ADAPTING TO RISING TIDES WHITE PAPER
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ADDRESSING SOCIAL VULNERABILITY AND EQUITY IN CLIMATE CHANGE ADAPTATION PLANNING

Report prepared as part of the Adapting to Rising Tides project, a collaborative effort of local, state and federal agencies and organizations, and is being led by the San Francisco Bay Conservation and Development Commission. More information about this project can be found on the web at: www.adaptingtorisingtides.org

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San Francisco Bay
Conservation and Development Commission

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1. Introduction

As planning for sea level rise and extreme storm events moves forward, so too should state objectives for achieving environmental justice and equity for all Californians. The purpose of this white paper is to highlight the links between equity and planning for sea level rise and storm events and is designed to inform the Adapting to Rising Tides project (ART) being led by the San Francisco Bay Conservation and Development Commission.

Social equity is "fair access to livelihood, education and resources; full participation in the political and cultural life of the community; and self determination in meeting fundamental needs" (Ecotrust, 2011). Communities and populations that experience social inequalities are likely to be more vulnerable or susceptible to immediate and lasting harm from hazards such as coastal flooding. An analysis of social equity involves understanding the effects of a change (e.g. a project or event) on communities and the services that they rely on and value, with specific attention to effects that are borne disproportionately due to existing inequalities. As a result of continually strengthened policies and agency mandates since the 1990's as well as the hard work of community groups to advocate for equity, planners and policy-makers have increasingly worked to integrate consideration of equity issues into relevant projects, policies and programs.

Social equity has diverse roots, including the environmental justice movement, which came about in response to the growing recognition that minority and low-income communities experience greater exposure to environmental hazards. Requirements to address environmental justice began with President Clinton's Executive Order 12898 of 1994, which requires federal government agencies to:

> *Make achieving environmental justice part of its mission by identifying…disproportionately high and adverse human health or environmental affects of its programs, policies and activities on minorities and low-income populations (Presidential Executive Order 12898).*

The US Environmental Protection Agency (EPA) set up the Office of Environmental Justice in 1992 to address negative environmental consequences from industrial, municipal or commercial activities on communities. The state of California Government Code defines environmental justice in statute as:

> *The fair treatment of people of all races, cultures and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations and policies (Government Code Section 65040.12).*

Section 1 introduces key concepts related to climate change adaptation and provides background information on the ART project. Section 2 introduces the concept of social vulnerability and the existing body of literature on equity, resiliency and climate change adaptation, and explores historic examples of flood events, such as Hurricane Katrina. In addition, it lays out the assessment framework used in the ART project and key findings from a social vulnerability analysis completed for the study area. Section 3 includes three case studies of recent or ongoing planning processes that have sought to integrate equity and community issues. Finally, section 4 summarizes key conclusions and recommendations from demographic and survey analysis to inform equity considerations in the Adapting to Rising Tides project and for the larger community of climate change adaptation and equity planners, organizers, and advocates in the San Francisco Bay Area.

Environmental Justice in California State Planning

The Governor's Office of Planning and Research (OPR) is designated as California's coordinating agency for environmental justice, a role that includes providing guidance to local governments and serving as a clearinghouse on environmental justice issues. OPR has developed programs, policies and standards for environmental justice in planning. The following are goals for environmental justice based on findings put forth by OPR and adopted by the Cal/EPA Interagency Working Group.

Statewide Environmental Justice Goals:

- State government that is inclusive and responsive to people of all back grounds with regard to environmental policies, laws and regulations.
- People of all backgrounds are ensured a healthy environment.
- Environmental justice leadership across all state agencies

Source: OPR, 2003

1.1 Key Concepts–Vulnerability Assessments and Equity

Vulnerability is defined by three primary factors: exposure, sensitivity and adaptive capacity (ICLEI, 2009). An impact can be a distinct hazard event (e.g., a storm) or a chronic or cumulative stress (e.g., rising groundwater). **Exposure** describes whether and to what degree a community will experience a stress or hazard due to a climate change impact. In the ART project, which is focused on the climate impacts of sea level rise and storm events, exposure is defined as whether a geographical area will be exposed to either sea level rise or storm events, an approximation of the magnitude of the exposure and the general timeframe that the exposure is likely to occur.

Sensitivity is the degree to which a community is affected by the climatic stressor. For example, in the analysis of vulnerability of park and recreation areas within the ART project area, the sensitivity of a trail that is exposed to sea level rise and storm events will be greater for an unpaved trail that is already experiencing erosion and drainage problems than for a paved, well-drained trail. These two trails may be exposed to the same storm event but the unpaved trail will be much more sensitive to and more damaged by that exposure. Generally, effects can be direct (damage to the community and its assets) or indirect (stressors can make populations more susceptible to extreme conditions associated with climate change) (Moser and Ekstrom, 2010).

