities, individual departments and agencies pursued adaptation independently, integrating climate projections into their existing plans and programs. Seattle Public Utilities (SPU) was a key actor in Seattle's regional climate adaptation action. After two extreme storm events and devastating floods in 2006 and 2007, SPU more aggressively pursued climate adaptation and implemented several no-regrets adaptation measures, including updating and integrating climate projections into emergency planning and response plans, remapping flood prone areas, and launching a regional educational campaign (Institute for Sustainable Communities 2010). SPU developed numerous strategies to address social equity and facilitate community engagement in utility planning processes and was able to build upon these programs for its climate adaptation efforts. For example, SPU staff was required to attend training workshops on institutionalized racism, rate-payer equity, and environmental and social justice issues to build staff awareness and capacity in developing more equitable programs. In addition, staff developed equity planning guides that are used at every stage of program development, mandating assessment and documentation of racial equity and social justice issues around project budgeting, contracting, staffing, community and user impact assessments, outreach and communications, and project evaluation.

Furthermore, SPU staff in the Race and Social Equity Division worked directly with local organizations and community groups to ensure that their programs are culturally, economically, and linguistically appropriate and accessible for their specific customer groups. SPU frequently established paid contracts or collaborations with local community-based organizations. Leveraging local knowledge, expertise, and existing social networks, these organizations worked with SPU to conduct research, develop program strategies, and deliver more effective and appropriate messaging and campaigns. Through such collaborations, SPU continued to build relationships in the local community and ensure the implementation of more equitable and effective adaptation policies and programs.

Funding is a key barrier for community-based partner organizations to fully participate in climate adaptation planning efforts. Just as localities require resources to develop and implement climate plans, community-based organizations require resources to meaningfully partner with city agencies to design and participate in the planning process. Community partner organizations can be included in grant budgets as sub-recipients or contractors providing valuable capacity or services in implementing the proposed project. Fundraising efforts with community partners should account for their staff time and personnel costs involved in attending planning meetings, reviewing and commenting on draft documents, conducting outreach and education with local residents, and other project-related activities. To maximize participation, stipends for leaders or members of community partner organizations who will be enlisted as outreach workers or key participants in the planning effort should be included in grant budgets. Grant budgets should also account for providing food, transportation, translation, child care, facility rental fees, copying materials, and other logistical costs of community meetings, workshops, or outreach activities.

In the adaptation planning processes reviewed for this study, community engagement was funded in multiple ways. In some cases, cities absorbed the cost for community engagement, although it is unclear whether community organizations were compensated for their efforts. Private foundations, however, played a key role in supporting community engagement. For example, the Boston Foundation and the Barr Foundation provided financial resources to support community engagement in Boston. In Los Angeles, the Liberty Hill Foundation and Environment Now provided support to the GreenLA coalition, which in turn allowed environmental and environmental justice organizations engage in a variety of city efforts, including adaptation planning. In Chicago, a grant from the Legacy Fund allowed for the establishment of an independent committee comprised of leaders of major non-profits, foundations, and businesses to participate in the adaptation planning process.

3.3.2.4.Adaptation Planning and Advocacy in Oakland CA

In Oakland, California, the work of the community-initiated OCAC has been instrumental to local adaptation planning efforts. Since its formation in 2009, OCAC member organizations have worked closely with city staff assembling the city's Energy and Climate Action Plan (ECAP) to integrate community-based adaptation planning priorities into the development of the plan and implementation strategies following its passage in March 2011. The OCAC's Resilience and Adaptation Subcommittee drafted language for local policy priorities and actions included in the ECAP's adaptation section, most notably that the City of Oakland commit to developing a community-based adaptation plan in partnership with vulnerable communities in Oakland. The OCAC Resilience Subcommittee also led a coalition engagement process for this study, which is listed in the ECAP as a key component of the baseline research that will inform City efforts on adaptation planning.

Members of the OCAC Resilience and Adaptation Subcommittee collaborated with other local agencies leading adaptation planning efforts. For example, members of the OCAC Subcommittee successfully advocated for the inclusion of community engagement and social vulnerability in the scope of an adaptation planning project led by the Bay Conservation and

Development Commission (BCDC), which focused on assessing the potential impacts of sea level rise on transportation infrastructure and shoreline habitat along the East San Francisco Bay. Pacific Institute subsequently worked with BCDC to conduct a social vulnerability assessment of the project area to include this as a component of this analysis and worked with BCDC staff to design a survey for project stakeholders on social equity concerns.

Now in the implementation phase of the process, the OCAC's Resilience and Adaptation Subcommittee is working to ensure that community adaptation priorities included in the ECAP are resourced and implemented in vulnerable communities. For example, Subcommittee members are working with the City's Sustainability Coordinator to develop a strategy for expanding awareness of and access to weatherization programs for low-income renters in Oakland, which would support community adaptation goals. Due to a lack of funding to resource additional adaptation planning at a city level, the Subcommittee is currently advocating for adaptation planning to be integrated into existing local planning efforts, such as the West Oakland Specific Plan process and the City of Oakland's General Plan through the inclusion of a Health Element that addresses vulnerability to climate impacts.

Section 4: Conclusions and Recommendations

Adaptation planning it still in its infancy and local governments are struggling with how to navigate the planning process. A handful of communities in the United States have embarked on planning efforts and have engaged the local community in some manner. The goal of this study was to inform the development of a comprehensive and equitable climate adaptation plan efforts. This research project engaged active members of the OCAC, including community-based organizations and resident leaders, in analyzing both the impacts of and vulnerabilities to climate change. Further, it enumerated adaptation strategies that can be implemented at the local level, discussed their advantages and disadvantages, and identified social equity concerns. Finally, it identified trends and best practices in climate adaptation planning processes, focusing specifically on their efficacy in engagement of the wider community and in addressing the needs of all residents, especially the most vulnerable. This paper is meant to serve as a tool for both city planners and community members everywhere, as they work in tandem to develop more equitable and resilient cities for the climate of the future. The section below provides recommendations, developed in partnership with the OCAC, for how local governments can involve vulnerable communities as equal partners in developing and implementing a climate adaptation plan.

4.1 Community Engagement in Research

a. Develop partnerships with community-based organizations with a membership base in vulnerable communities and pursue joint fundraising efforts to resource partnership work.

b. Work with community partners to design a participatory research process that involves vulnerable residents in identifying research needs and gathering information about community priorities to inform adaptation planning.

c. Engage residents in vulnerable communities in decisions about the scope of the adaptation research, how it will be carried out, and how results will be shared with impacted communities. This can help build the capacity of these residents to meaningfully participate in adaptation planning efforts.

d. Provide financial resources, such as through a mini-grant program, to community-based organizations to host community workshops on climate adaptation and to help identify impacts of primary concern to vulnerable communities through informal surveys or other means.

e. Identify communities and population segments that are especially vulnerable to anticipated climate change impacts through a vulnerability assessment that includes impacts of concern and vulnerability factors identified by vulnerable residents.

f. Involve vulnerable communities in identifying community adaptation needs and options to be considered and in developing criteria to assess and prioritize adaptation

strategies to maximize their relevance and address social equity concerns associated with their implementation.

g. Provide community-friendly materials translated into appropriate languages with accessible information on the economic costs, benefits, and trade-offs associated with adaptation options.