The final component of vulnerability is **adaptive capacity.** Adaptive capacity describes the ability of a system to adjust to potential climate changes (CARE, 2009). It can be assessed across scales, from the level of the individual to cities or nations. Factors influencing adaptive capacity include levels of economic resources, competency and reliability of institutions, adequacy of infrastructure, technological capability, education and knowledge, stakeholder engagement, and equity in access and distribution of resources (Moser and Ekstrom, 2010). Those individuals, communities, cities and nations with a greater degree of adaptive capacity will suffer less harm from exposure to the climate impact and recover more quickly from the impact than those with a lower degree of adaptive capacity.

Another way to think about adaptive capacity is **resilience**. Community resilience is the ability to withstand and recover from difficult times while meeting basic needs for community members (Bay Localize, 2009). It has been described as the ability to reorganize in response to change while still being able to preserve the structure and function of a community (Eakin and Luers, 2006). As Carl Folke, et al., explain,

> *Vulnerability is the flip side of resilience: when a social or ecological system loses resilience it becomes vulnerable to change that previously could be absorbed. In a resilient system, change has the potential to create opportunity for development, novelty and innovation. In a vulnerable system, even small changes may be devastating. (Folke, et al., 2002).*

For communities across the Bay Area, vulnerability and resilience play out in every day examples. Imagine a bus line is eliminated along a route that serves a diverse population of residents. For some, the loss of a bus line could mean the difference between being able to get to work, medical appointments, or other important daily tasks. For car owners, bicyclists, or families who can afford to purchase these items, a disruption of service can prove a minor inconvenience.

Strong community relationships can also play a role in vulnerability and resilience. Neighbors with strong ties and social relationships will more inclined to help each other out in times of crisis or change. The elimination of a bus route in a community with strong social relationships might not be as significant, as those existing relationships could lead to ride-sharing and car-sharing. In these examples, individual, household and neighborhood factors play a role in community vulnerability and resilience. Such effects can also play out at the city or county scale. For example, in cities that serve residents with a network of public transit that has some redundancies in the system, the loss of the same bus line would be less likely to cut off a low-income community or household from important services and employment. Folks could simply take another bus or train. Similarly, community centers, parks, and places of worship can improve resilience by bringing neighbors closer together and providing emergency facilities and resources during a disaster.

1.2 Influences on Vulnerability

As described above, understanding vulnerability to hazards requires in-depth knowledge of the linkages between social, environment, economic and governance factors and how these are brought to bear on a community (Cutter, 1996). In the context of climate change, it can be understood as:

> *The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of [the] character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001).*

ART Existing Conditions and Stressors Report

In the ART project Existing Conditions and Stressors Report, equity is considered along with economy, environment and governance across all asset categories. The Existing Conditions and Stressors Report was published in January 2012. The report was intended to provide information on the current conditions within the project area, and serves as the foundation for the vulnerability and risk assessment. The current condition of, and existing stressors on an asset have implications for an asset's vulnerability and risk, and can contribute to its resilience (or lack thereof) to projected climate impacts.

The themes of economy, equity, environment and governance provided the overall framework for evaluating the asset categories in the report, in addition to providing an overview of the physical location of assets, characteristics, and existing stressors. Socio-economic trends for the study area are also highlighted, including population trends and a discussion of vulnerable populations and existing inequalities.

Vulnerability is a dynamic state influenced by factors such as existing inequalities, historic patterns of marginalization, policy and management activities and degree of community engagement (Eakin and Luers, 2006).

Figure 1: ART Project Study Area

It is important to recognize that vulnerability can apply to the physical, the social and the economic attributes of communities. Physical vulnerability describes the ways in which the built and natural environment has the potential to be harmed and include buildings, utilities, transportation networks, natural areas and agricultural land. Social and economic vulnerability describes the ways individuals, households and neighborhoods may be disproportionately harmed by a hazard, and considers a wide range of characteristics such as family relationships, gender, race, income, and hazard exposure (Colten, et al., 2008). Physical, social and economic vulnerability greatly influence each other. For example, the loss of the functionality of physical infrastructure, such as a hospital, can have major social and economic implications such as loss of employment, loss of services and loss of an emergency evacuation center. Similarly, major economic losses within a region can reduce opportunities to improve physical infrastructure and provide community services, thus impacting both physical and social vulnerability. In fact, community health and safety relies on continual efforts to reduce vulnerability in all of these areas and to understand the effects that physical, social and economic factors can have on each other.

1.3 Equity and the ART Project

The ART project is conducting a vulnerability assessment for a number of assets–physical, social and economic–within a subregion of the Bay Area and developing an adaptation strategy to respond to the vulnerabilities identified within that area. It is a collaborative effort evaluating how a subregion in the Bay Area can become more resilient to climate change, particularly to sea level rise and storm events. The ART project is a pilot project that will ultimately provide guidance on how best to approach two broad questions:

- How will sea level rise and other climate change impacts affect the future of Bay Area communities, ecosystems, infrastructure, and economy?
- What strategies should we pursue, both locally and regionally, to address these challenges and reduce and manage these risks?

The only way to answer both of these questions is to incorporate equity considerations and focusing on protecting and preserving quality of life for Bay Area residents during uncertain times. The primary goal of the ART project is to increase the Bay Area's preparedness and resilience to sea level rise and storm events while protecting critical ecosystem and community services. The study area encompasses a portion of the Alameda County shoreline from the City of Emeryville to the City of Union City, extending inland approximately a half a mile beyond the area projected to be exposed to storm event flooding with 55 inches of sea level rise.

ART project staff is integrating equity into planning and analysis in three primary ways. First, project staff is taking an integrated approach to evaluate the vulnerability and risk of shoreline communities, critical facilities and assets such as transportation networks, the airport and seaport, as well as parks and recreation. This approach includes evaluating effects on communities and ecosystems through the lens of four, overarching frames: society and equity, economy, environment, and governance. These four frames comprise an approach to developing adaptation strategies that will address how shoreline communities and the region as a whole can support a sustainable, resilient and prosperous Bay Area.

Using Metrics to Track Equity

ART project staff developed asset specific metrics in collaboration with project partners. These metrics will be used to inform sensitivity, adaptive capacity and consequences of sea level rise and storm events. Metrics were developed for four broad areas: equity/society, economy, environment and governance.

Equity specific metrics covered:

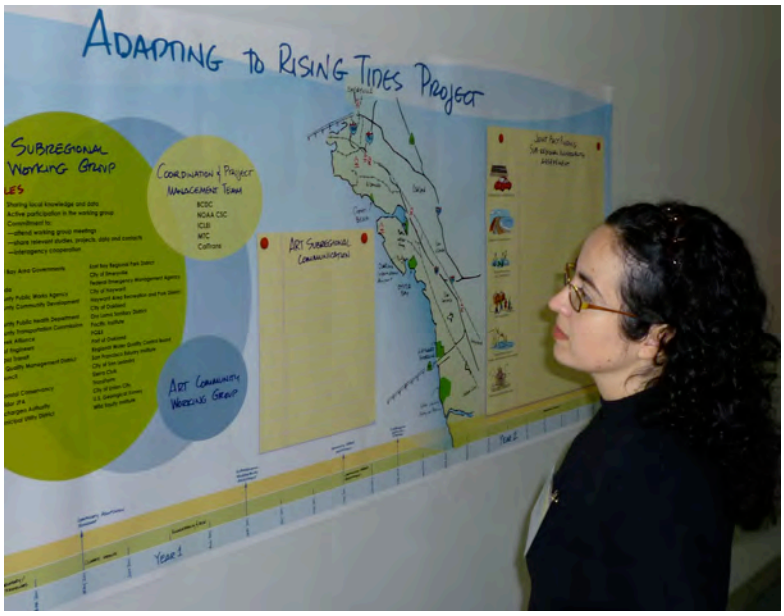
- Public health
- Proximity of assets/services to sensitive populations
- Historic exposure
- Sensitive populations served by assets/services
- Emergency preparedness for sensitive populations
- Critical facilities (hospitals, transportation, fire stations, etc.)
- Public access

Second, staff developed and administered a survey to project partners, which includes local, regional, state and federal agencies. The survey was also sent to advocacy groups, local governments, community leaders and non-profit organizations outside of the ART working group. The survey asked local experts and community advocates on climate change, social justice and equity for their best professional judgment on major equity issues related to sea level rise. It identified:

- Ways that a diverse range of practitio ners define resilience in the context of equity;
- Specific equity concerns in analyzing and adapting to sea level rise;
- Barriers to integrating equity into adap tation; and
- Major success stories that can be built upon for future sea-level rise planning efforts.

Survey analysis will provide valuable insight into current thinking on equity and resilience planning in the San Francisco Bay

Area. See section 2.5 for analysis of survey results. Third, this white paper will serve as a tool to highlight the current state of integrating equity into climate change adaptation planning, the multiple methods and approaches that can be used and key findings from the equity and community work done in the ART project that will be incorporated to the development of adaptation strategies.