4.2 Community Engagement in Planning

a. Work with organizations based in vulnerable communities to design and facilitate a multi-stakeholder process to develop a climate adaptation plan. For example, the planning process can be presided over by a multi-stakeholder task force with one-third of the seats reserved for representatives of vulnerable communities.

b. Include a community engagement component that is developed and resourced in partnership with community-based organizations in each phase of the adaptation planning process.

c. Prioritize outreach and education efforts in communities that are most vulnerable to the impacts of climate change. For example, local governments can contract with community-based organizations to fund part-time positions for community outreach workers who recruit, educate, and prepare residents to participate in the adaptation planning process.

d. Use accessible and culturally relevant language to provide information needed to meaningfully participate in the planning process. This information should be accessible to people a diverse range of hearing, movement, sight, and cognitive abilities.

e. Develop a multi-stakeholder adaptation planning process that involves all City agencies charged with: 1) developing, assessing, and repairing public infrastructure that could improve community resilience to climate change; 2) providing key services during climate-related emergencies; and 3) managing municipal budgets for City programs and projects.

f. Engage city agencies in working with vulnerable communities to identify how their ongoing programs and public works projects can begin to integrate climate change adaptation goals. For example, utility undergrounding of overhead electrical lines, storm drain repairs, and sewer maintenance can mitigate the impacts of sea-level rise. The City of Oakland's C.O.R.E (Citizens of Oakland Respond to Emergencies) program can equip vulnerable communities with the knowledge and resources to respond to more frequent extreme weather events, like floods and droughts. The City, in collaboration with community groups, can engage lead agencies responsible for these programs and projects in adapting their planning documents to account for the anticipated local impacts of climate change.

4.3 Community Engagement in Implementation

a. Develop a timeline and work plan for implementation, help secure necessary funding and other resources, and design metrics to assess the effectiveness of implementation efforts in partnership with vulnerable communities

b. Include evaluation metrics that track whether vulnerable communities are directly and equitably benefitting from implementation of adaptation measures prioritized in the plan. For example, these evaluation metrics may include tracking the percentage of residents from vulnerable communities who have received city services or participated in programs targeted towards adaptation.

c. Design an implementation work plan that accounts for the resources necessary for continued engagement of community-based organizations in educating residents about adaptation measures and connect them to the resources they need to carry them out. For example, City agencies and community-based organizations can partner to develop a "how-to" training series on community adaptation and recruit participants from vulnerable communities for the training to carry out adaptation measures. These training participants can provide valuable feedback on challenges they encountered in carrying out adaptation measures that can in turn be used to improve the delivery of programs and services related to adaptation.

d. Develop and provide training to City staff on how to conform to the implementation plan by making necessary changes in their programs, projects, or service delivery in partnership with organizations based in vulnerable communities

e. Support efforts of community partners to conduct outreach and education to vulnerable residents about improved city programs and services related to adaptation by providing financial and technical resources or in-kind staff time

f. Designate staff time and resources to develop community-based maps that track the location of adaptation support services and identify areas where investments for adaptation have been made.

4.4 Research Needs

a. Our analysis of climate change and air quality was limited to particulate matter with a diameter < 2.5 μm ($PM_{2.5}$) because it was among the only datasets currently available. There are a number of other air quality parameters, however, that are important to human health, particularly ozone, for which reliable data are not as readily available. Additional research is needed to develop projected air quality estimates for a variety of parameters, especially ozone.

b. Climate impacts data are becoming available at increasingly finer spatial resolution as a result of advances in downscaling methods. In some cases, however, the available data are inadequate for local decision making. Better communication and coordination are

needed between researchers and practitioners to identify the types and forms of data that are needed.

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Glossary

BCDC	Bay Conservation and Development Commission
CORE	Citizens Organized in Response to Emergencies
ECAP	Energy and Climate Action Plan
ECCo	Environment, Culture and Conservation
ENSO	El Nino Southern Oscillation
IPCC	Intergovernmental Panel on Climate Change
LARC	Los Angeles Regional Collaborative for Climate Action and Sustainability
OCAC	Oakland Climate Action Coalition
OLTPS	Office of Long-Term Planning and Sustainability
PIER	Public Interest Energy Research
PM	particulate matter
RD&D	research, development, and demonstration
SPU	Seattle Public Utilities
SoVI	Social Vulnerability Index
SRES	Special Report on Emissions Scenarios
UEPI	Urban & Environmental Policy Institute

Appendix A. Summary of Adaptation Strategies

A.1 Adaptation Strategies for Extreme Heat

1. **Develop early warning systems for extreme heat events**
    a. ***Description:*** Develop a system to identify and alert resident when projected heat conditions pose a health risk
    b. ***Advantage:*** Helps people prepare a plan for dealing with heat stress; allows cities to have additional EMT on call and activate other preparedness measures
    c. ***Disadvantage:*** Expensive to ensure efficacy and mass-dissemination
    d. ***Equity Concern:*** Must be designed to communicate effectively to all groups, especially the particularly vulnerable; may not effectively address their needs if they still have limited mobility
    e. Policy Solution:
        i. Provide warnings in multiple languages
        ii. Provide warnings through multiple culturally or economically appropriate/accessible information streams, e.g., TV, radio, telephone, TTY, SMS, people-delivered
        iii. Establish a system of neighborhood outreach workers to disseminate information and check in on especially vulnerable residents
        iv. Conduct reverse 911 phone calls to the elderly and those at risk
        v. Increase day-time outreach to homeless

2. **Incorporate public health objectives into city general plan**
    a. ***Description:*** Develop a public health plan that improves overall health and takes into account extreme heat projects when considering local health needs
    b. ***Advantage:*** Wide benefits beyond climate adaptation
    c. ***Disadvantage:*** Resource constraints on meaningful implementation
    d. ***Equity Concern:*** Plan may not address the particular health and health service needs of all communities, especially low-income, communities of color, immigrants, and non-English speakers
    e. Policy Solution:
        i. Conduct an assessment of community health issues, concerns, and needs in collaboration with local community groups and health providers
        ii. Work in collaboration with local community groups to develop programs and services that address the needs of all residents, particularly those who have been historically under-represented