An ART project wroking group member at the Subregional Kickoff Meeting

2. Social Vulnerability to Hazards

2.1 Learning from Historic Exposure to Hazards

Equity can play out on the ground before, during and after a disaster or hazard event, leading to disproportionate burdens in communities as well as longer rebuilding and recovery periods. Disasters can bring to light the ways environmental injustice impairs community health and resilience. Manuel Pastor et al. (2006) observed:

> *The social dynamics that underlie the disproportionate environmental hazards faced by low-income communities and minorities also play out in the arena of disaster prevention, mitigation, and recovery. In a sense, environmental justice is about slow motion disasters—and disasters reveal environmental injustice in a fast-forward mode. Both revolve around the axes of disparities of wealth and power.*

Environmental justice issues can play a role in heightening the risks of individuals and entire communities to hazards. Communities that have historically been impacted by environmental degradation often lack the resources that would give them access to resources and redundancies to reduce harm during times of crisis. This creates a situation in which, prior to a disaster, a community has high potential risks due to factors such as less insurance, lower income and savings, greater unemployment and diminished access to information. Once exposed to a hazard, the community's resilience is further sapped, causing an intensification of existing poverty and other risk factors. (Pastor, et al., 2006).

Hurricane Katrina illustrates the second part of Pastor's point–a disaster that revealed environmental injustice in days rather than years. Numerous factors, foremost among them emergency preparedness that failed to address equity and the needs of the city's varied populations, combined with the impacts of an extreme storm event, resulted in a social and economic disaster. At the height of the storm, water covered 80% of the city in some places at a depth of 15 feet, and it is estimated that there were 1,570 deaths and $40-$50 billion in monetary losses as a result (Kates, et al., 2006). Had the region defined the

likely vulnerabilities of its services, sectors and people; developed an emergency response plan to reduce vulnerabilities during the event; and adopted a recovery plan to implement after the event and included the community in creating the plan, the impacts of the event would likely have been significantly reduced.

Hurricane Katrina should not have come as a surprise to the emergency response planners and others in local, state and federal government. In the years leading up to Katrina, experts provided repeated warnings that a "big one" would some day hit New Orleans. At the time, half of the city's 437,186 residents lived below sea level as a result of growth that was facilitated by decades of construction in low-lying areas behind an expanding levee system. The New Orleans levee system was known to have vulnerabilities, although the extent was unclear. At the same time, wetlands that can act as buffers during storm events were being depleted. These trends toward suburbanization in low-lying areas and environmental degradation are not unique to New Orleans, and they created significant physical, economic and social vulnerability in the region prior to Hurricane Katrina (Gotham and Campanella, 2011). As the hurricane made landfall, the levees were inadequate to protect the communities behind them, as overtopping and levee failure caused waters to flow into low-lying areas. In addition to locating neighborhoods in low lying areas and environmental degradation, New Orleans lacked a strategy to ensure the safety of it's community members.

Communities have been working to rebuild since Harricane Katrina
Photo credit: David Currier

Although the event was extreme, it fell within existing projections. Planning for emergency and recovery response did not consider the unique challenges that vulnerable communities would have both during the disaster and in recovering from it. Addressing such considerations would have reduced the economic and social cost of the disaster. The Louisiana State Emergency Plan had failed to address the needs of the 130,000 residents in the region who lived without vehicles, or otherwise had limited mobility (homebound, in hospitals or in-care facilities) (Kates, et al., 2006). While some 1.2 million evacuees found shelter, others some stayed in place because they did not believe the storm was as bad as predicted, or because they lacked automobiles, access to transportation or funds to evacuate. Other residents who stayed behind did so to care for family members and/or pets, or institutionalized populations in hospitals and nursing homes (Colten, et al., 2008). The emergency response plans at all levels of government failed to address these likely outcomes and failed to identify strategies to address them.

Learning from past mistakes, the Louisiana Recovery Authority is moving ahead with coastal restoration and improved levee protections to minimize risks from future disasters. In addition, the city of New Orleans now has a City-Assisted Evacuation Plan, which makes provision for residents without cars or

without enough transportation to accommodate their entire family (including pets), homeless residents and residents with medical needs that prevent them from evacuating on their own (City of New Orleans, 2012). In addition, the Army Corps of Engineers has moved forward with studies to understand the causes of levee failures during the storm and improve standards for future levees. The Federal Emergency Management Agency has also come out with new standards for New Orleans residents seeking to rebuild in flood prone areas that require ground floors be built at the Base Flood Elevation, 3 feet above grade. Finally, the state has also sought to improve planning for its coastal zone with a blend of coastal restoration and improvement of levee protections. However, while these planning efforts focus on sustainable development, they also continue to promote economic development in low lying and vulnerable areas (Colten, et al., 2008).

In addition to Hurricane Katrina, examples from the San Francisco Bay Area also demonstrate the need to plan for sensitive populations. Sometimes, relatively minor aspects of emergency response can greatly influence a community's resilience. For example, in March, 2011 an earthquake hit Japan and triggered a tsunami that spread across the Pacific Ocean and caused millions of dollars of damage on the California coast (Lagos, et al., 2011). Coordinated response to warn residents occurred statewide. However, as the tsunami approached, it became clear that large-scale evacuation for residents of low-lying areas was not necessary. In San Mateo County, the Office of Emergency Services updated residents by sending out telephone messages. Yet while the original message to evacuate had gone out in multiple languages, there was no translation service available in the updated message. Thus, Spanish-speaking residents continued to evacuate their homes. In one shelter in Half Moon Bay, 90 percent of the nearly 300 evacuees were Spanish-speaking and there were no translation services available (Reis, 2011). Fortunately, this oversight in preparedness caused relatively little harm to the community, but it illustrates the importance of understanding local populations and needs. Social factors can influence the severity of a coastal hazard on a community in conjunction with other factors such as planning, development patterns, and community engagement. As Colten, et al. (2008) point out:

> *The impacts of hazard events are made more severe by preconditions of social vulnerability and other concurrent stresses or events. For example, the impacts of floods can be made worse by floodplain development, low-income populations in inferior housing in vulnerable locations, land subsidence, stream channel alteration associated with transportation or levee building, and precipitation and tropical cyclone intensity from climate change.*

Lessons learned from these examples inform climate adaptation planning in the San Francisco Bay Area. While some vulnerable populations were identified prior to Hurricane Katrina, planning failed to provide solutions for these residents, and thus many remained in harms way during the disaster. Social equity factors, such as disparities in income, linguistic isolation, educational attainment and access to resources can greatly influence the ways populations experience a hazard. Understanding equity and engaging communities that will be most affected before, during and after a hazard event are steps toward building an adequate response to climate change. By helping to facilitate responses that are rooted in the needs of local communities and local challenges, climate change adaptation planning can become more effective.

2.2 Social Vulnerability Analysis

Social vulnerability is a key determinant of overall vulnerability within a population. It is defined as "the interplay of social, economic and demographic characteristics that determine the resiliency of individuals and communities to climate change" (Cox, et. al, 2006). Social vulnerability analysis plays a critical role in identifying sensitive populations and community resilience for diverse populations, and should play a significant role in hazard and emergency preparedness and response, as well as in climate change adaptation planning. It also considers historic exposure of existing populations if relevant. A broad range of demographic, social and economic factors should be evaluated in a social vulnerability study. Factors that affect social vulnerability occur at a variety of scales, from the individual to the community. Figure 2, taken from the Australian report, "Quantifying Social Vulnerability: A methodology for identifying those at risk to natural hazards," depicts the various social and demographic factors and the kinds of questions to consider in a social vulnerability study.

Figure 2: Factors that Contribute to Social Vulnerability

Individual in a Household	Community	Access to Services	Organizational/ Institutional
Guiding Questions			
• How do personal attributes and living situations affect vulnerability? • How do finances contribute to recovery?	• How do social networks affect vulnerability? • How does an individual's relationship to communities contribute to recovery?	• How does access to community services and support affect vulnerability? • How does proximity to important infrastructure and services contribute to recovery?	• How do state and local risk management policies affect vulnerability? • How does federal funding contribute to recovery?
Possible Indicators			
• Age • Income • Residence Type • Tenure Type • Employment • Linguistic isolation • Household type • Physical mobility • Homeowners/ Renters insurance • Health insurance • Debt and savings • Car ownership	• Reciprocity • Sense of efficacy • Cooperation • Social and civic participation • Community and emotional support • Network size • Communication • Common action • Bonding • Bridging • Linking • Isolation	• Major cities • Inner regional • Outer regional • Remote • Very remote	• Local government collaboration • State assistance • Funding

Adapted from: Dwyer, et al., 2004

The topic of social vulnerability is of emerging interest in California and the San Francisco Bay Area. "The Climate Gap," highlights linkages between climate change, human rights, public health and social fairness. The report explored the ways that heat waves and increased air pollution will disproportionately impact low income families and people of color, the elderly and young children. Factors such as the costs of basic necessities, limited job opportunities and the inability to afford insurance could lead to disproportionate burdens from climate change impacts (Morello-Frosh, et al., 2009). As researchers in this report conclude:

> *What hasn't made headlines –yet – is the climate gap: the disproportionate and unequal impact the climate crisis has on people of color and the poor. Unless something is done, the consequences of America's climate crisis will harm all Americans – especially those who are least able to anticipate, cope with, resist and recover from the worst consequences (Morello-Frosh, et al., 2009).*

Conducting a social vulnerability analysis of a community or region to understand existing underlying inequalities and the social context of vulnerability is an integral part of the process of developing strategies for adapting to climate change.

In order to ensure that equity considerations are addressed in planning and emergency preparedness, social vulnerability studies should include the following:

- A socio-economic analysis of vulnerable communities;
- A description of historic exposure and response to past hazards,
- An understanding of community needs, resources and opportunities for cross-jurisdictional co operation.