3. **Deliver essential medical services and supplies to the homes**
    a. ***Description:*** Collaboration between cities and health-care providers to transport water and essential medicines to the disabled, frail, or otherwise ill people bound to their homes in periods of extreme heat
    b. ***Advantage:*** Reduces risk of heat-related deaths or medical complications

c. ***Disadvantage:*** Difficult to staff and coordinate
d. ***Equity Concern:*** May be difficult to reach/identify the most vulnerable
e. ***Policy Solution:***
    i. Conduct vulnerability assessments and pair with effective early warning systems, multi-lingual hotlines, and outreach
    ii. Establish a buddy or neighborhood watch network

4. Open cooling centers during extreme heat events

a. ***Description:*** Establish and staff air-conditioned buildings open to community members during extreme heat events. Cooling centers can include existing public buildings, such as recreation centers, city hall, etc.
b. ***Advantage:*** Free to use, shown to be effective (even a few hours in AC reduced heat-related illness)
c. ***Disadvantage:*** Requires access to transportation or ability to walk to center
d. ***Equity Concern:*** May not be accessible to residents with limited mobility or certain disabilities; undocumented individuals may not seek out government services
e. ***Policy Solution:***
    i. Provide a free shuttle service from neighborhoods with identified vulnerable populations or from central public spaces (parks, libraries, etc.) to cooling centers
    ii. Dispatch teams of mobile nurses or outreach workers to provide water and fans or other cooling equipment to residents or areas identified as being especially vulnerable
    iii. Create neighborhood-level communication network to inform residents of location and directions to the nearest cooling center, and coordinate transportation to these centers for limited-mobility residents during extreme heat events
    iv. Collaborate with community-based groups to identify suitable locations for cooling centers, develop effective messaging to notify residents, conduct outreach, and plan appropriate activities for residents at centers

5. Work with utilities to require that electricity and water are not cut off due to nonpayment during extreme heat

a. ***Description:*** Ensure that homes will have electricity to run air conditioners and water to stay hydrated during extreme heat events
b. ***Advantage:*** Assist/protect economically vulnerable residents during extreme heat
c. ***Disadvantage:*** May be difficult to negotiated and coordinate with relevant agencies
d. ***Equity Concern:*** May not be properly implemented or monitored if historically under-represented groups are less likely to be considered in assessments of program efficacy or report failures in the program, e.g., if the rate payer is undocumented
e. ***Policy Solution:***

i. Work closely with utilities to ensure they have conducted user assessments and collected demographic information, and have developed programs to ensure rate-payer equity
ii. Work with local community organizations and advocates to determine efficacy of programs if information cannot be collected directly from rate-payers or traditional monitoring strategies

6. Plant trees/increase green space

a. ***Description:*** Plant trees and other vegetation to help cool urban environment by providing shade and increasing evapotranspiration
b. ***Advantage:*** Provides multiple benefits, e.g., aesthetic, stormwater runoff reduction, energy savings on cooling, air quality improvements, carbon sequestration, etc.; generally have positive costs/benefit ratios due to co-benefits
c. ***Disadvantage:*** Requires ongoing maintenance and, in some cases, water
d. ***Equity Concern:*** Focused installation only in wealthier areas of the city; gentrification; displacement of homeless populations with the rejuvenation or ecological objectives of new green space; gentrification related to neighborhood greening efforts
e. Policy Solution:
i. Prioritize neighborhoods with greatest need for tree planting programs
ii. Promote planting of native trees and plants to reduce water requirements.
iii. Ensure neighborhoods retain affordable or low-income housing options
iv. Develop mixed-use, mixed-income area with high levels of community input, engagement, and involvement in the planning process
v. Train Oakland youth and/or young adults to plant trees as part of the Oakland summer jobs program

7. Air condition and weatherize schools

a. ***Description:*** Ensure schools are both energy efficient and equipped with cooling systems to respond to extreme heat events
b. ***Advantage:*** Weatherization also acts as mitigation; measure to protect youth, who are often the most vulnerable
c. ***Disadvantage:*** Expensive to install and run; additional greenhouse gas emissions
d. ***Equity Concern:*** Initiatives may benefit or prioritize wealthier neighborhood schools in their implementation
e. Policy Solutions:
i. Establish a rigorous system of self-evaluation to ensure that infrastructure is provided equitably and across a variety of socio-economic spaces in the city;
ii. Engage public in decision-making and implementation

8. Air condition homes

a. ***Description:*** Promote air conditioning in homes

b. ***Advantage:*** Effective in protecting against heat-related mortality; don't have to leave home
c. ***Disadvantage:*** Expensive to install and run; additional greenhouse gas emissions
d. ***Equity Concern:*** Expensive to install and run
e. ***Policy Solutions:***
    i. Establish a subsidy or rebate system to assist low-income residents in purchasing/installing air conditioning;
    ii. Establish a system of reduced or sliding rates for low-income residents
    iii. Prioritize limited mobility residents such as the elderly, those with preexisting medical conditions and disabilities, and heat sensitivity for installation of air conditioning

9. Weatherize homes

a. ***Description:*** Install attic insulation, radiant barriers, solar attic fans, and other measures in homes to keep them cooler and more energy efficient
b. ***Advantage:*** Weatherization also acts as mitigation; reduces energy costs
c. ***Disadvantage:*** Expensive
d. ***Equity Concern:*** Initial installation can be expensive; renters may not have control over building and retrofit decision-making
e. ***Policy Solutions:***
    i. Support the Weatherization Assistance Program (WAP), which serves low income families at no cost
    ii. Support the Weatherization and Energy Retrofit Loan Program (WERLP), which provides zero-interest loans to help low-to-moderate income residence improve energy efficiency
    iii. Establish a low-income subsidy, or forgivable loan-funds to be repaid with anticipated energy savings to assist residents in weatherizing their home
    iv. Expand job training and placement of low-income residents in jobs generated by home weatherization programs

10. Install cool roofs

a. *Description:* Install roofing materials with high solar reflectance and thermal emittance to keep buildings cooler
b. *Advantage:* Reduce electricity use/costs on cooling
c. *Disadvantage:* Expensive, may make homes colder in the winter
d. *Equity Concern:* Initiatives may benefit or prioritize wealthier neighborhoods in their implementation; expensive to install
e. *Policy Solutions:*
    i. Establish a rigorous system of self-evaluation to ensure that infrastructure is provided equitably and across a variety of socio-economic spaces in the city
    ii. Engage public in decision-making and implementation

11. Install cool pavement

a. *Description:* Install reflective and permeable pavement, which provides evaporative cooling when wet to reduce heath island effect in paved areas
b. *Advantage:* Cooler urban environment; increased pavement life, resulting in less waste and government expenditure; quality of life benefits such as noise reduction and nighttime illumination
c. *Disadvantage:* Higher upfront costs
d. *Equity Concern:* Initiatives may benefit or prioritize wealthier neighborhoods in their implementation; expensive to install
e. *Policy Solutions:*
    i. Establish a rigorous system of self-evaluation to ensure that infrastructure is provided equitably and across a variety of socio-economic spaces in the city
    ii. Engage public in decision-making and implementation