Previous studies can provide a framework to use as a starting point. For example, the guiding questions mentioned in Figure 2 suggest questions to consider, and existing studies from the San Francisco Bay region provide guidance on populations that might be most vulnerable. It is important to note that socially vulnerable communities can also possess many strengths that can prove essential during difficult times. While these vary across neighborhoods, they can include a history of community organizing, strong intergenerational ties, and ethnic and linguistic diversity.

2.3 ART Integrated Vulnerability Assessment Framework

Using a comprehensive framework that considers economy, society/equity, environment and governance, the ART project is integrating social vulnerability in assessing critical infrastructure, services and institutions. As illustrated above, a social vulnerability study improves understanding of household and community vulnerability to sea-level rise and storm events by identifying sensitive populations who may be exposed to a coastal hazard. Considerations in a social vulnerability study include race, income, mobility, social networks, access to disaster response services and community support, and organizational/government response capacity. The study should also examine historic exposure to and impacts of hazards, and incorporate community input to ensure that all vulnerable populations have been considered and have 'ground-truthed' the assessment.

Figure 3: Framework for Integrated Vulnerability Assessment

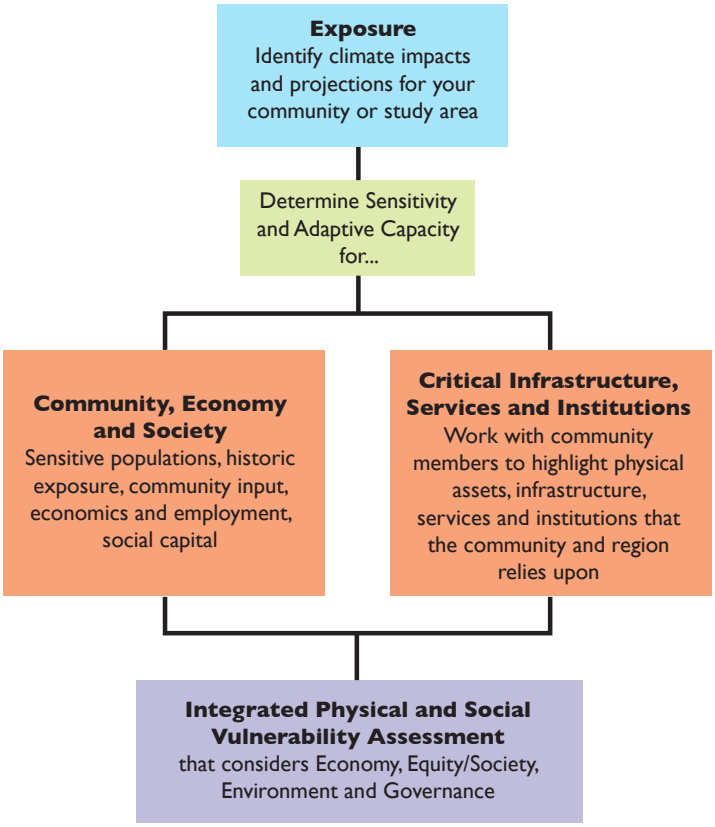


Figure 3 shows the assessment framework used in the ART project. Overarching this approach are the four "frames" that guide the ART project: equity/society, economy, environment and governance. The ART planning process involves multiple phases – project scoping and organization; assessing impacts, vulnerabilities and risks; developing a plan; and implementing and monitoring adaptation strategies. During the assessing impacts phase, a social vulnerability assessment is combined with an assessment of physical vulnerability, including critical infrastructure, services and institutions within the study area. After completing an exposure analysis to understand climate impact projections using best available science for the study area, project staff began to look at sensitivity and adaptive capacity. These were determined for two primary topic areas: (1) community, economy and society (i.e., social vulnerability assessment); and (2) critical infrastructure, services and institutions (i.e. physical vulnerability of critical assets). The final product of this approach will be an integrated assessment that can be used to build resilience and define an emergency and recovery response plan that will protect and preserve communities to the greatest degree possible.

Understanding influences on vulnerability includes engaging stakeholders and gathering local knowledge. For the ART project, a working group representing stakeholders in the study area and two subcommittees were formed to meet regularly, review documents, and assist the project management team with data needs and project design. From the beginning, the ART project team wanted to ensure that the project was a collaborative effort because the people in the best position to understand the resources in the project area, and develop strategies to protect these resources, are the people at the local and county level who interact with them on a daily basis—from wastewater systems, to parkland to seaport facilities. Since much of the responsibility and authority for undertaking adaptation lies at the local level, the project was designed to ensure that local perspectives were included in an ongoing way throughout the project. The working group and subcommittees have provided a valuable conduit through which the project team has received informed input to help shape the project. The working group members have defined many aspects of the project, including the asset categories to be evaluated, the climate impacts to consider, and the overall scope and extent of the project.