12. Install green roofs

a. *Description:* Install a vegetative layer on rooftops to shade surfaces and remove heat from the air through evapotranspiration
b. *Advantage:* Stormwater management technique; reduced heat island effect; reduced cooling needs; increased biodiversity; lower cooling and heating costs; additional space for growing food
c. *Disadvantage:* Higher upfront costs; requires maintenance
d. *Equity Concern:* Initiatives may benefit or prioritize wealthier neighborhoods in their implementation; expensive to install
e. *Policy Solutions:*
    i. Provide zero interest loans or financial assistance for low-income residents to incentivize the investment and reduce financial risk
    ii. Provide education about how to start and maintain gardens

13. Public outreach/education

a. *Description:* Educate at-risk groups and their caregivers to detect signs and symptoms and prevent heat-related illness. Emphasize importance of immediate medical assistance for heat-related illness
b. *Advantage:* Reduces risk of heat-related deaths and medical complications
c. *Disadvantage:* Expense, required city resources and staff time
d. *Equity Concern:* Outreach may be linguistically, culturally, or otherwise inaccessible to vulnerable populations
e. *Policy Solutions:*
    i. Provide information in multiple languages
    ii. Provide information through multiple culturally or economically appropriate/accessible information streams, e.g., TV, radio, telephone, SMS, people-delivered
    iii. Establish a system of neighborhood outreach workers to disseminate information and check in on especially vulnerable residents

iv. Conduct reverse 911 phone calls to the elderly and those at risk
v. Increase day-time outreach to homeless

14. Outreach to businesses/workers about state health programs and standards for heat illness and employees working outdoors

a. *Description:* Ensure that legal protections for workers are known, respected, and enforced
b. *Advantage:* Reduces risk of heat-related deaths and medical complications; increase accountability and safety in the workplace for all employees
c. *Disadvantage:* Expense; required city resources and staff time; difficult to monitor and enforce
d. *Equity Concern:* Programs or standards may not be extended to those with poor job security, particularly undocumented individuals working outdoors
e. *Policy Solutions:*
    i. Prioritize stricter enforcement to ensure illness prevention to all workers, regardless of legal status
    ii. Ensure that employers are aware of the rights of employees with disabilities that involve sensitivity to heat to reasonable accommodation in the workplace, under the Fair Employment and Housing Act and the ADA.
    iii. Conduct state-wide traveling heat sweeps and local district actions during episodes of extreme heat

15. Outreach to local schools and teachers

a. *Description:* Ensure that school programs are in place to adapt to episodes of extreme heat during school hours
b. *Advantage:* Reduces risk of heat-related deaths and medical complications
c. *Disadvantage:* Expense, required city resources and staff time
d. *Equity Concern:* Outreach may be linguistically, culturally, or otherwise inaccessible or may not take into account limited resources of some schools
e. *Policy Solutions:*
    i. Provide information in multiple languages
    ii. Provide information through multiple culturally or economically appropriate/accessible information streams, i.e., TV, radio, telephone, SMS, people-delivered
    iii. Provide resources to the school for alternative programming and service provisions on days of extreme heat, such as low-intensity physical education classes

A.2 Adaptation Strategies for Floods

1. Limit development in flood plain

a. Description: Limit new and redevelopment in floodplains

b. ***Advantage:*** Preventative approach protects both human life and economic damages
c. ***Disadvantage:*** May be politically or economically difficult to enforce due to development pressure
d. ***Equity Concern:*** May reduce availability of low-income housing; may deter redevelopment in economically disadvantaged areas
e. ***Policy Solution:***
    i. Ensure that low- and mixed-income development projects are pursued in areas of the city at low risk of flooding
    ii. Require mitigations that address flood risk in proposed developments within high risk areas
    iii. Monitor regional, state, and federal programs and policies that might guide entities within city boundaries in undertaking climate adaptation projects (e.g. revisions of the Coastal Construction Manual by the Federal Emergency Management Agency, FEMA)

2. Install green infrastructure

a. ***Description:*** Install permeable pavement, green roofs, rain gardens, and other green infrastructure promoting infiltration of water and reducing runoff and flooding
b. ***Advantage:*** Multiple benefits, e.g., stormwater management, reduce heat island, reduce cooling needs, increase biodiversity
c. ***Disadvantage:*** High installation costs, requires maintenance
d. ***Equity Concern:*** Gentrification through new infrastructure and neighborhood rejuvenation
e. ***Policy Solution:***
    i. Ensure neighborhoods retain affordable or low-income housing options
    ii. Develop mixed-use, mixed-income areas with high level of community input, engagement, and involvement in planning process
    iii. Prioritize areas at high risk of flooding with vulnerable populations for green design and infrastructure programs

3. Preserve or restore wetlands

a. ***Description:*** Protect wetlands, which can act as a buffer to slow down and absorb flood waters
b. ***Advantage:*** Multiple benefits, e.g., habitat restoration, groundwater infiltration
c. ***Disadvantage:*** May be politically or economically difficult to enforce due to development pressure
d. ***Equity Concern:*** May reduce availability of low-income housing if development forgone
e. ***Policy Solution:***
    i. Ensure that forgone low- and mixed-income development projects are pursued in areas of the city at low risk of flooding

ii. Prioritize areas at high risk of flooding with vulnerable populations for wetland preservation and restoration programs
iii. Expand job training and placement of low-income residents in jobs generated by wetland preservation and restoration programs

4. Raise existing structures above flood level

a. ***Description:*** Raise transportation infrastructure and buildings above flood levels
b. ***Advantage:*** In some cases, more cost effective than building seawalls to protect infrastructure
c. ***Disadvantage:*** Expense
d. ***Equity Concern:*** Initiatives may prioritize minimizing predicted economic loss rather than protect the most vulnerable populations, leading to the prioritization of valuable city infrastructure and wealthier neighborhoods in their implementation
e. ***Policy Solution:***
i. Conduct vulnerability assessments and engage in community outreach when developing adaptation plan
ii. Prioritize low-income housing and other developments with vulnerable populations for programs to raise existing structures above flood level

5. Integrate climate change projections into new and existing stormwater and sewer infrastructure improvements

a. ***Description:*** Include future sea level and precipitation projections into all stormwater and sewer improvements
b. ***Advantage:*** Allows for ongoing improvements in stormwater and sewer systems
c. ***Disadvantage:*** Expense
d. ***Equity Concern:*** Initiatives may prioritize minimizing predicted economic loss rather than protect the most vulnerable populations, leading to the prioritization of valuable city infrastructure and wealthier neighborhoods in their implementation
e. ***Policy Solution:***
i. Conduct vulnerability assessments and engage in community outreach when developing adaptation plan
ii. Prioritize low-income housing and other developments with vulnerable populations for programs to raise existing structures above flood level

6. Build and/or expand protective infrastructure, e.g., levees and seawalls, where appropriate.

a. ***Description:*** Build seawalls and levees to protect structures from flood waters
b. ***Advantage:*** Protects structures in flood plain
c. ***Disadvantage:*** Expense, beach loss
d. ***Equity Concern:*** Initiatives may prioritize minimizing predicted economic loss rather than protect the most vulnerable populations, leading to the prioritization

of valuable city infrastructure and wealthier neighborhoods in their implementation

e. ***Policy Solution:***

i. Conduct vulnerability assessments and engage in community outreach when developing adaptation plan

ii. Monitor and advise projects to build seawalls to protect berths and runways from rising sea levels at Port and airport facilities to include a process for public participation (e.g. public notices and hearings) and ensure that they do not redirect climate change impacts to neighboring communities

7. Develop early warning systems for flooding

a. ***Description:*** Support meteorological forecasting and early warnings about possible flood conditions

b. ***Advantage:*** Allows residents more time to take proper action to protect their health and property

c. ***Disadvantage:*** Expensive to ensure efficacy and mass-dissemination

d. ***Equity Concern:*** Must be designed to communicate effectively to all groups, especially particularly vulnerable groups; may not effectively address their needs if they still have limited mobility

f. ***Policy Solution:***

i. Provide warnings in multiple languages

ii. Provide warnings through multiple culturally or economically appropriate/accessible information streams, i.e., TV, radio, telephone, SMS, people-delivered, etc.

iii. Establish a system of neighborhood outreach workers to disseminate information and check in on particularly vulnerable residents

iv. Conduct reverse 911 phone calls to the elderly and those at risk

v. Increase day-time outreach to homeless.

8. Develop and support local food systems

a. ***Description:*** Grow food locally to reduce impact of disasters by supporting local, diverse, and resilient food systems

b. ***Advantage:*** Cultivates local skills and knowledge, build local economy, can save money and generate income

c. ***Disadvantage:*** Requires skill and time for ongoing labor and maintenance

d. ***Equity Concern:*** Local or organic food frequently very expensive; farmers markets often do not accept food stamps; pesticide use can be hazardous and can cause severe health problems for neighbors with certain respiratory and neurological conditions

e. ***Policy Solution:***

i. Partner with the city and local organizations to refund produce vendors for food stamps in order to double the value of produce purchased in

order to encourage and enable the purchase of locally produced health foods

ii. Subsidize local agriculture to keep down consumer costs

iii. Support food local food systems that do not involve the use of chemical pesticides.

9. **Promote home insurance**
    a. ***Description:*** Encourage residents to purchase home insurance to recover from disasters such as a flood
    b. ***Advantage:*** Builds resilience by building capacity to recover from flood disasters
    c. ***Disadvantage:*** Expensive
    d. ***Equity Concern:*** Insurance may not be affordable or accessible for many residents
    e. ***Policy Solution:***
        i. Establish a system to subsidize insurance, particularly for low-income families
10. ***Develop evacuation, emergency response, and recovery planning***
    a. ***Description:*** Develop comprehensive community-based plans for emergency evacuation, response, and recovery in the event of a flood disaster
    b. ***Advantage:*** Builds resilience by building community capacity to prepare for, respond, and recover from flood disasters
    c. ***Disadvantage:*** Require long-term multi-stakeholder engagement in planning and implementation as well as interagency coordination
    d. ***Equity concern:*** Planning efforts may be focused in more affluent and politically enfranchised areas instead of those with the greatest need
    e. ***Policy solution:***
        i. Prioritize areas of high flood risk with concentrations of vulnerable populations for community-based planning efforts
        ii. Require interagency task force to partner with and resource community-based organizations to develop and implement planning process
        iii. Prioritize evacuation planning and drills in neighborhoods with mixed industrial and residential land uses with the involvement of hazardous materials specialists
        iv. Involve public transit and paratransit providers in evacuation route planning to ensure access to transportation for residents with limited mobility
        v. Provide temporary housing for low-income residents and other vulnerable populations impacted by floods
        vi. Provide financial assistance programs to repair flood-damaged homes and rental units for low-income residents

A.3 Adaptation Strategies for Wildfires

1. **Vegetation management**

a. ***Description:*** Replace flammable vegetation with less-flammable vegetation; remove dead trees, keep grass short, and prune and thin trees
b. ***Advantages:*** Preventative approach protects life and property
c. ***Disadvantage:*** Requires time and resources for ongoing management
d. ***Equity Concern:*** Management may occur only in areas where local residents have high levels of political representation or resources
e. ***Policy Solution:***
    i. Establish rigorous system of self or 3rd party evaluation to ensure that management is implemented equitably across all regions
    ii. Prohibit the use of toxic chemicals in vegetation control

2. **Land use planning**
    a. ***Description:*** Limit development in fire prone areas, when possible
    b. ***Advantages:*** Preventative approach protects life and property
    c. ***Disadvantage:*** May be politically or economically difficult due to development pressure
    d. ***Equity Concern:*** May reduce availability of low-income housing
    e. ***Policy Solution:***
        i. Ensure the neighborhood retains affordable or low-income housing options;
        ii. Develop mixed-use mixed-income area with high level of community input, engagement, and involvement in the planning process

3. **Ensure adequate shelters are in place as part of wildfire emergency response plans**
    a. ***Description:*** Provide a health and safe temporary shelter for those displaced by fires
    b. ***Advantages:*** Free to use, shown to be effective
    c. ***Disadvantage:*** Requires access to transportation or ability to walk to center
    d. ***Equity Concern:*** Some residents may have limited mobility which would hinder them from seeking shelter
    e. ***Policy Solution:***
        i. Provide free emergency transport to shelters
        ii. Conduct reverse 911 calls to ensure immobile residents are not trapped in their homes

4. **Identify high fire risk areas that would allow for the safe burial of existing power lines to avoid interruptions due to wildfire events**
    a. ***Description:*** Prevent energy infrastructure damages/outages during wildfire by burying power lines
    b. ***Advantages:*** Increase community and infrastructural resilience to wildfires
    c. ***Disadvantage:*** Expense
    d. ***Equity Concern:*** Burial may occur only in areas where local residents have high levels of political representation or resources

e. ***Policy Solution:***
    i. Establish rigorous system of self or 3rd party evaluation to ensure that management is implemented equitably across all regions