2.4 Social Vulnerability in the ART Subregion

As part of the ART project, the Pacific Institute conducted an analysis of social vulnerability. The analysis describes the demographics and social vulnerability of populations exposed to flooding under different inundation scenarios. Results presented here describe two scenarios: populations exposed to 16" and 55" of sea level rise in combination with an extreme storm event (see footnote), also known as the 100-year stillwater elevation[1,2]. The analysis presented here is for the ART study area, which encompasses the shoreline of Alameda County, from Emeryville to Union City, and extending inland approximately a half a mile beyond the area projected to be exposed to the 100-year stillwater elevation with an additional 55 inches of sea level rise.

Data sources used in this analysis include 2000 US Census data at the household and the census block level. The analysis of social vulnerability was obtained through a publically available source from NOAA Coastal Services Center. Through their online Digital Coast, social vulnerability data can be downloaded for all US coastal states (http://www.csc.noaa.gov/digitalcoast/data/sovi). These results reflect the most up-to-date understanding of demographic analysis, but social vulnerability cannot be predicted with complete certainty. While data from the 2000 US Census represents the most reliable dataset to work with, population demographics have likely changed significantly since then. In addition, certain populations with increased vulnerability are not always fully represented in Census datasets, such as homeless individuals and families. While this information is available at the county level, it is not broken down by geographic area within the county. Finally, the social vulnerability analysis presents population demographics at the census block level. This rougher scale of analysis obscures population variability within block groups.

In the ART project area, there are approximately 17,321 residents currently living in areas that would be exposed to inundation under a 16-inch rise in stillwater elevation, and 80,063 exposed under a 55-inch rise (Table 4) under the 100-year stillwater elevation. The percentage of the population at risk of flooding

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[1] The extreme storm event scenarios in the ART project show exposure to 16" and 55" above the current 100-year stillwater elevation, or the tide elevation associated with an event having a 1% chance of occurring in any given year (also known as the 100-year storm event).

[2] More information on the sea-level rise scenarios used in the ART project can be found here: http://risingtides.csc.noaa.gov/about.html.

within the study area (Table 4) under the 55" scenario is distributed as a percentage of population for each city as Alameda (60%), Union City (20%), Oakland (18%), San Leandro (22%), Emeryville (16%), San Lorenzo (25%) and Hayward (36%). The population at risk of inundation under the less severe scenarios is substantially smaller, with as few as 1,952 people at risk under a gradual sea level rise scenario of 16 inches.

Table 4: Population at risk of inundation for sea level rise under a 100-year Stillwater Elevation, by city

	100-Year Stillwater		City Population
	+16"	+55"	(for reference)
Alameda	8,619	30,009	72,259
Emeryville	56	725	6,882
Hayward	167	5,011	140,030
Oakland	233	6,107	399,484
San Leandro	3,220	10,070	79,452
San Lorenzo	177	2,888	21,898
Union City	4,849	25,253	66,869
Total	**17,321**	**80,063**	**786,874**

Source: Heberger and Moore, 2012

Table 5: Percentage of each city's population exposed to flood risk under a 100-year Stillwater Elevation, by city

	100-Year Stillwater	
	+16"	+55"
Alameda	11.9%	41.5%
Emeryville	0.8%	10.5%
Hayward	0.1%	3.6%
Oakland	0.1%	1.5%
San Leandro	4.1%	12.7%
San Lorenzo	0.8%	13.2%
Union City	7.3%	37.8%
Total	**2.2%**	**10.2%**

Source: Heberger and Moore, 2012

In New Orleans during Hurricane Katrina, individuals without a car, people of color, and low income households were among those less likely to evacuate before the storm (Colten et al., 2008). Within the ART study area, a number of social groups were analyzed for their exposure to sea level rise. These include renter-occupied households, linguistically isolated households, households with no vehicle, low income population and people of color (See Table 6 below).

Table 6: Socially vulnerable households exposed sea level rise under a 100-year Stillwater Elevation, by city

	Renter occupied households		Linguistically isolated households		Households with no vehicle		Low income population		People of color	
	+16"	+55"	+16"	+55"	+16"	+55"	+16"	+55"	+16"	+55"
Alameda	1,319	5,139	248	891	280	1,012	1,218	5,172	3,055	11,926
Emeryville	23	285	3	33	3	33	13	168	26	334
Hayward	10	213	4	137	4	86	20	980	70	2,561
Oakland	73	1,128	27	262	20	427	97	3,267	169	4,833
San Leandro	290	732	126	339	68	179	483	1,352	1,471	4,733
San Lorenzo	9	121	2	26	1	28	15	339	44	770
Union City	357	1,497	233	861	72	252	851	4,243	3,586	18,465
Total	**2,081**	**9,115**	**643**	**2,549**	**448**	**2,017**	**2,697**	**15,521**	**8,421**	**43,622**