5. **In high fire risk areas, require new construction builders to bury utilities during the construction phase**
    a. ***Description:*** Prevent energy infrastructure damages/ outages during wildfires
    b. ***Advantages:*** Increase community and infrastructural resilience to wildfires
    c. ***Disadvantage:*** Expense, difficult to regulate
    d. ***Equity Concern:*** May not be equitably implemented in every community due to less strict regulation or monitoring in low-income and communities of color due to institutionalized racism
    e. ***Policy Solution:***
        i. Establish rigorous system of self or 3rd party evaluation to ensure that management is implemented equitably across all regions

6. **Develop air quality warning system**
    a. ***Description:*** Develop system to alert residents when air quality is poor due to wildfire smoke, and actions that should be taken, e.g., restrict outdoor exercise
    b. ***Advantages:*** Allows residents to choose to take measures to protect their health
    c. ***Disadvantage:*** Expense, required city resources and staff time
    d. ***Equity Concern: :*** Must be designed to communicate effectively to all groups, especially the particularly vulnerable; may not effectively address their needs if they still have limited mobility
    e. ***Policy Solution:***
        i. Provide warnings in multiple languages
        ii. Provide warnings through multiple culturally or economically appropriate/accessible information streams, e.g., TV, radio, telephone, SMS, people-delivered, etc.
        iii. Establish a system of neighborhood outreach workers to disseminate information and check in on particularly vulnerable residents
        iv. Reverse 911 phone calls to the elderly and those at risk
        v. Increase outreach to homeless
        vi. Provide evacuation transportation for immobile residents and other residents who need such transportation for health reasons

7. **Public education/awareness**
    a. ***Description:*** Educate the public about the potential risk of wildfire and, in the case of a wildfire disaster, what protective measures to take
    b. ***Advantages:*** Increase community awareness of potential adaptive measures that can be taken to reduce vulnerability to wildfire
    c. ***Disadvantage:*** Expense, required city resources and staff time

d. ***Equity Concern:*** Outreach may be linguistically, culturally, or otherwise inaccessible to vulnerable populations

e. ***Policy Solutions:***

i. Provide warnings in multiple languages

ii. Provide warnings through multiple culturally or economically appropriate/accessible information streams, e.g., TV, radio, telephone, SMS, people-delivered, etc.

iii. Establish a system of neighborhood outreach workers to disseminate information and check in on particularly vulnerable residents

iv. Reverse 911 phone calls to the elderly and those at risk

v. Increase outreach to homeless

vi. Provide evacuation transportation for immobile residents

8. Home Insurance

a. ***Description:*** Purchase home insurance to assist in recovery from a disaster such as a wildfire

b. ***Advantages:*** Increase resilience of residents and decrease financial burden of emergency relief on city

c. ***Disadvantage:*** Expensive for individual households

d. ***Equity Concern:*** Insurance may not be affordable or accessible for many residents

e. ***Policy Solution:***

i. Establish a system to subsidize insurance, particularly for low-income families

ii. Ensure that insurance mandates account for the household's ability to pay

9. Wildfire response and recovery

a. ***Description:*** Develop comprehensive community-based plans for emergency evacuation, response, and recovery in the event of a wildfire

b. ***Advantage:*** Builds resilience by building community capacity to prepare for, respond, and recover from wildfires

c. ***Disadvantage:*** Require long-term multi-stakeholder engagement in planning and implementation as well as interagency coordination

d. ***Equity concern:*** Planning efforts and financial resources may be focused in more affluent and politically enfranchised areas

e. ***Policy solution:***

i. Prioritize areas of high wildfire risk with concentrations of vulnerable populations for community-based planning efforts

ii. Require interagency task force to partner with and resource community-based organizations to develop and implement planning process

iii. Prioritize evacuation planning and drills in neighborhoods with mixed industrial and residential land uses with the involvement of hazardous materials specialists

iv. Involve public transit and paratransit providers in evacuation route planning to ensure access to transportation for residents with limited mobility

v. Provide temporary housing for low-income residents and other vulnerable populations impacted by wildfires

vi. Provide financial assistance programs to repair wildfire-damaged homes and rental units for low-income residents

vii. If property tax assessments are used to pay for wildfires, account for ability to pay in covering the costs of wildfire response

A.4 Adaptation Strategies for Rising Utility and Food Costs

1. **Provide incentive programs to promote installation of water/energy efficient appliances and fixtures**
    a. ***Description:*** Promote use of water- and energy-efficient appliances and fixtures to help keep energy costs affordable as water and electricity become more expensive;
    b. ***Advantage:*** Mitigation strategy, reduce utility bills
    c. ***Disadvantage:*** Expensive,
    d. ***Equity Concern:*** Affordability; renters may not have control over building and retrofit decision-making; may be more expensive than the less-efficient alternatives and thus not a viable adaptive option for low- or fixed-income residents; rebate-based programs place risk and upfront cost burden on households, unduly burdening or excluding low-income residents
    e. ***Policy Solution:***
        i. Develop low-income direct install programs
        ii. Provide rebates at point-of-sale for the purchase of efficient fixtures and appliances
        iii. Design model tenant-landlord agreements so that all parties can equitably share in the costs and benefits of efficiency programs
        iv. Develop zero-interest loan programs to help low-to-moderate income residents install efficiency measures
        v. Establish a low-income subsidy, or forgivable loan-funds to be repaid with anticipated water and energy savings to assist residents in installing efficient appliances and fixtures

2. **Provide home weatherization programs**
    a. ***Description:*** Install attic insulation, radiant barriers, solar attic fans and other measures in homes to keep them cooler and more energy efficient
    b. ***Advantage:*** Weatherization also acts as mitigation; reduces energy costs

c. ***Disadvantage:*** Expensive
d. ***Equity Concern:*** Initial installation can be expensive; renters may not have control over building and retrofit decision-making; existing weatherization programs do not typically cover expensive improvements that can result in the greatest energy savings
e. ***Policy Solutions:***
    i. Develop assistance programs that provide weatherization to low-income families at no cost
    ii. Develop zero-interest loan programs to help low-to-moderate income residents weatherize their residence
    iii. Establish a low-income subsidy, or forgivable loan-funds to be repaid with anticipated energy savings to assist residents in weatherizing their home
    iv. Develop programs so that direct revenues collected by utilities can fund energy efficiency programs

3. Install water catchment and grey water use/water recycling

a. ***Description:*** Install water catchment and grey water systems on buildings and residential homes
b. ***Advantage:*** Reducing water demand would both reduce residents' water bills as well as conserve precious water and energy resources
c. ***Disadvantage:*** High initial installation cost; potential public health concerns if not properly implemented/maintained
d. ***Equity Concern:*** Affordability: high initial installation cost; favors homeowners, i.e., little incentive for renters or landlords to install; users must be given appropriate and accessible education on proper use of captured and grey water to prevent health issues
e. ***Policy Solution:***
    i. City provides assistance designing model tenant-landlord agreements so that all parties can equitably share in the costs and benefits of water efficiency

4. Develop and support local food systems

a. ***Description:*** Grow food locally to reduce impact of disasters by supporting local, diverse, and resilient food systems
b. ***Advantage:*** Cultivates local skills and knowledge, build local economy, can save money and generate income
c. ***Disadvantage:*** Requires skill and time for ongoing labor and maintenance
d. ***Equity Concern:*** Local or organic food frequently very expensive; farmers markets often do not accept food stamps; pesticide use can be hazardous and can cause severe health problems for neighbors with certain respiratory and neurological conditions
e. ***Policy Solution:***

i. Partner with the city and local organizations to refund produce vendors for food stamps in order to double the value of produce purchased in order to encourage and enable the purchase of locally produced health foods
ii. Subsidize local agriculture to keep down consumer costs
iii. Conduct community outreach and education to expand access to food stamps and healthy food distribution programs
iv. Expand access to public and privately owned land for local food production
v. Change permitting requirements and regulations that pose barriers to community food security strategies such as street food vending and selling home-cooked foods
vi. Invest in commercial food kitchens run in partnership with local community organizations to meet community food needs
vii. Develop healthy food distribution systems to make available and incentivize the purchase of healthy foods in local stores
viii. Support food local food systems that do not involve the use of chemical pesticides.

5. **Develop programs to reduce financial hardship of increased food, energy and utility costs on residents**
    a. ***Description:*** Assess impact of climate change on food, energy, and utility costs, including residents most vulnerable to these impacts, and develop programs to address alleviate financial hardship of impacted groups
    b. ***Advantage:*** Greater rate payer equity, ensuring the health and wellbeing of all residents
    c. ***Disadvantage:*** Potentially expensive or difficult to develop programs in collaboration with appropriate corporations or agencies
    d. ***Equity Concern:*** Most impacted groups are likely to be low- and fixed-income, communities of color, immigrants, non-native English speakers, and other historically marginalized communities, thus programs developed may not adequately address these communities' particular needs or dynamics
    e. ***Policy Solution:***
        i. Work with local community organizations or institutions such as schools or religious organizations to develop appropriate and effective programs
        ii. Work with local research institutions and ethnographers to gather information on community values and concerns to develop appropriate and effective programs
        iii. Prohibit utilities from using water and electricity shut-offs as a means of collecting past-due bills
        iv. Develop rate structures and pricing policies that charge high-volume consumers and businesses more for water and electricity

v. Increase outreach for Supplemental Nutrition Assistance Program (SNAP)
vi. Remove the ban for SNAP benefits for drug offenders
vii. Provide incentives for purchasing healthy foods, especially for SNAP benefits recipients

6. **Create green economy/new green work force**
    a. ***Description:*** Develop programs to accelerate Brownfield cleanup and redevelopment; train workers to install and maintain green technologies, infrastructure, and construction
    b. ***Advantage:*** Creates jobs; increase economic prosperity and resilience
    c. ***Disadvantage:***
    d. ***Equity Concern:*** May not provide appropriate training or opportunities for those with low-levels of education, non-English speaking, or low-income; certification programs may not be affordable
    e. ***Policy Solution:***
        i. Provide environmental job training for vulnerable populations, including the formerly incarcerated chronically unemployed, young adults at risk, on public assistance or among the working poor
        ii. Prioritize low-income communities for renewable energy demonstration programs and green job training/placement in jobs created by these programs
        iii. City wage subsidy programs encouraging employers to provide job opportunities to graduates of environmental training programs

7. **Assess the sectors and populations that will benefit from new economic development opportunities associated with resilience building**
    a. ***Description:*** Conduct a participatory science-based assessment in collaboration with community organizations to determine those sectors and populations that will benefit from new employment, training, and growth opportunities
    b. ***Advantage:*** Enable targeted and equitable job creation
    c. ***Disadvantage:*** Expense
    d. ***Equity Concern:*** Assessments and programs do not capture or address the employment needs of those unemployed, untrained, or uneducated residents
    e. ***Policy Solution:***
        i. Integrate affordable green training and certification programs into economic plan for those currently unemployed, underemployed, or not employable due to lack of education, skill, or disenfranchisement, etc.

8. **Pursue infill, smart growth, and urban renewal projects to build better integrated and more resilient communities**

a. ***Description:*** Work on holistic renewal plans for communities considering green space, transportation infrastructure, local access to essential goods, services, and employment
b. ***Advantage:*** Contributes to more resilient and healthy communities
c. ***Disadvantage:*** Expensive, requires extensive stakeholder engagement of many local and regional agencies for effective implementation
d. ***Equity Concern:*** Infill, smart growth, or urban development may adverse impact low- and fixed-income residents through gentrification and increased rent
e. ***Policy Solution:***
    i. Work with researchers to assess potential economic and social impacts of projects on all current residents before implementation
    ii. Include elements of mixed-use and mixed income development to combat differential impacts of urban renewal on local populations, particularly taking into account the potential effects of increased rent on low-income residents
    iii. Incentivize and fund cleanup and redevelopment of underutilized, contaminated properties and abandoned buildings (brownfields) for end uses that strengthen community resilience, such as urban gardens, green job incubators, and renewable energy demonstration projects

9. Support existing community organizing efforts around climate change and resilience

a. ***Description:*** Provide funding, resources, and opportunities for collaboration with city to existing community organizations working to increase resilience in their communities
b. ***Advantage:*** Empowering local communities and supporting their capacity to adapt and recover
c. ***Disadvantage:*** Resource constraints
d. ***Equity Concern:*** City may choose to support those groups most politically aligned or allied with the city, excluding those that work with that have been historically under-represented or discriminated against by the city
e. ***Policy Solution:***
    i. Assess and monitor recipients of government support to ensure issued the communities groups represent a diversity of demographic communities, neighborhoods, and concerns
    ii. Contract with and resource community-based organizations to train community resilience specialists in neighborhoods that educate residents on existing programs and resources available to build resiliency

A.5 Adaptation Strategies for Poor Air Quality

1. **Modify emissions reduction plan**
    a. ***Description:*** Modify emissions reduction plan, e.g., regional air quality attainment plans and the State Implementation Plan, to account for the increase in air pollution attribute to climate change
    b. ***Advantage:*** Potentially effective way to prevent worsening air quality
    c. ***Disadvantage:*** Must be implemented at high levels of governance (state or air quality region), little community/local control
    d. ***Equity Concern:*** Emissions reductions efforts may exclude or disproportionately burden low- and fixed-income residents through increased energy costs and financial burden of transitioning to more efficient technologies, etc.
    e. ***Policy Solution:***
        i. Conduct a science-based assessment of target sectors and populations for emissions reductions standards, considering effect of new plan on employment and individual consumer options
        ii. Work with local community organizations and advocates to develop and determine efficacy of regulations and programs
        iii. Prioritize communities with the highest health risk from poor air quality for emissions reduction programs and resources
        iv. Require industrial and transport-related sources of emissions, such as port, rail yard, and warehouse facilities, to provide funding to mitigate negative impacts of their operations on local air quality

2. **Insulate/ seal homes**
    a. ***Description:*** Use duct tape and plastic sheeting to seal cracks around doors and outside vents in periods of poor air quality, particularly during wildfires
    b. ***Advantage:*** Reduces exposure and only requires individual action
    c. ***Disadvantage:*** Inconvenient, more likely to be used during instances of extreme poor air quality than habitually
    d. ***Equity Concern:*** All residents may not have access to necessary materials; the homeless are excluded from this adaptive measure
    e. ***Policy Solution:***
        i. Establish central distribution points of necessary materials for those on low-or fixed-income
        ii. Work with local community groups to distribute materials and hold community workshops on health effects of poor air quality and strategies for sealing and protecting the home
        iii. Establish shelters or public cooling/indoor centers for homeless and low-income residents during extremely poor air quality events
        iv. Educating residents on measures they can take to protect indoor air quality such as reducing household chemical use
        v. Evaluate indoor air quality to ensure harmful air isn't being sealed in a home

3. **Replace furnace filter with a high efficiency filter**
    a. ***Description:*** Install a higher-efficiency filter to reduce air pollution in the home
    b. ***Advantage:*** Higher efficiency, reduces exposure to air pollution
    c. ***Disadvantage:*** Expense and inconvenience
    d. ***Equity Concern:*** May pose financial hardship to low and fixed-income individuals; the homeless are excluded from this adaptive measure
    e. ***Policy Solution:***
        i. Establish a subsidy or rebate system to assist low-income residents in purchasing or installing higher efficiency filters
        ii. Establish shelters or public cooling/indoor centers for homeless and low-income residents during extremely poor air quality events

4. **Run air conditioning system**
    a. ***Description:*** Constantly cycle air through air conditioning system with upgraded filters to remove some of the air pollutants
    b. ***Advantage:*** Adaptive measure to both extreme heat and reduced air quality
    c. ***Disadvantage:*** Contributes to greenhouse gas emissions, resulting in further reduced air quality and other adverse climate impacts; expensive
    d. ***Equity Concern:*** May pose financial hardship to low and fixed-income individuals due to increased cooling costs or the cost of purchasing and installing air conditioning; the homeless are excluded from this adaptive measure
    e. ***Policy Solution:***
        i. Establish a subsidy or rebate system to assist low-income residents in purchasing or installing higher efficiency filters
        ii. Establish shelters or public cooling/indoor centers for homeless and low-income residents during extremely poor air quality events

5. **Create a "safe room" at home using a HEPA filter**
    a. ***Description:*** Install a HEPA filter in a common space or a room where particularly sensitive members of the household can retreat
    b. ***Advantage:*** Reduces exposure, particularly for sensitive members of the household
    c. ***Disadvantage:*** Contributes to greenhouse gas emissions; expensive
    d. ***Equity Concern:*** May pose a financial hardship to low- and fixed-income individuals due to increased electricity costs and the costs of the HEPA filter; the homeless are excluded from this adaptive measure
    e. ***Policy Solution:***
        i. Establish a subsidy or rebate system to assist low-income residents in purchasing an energy-efficient HEPA filter
        ii. Provide funding for HEPA filter replacement for low-income households, those with chemical sensitivities and respiratory disabilities

iii. Establish shelters or public cooling/indoor centers for homeless and low-income residents during extremely poor air quality events

6. **Develop a warning system for air quality**
    a. ***Description:*** Publish and promote Air Quality Index in a variety of media for daily information about air quality and potential health effects
    b. ***Advantage:*** Provides residents with more information necessary to take precaution and reduce exposure
    c. ***Disadvantage:*** Information may not increase ability of residents to either mitigate or adapt if their resources and alternatives are still limited
    d. ***Equity Concern:*** Air quality index may not be published in multiple languages or presented in a manner intelligible to those unfamiliar with the measure; may not be distributed in economically, culturally, linguistically accessible forms, i.e., only online or in an English-language newspaper
    e. ***Policy Solution:***
        i. Provide warnings and education in multiple languages and multiple culturally or economically appropriate/ accessible information streams (radio, word-of-mouth, at pre-existing local gathering places, etc.)
        ii. Partner with local community-based organizations to determine most effective methods of information distribution and education about health effects of air pollution

7. **Public outreach/ education programs**
    a. ***Description:*** Develop public education and outreach programs to reduce emission-causing activities and limit exposure on high air pollution days
    b. ***Advantage:*** Increase community awareness of potential adaptive measures that can be taken to reduce vulnerability to poor air quality
    c. ***Disadvantage:*** Expense, required city resources and staff time
    d. ***Equity Concern:*** May not be designed to communicate effectively to all groups, especially the most vulnerable; education about preventative measures (i.e. sealing home, staying indoors, taking transport rather than walking to reduce time outdoors, etc.) are ineffective if residents have no alternatives or limited resources to carry out adaptive measures
    e. ***Policy Solution:***
        i. Provide warnings and education in multiple languages and multiple culturally or economically appropriate/ accessible information streams;
        ii. Provide resources to partner with community-based groups to develop and implement community education and outreach programs
        iii. Establish systems of neighborhood leaders/outreach workers who are trained and charged with disseminating information to local residents that capitalize on existing information streams, social networks and neighborhood institutions;

iv. Establish regulation to protect outdoor workers in periods of high air pollution; ensure information about adaptive measures is paired with information about assistance programs and less expensive alternatives for adaptive action

v. Conduct community education on that focuses on preventative care and solutions that address causes of poor outdoor and indoor air quality, such as environmentally-safe alternatives to household chemicals

8. Revise building design guidelines to address air quality

    a. ***Description:*** Revise building codes and design guidelines to consider and mitigate air quality impacts

    b. ***Advantage:*** Addresses air quality concerns in design of developments

    c. ***Disadvantage:*** Could be politically unpopular because it may increase costs of development; increased costs to developers could be passed on to residents in the form of higher housing costs, which could contribute to gentrification

    d. ***Equity Concern:*** Could benefit more affluent residents with a greater ability to pay for more expensive housing that conforms to revised building design guidelines

    e. ***Policy Solution:***

        i. Require proposed developments in areas with poor air quality to adhere to building design guidelines that mitigate health risk

Prioritize developments for vulnerable populations, e.g., low-income residents, those with pre-existing respiratory conditions, and those with sensitivities to poor air quality, for indoor air quality programs and resources that support green design