Source: Heberger and Moore, 2012

Approximately 9,100 (33%) of households at risk of inundation are occupied by renters, a population less likely to have the means to reinforce buildings and to prepare for flood events. Linguistically isolated populations are described by the US Census as households without a member over age 14 who 'speaks English well.' Depending on the social networks available to these households, linguistic isolation could prevent household members from accessing critical information about preparedness, response, and recovery. As the evacuation of New Orleans during Hurricane Katrina demonstrated, car ownership is another important marker of social vulnerability to storms and other coastal hazards. During a sudden flood event, households without a vehicle may be a greater risk of harm because they lack the capacity to evacuate. Income level is another demographic factor addressed in the ART vulnerability assessment. For the purposes of the study completed by the Pacific Institute, low income was defined as households earning less than 200% of the national poverty level. Low-income residents may have reduced means to prepare for, respond to, and recover from flood events. Using this standard measure of poverty, 15,521 people (based on year 2000 Census data) within the study area would be at risk of exposure under the 100-year stillwater scenario. Communities of color (defined as non-white non-Hispanic population), another demographic group addressed in the Pacific Institute study, have high rates of exposure to sea level rise as well. Lastly, according to the 2000 Census data, 294 people live in correctional or nursing institutions within the 100-year stillwater elevation scenario with 55" of sea level rise. The majority of this population is located in the City of Alameda.

In addition to analysis of specific populations' exposure to sea level rise, the Pacific Institute utilized a social vulnerability (SOVI) index to estimate overall relative social vulnerability for different populations within the study area. SOVI is a methodology used to account for the socio-economic conditions that influence population vulnerability to a range of hazards, including hurricanes and flood events. Some of the populations included in the SOVI scoring methodology are race, age, gender, renters, income and employment. NOAA provides a digital atlas where users can download SoVi scores by state for all coastal

US states. For this analysis, data for SoVi scoring in the study area were downloaded directly from the atlas. The SoVi methodology involves a principal component analysis of the factors depicted in Table 7. This analysis was conducted for the entire state of California. Thus, SoVi findings provide a picture of social vulnerability for the subregion relative to demographic trends across the state.

Table 7: Variables in Social Vulnerability Index Methodology

Variable
Percent African American
Percent Native American
Percent Asian and Hawaiian Islander
Percent Hispanic
Percent of population under 5 years of age
Percent of population age 65 and over
Median age
Percent female population
Average number of people per household
Percent renter occupied units
Percent female headed households, no spouse present
Nursing home residents per capita
Percent civilian unemployment
Per capita Income (2000 dollars)
Percentage of households earning 100,000 or more
Percent living below the poverty level
Mean House Value
Mean contract rent for renter occupied housing units
Number persons per 100,000 population employed as healthcare practitioners and technical occupations
Percent rural farm population
Percent of housing units that are mobile homes
Percent of population 25 years or older with no high school diploma
Percent of population participating in the labor force
Percent females participating in the labor force
Percent employment in farming, fishing, and forestry occupations
Percent employed in transportation, communications, and other public utilities
Percent Employed in service industry
Percent of population collecting social security benefits
Percent Foreign Born Citizens Immigrating between 1990 and 2000
Percent urban population
Housing Density

Source: Heberger and Moore, 2012

The SOVI methodology combines these factors into a composite score using principal component analysis to provide a picture of overall social vulnerability within a specific area. The Social Vulnerability Index for the ART study area group populations as high, medium and low based on the scoring index (See Table 8).

Table 8: Social Vulnerability Ranking of Populations within the study area for 100-year Stillwater Elevation, by city

	100-Year Stillwater	
	+16"	+55"
Alameda (total)	**8,619**	**30,009**
High	1,730	8,146
Medium	4,241	13,429
Low	2,648	8,404
Emeryville (total)	**56**	**725**
High	0	0
Medium	0	0
Low	56	725
Hayward (total)	**167**	**5,011**
High	69	3,668
Medium	0	1,203
Low	98	141
Oakland (total)	**233**	**6,107**
High	49	4,070
Medium	176	1,777
Low	8	261
San Leandro (total)	**3,220**	**10,070**
High	1,077	2,761
Medium	1,879	5,965
Low	265	1,344
San Lorenzo (total)	**177**	**2,888**
High	0	0
Medium	177	2,888
Low	0	0
Union City (total)	**4,849**	**25,253**
High	2,700	8,879
Medium	1,632	14,469
Low	516	1,905
Entire Study Area (total)	**17,320**	**80,065**
High	5,625	27,554
Medium	8,104	39,730
Low	3,591	12,780

Source: Heberger and Moore, 2012

Thirty four percent of the 82,048 people at risk of inundation under the 100-year extreme storm event fall within the category of high social vulnerability. An additional 39,730 or 50% are considered in the middle range of social vulnerability. Sorting the population vulnerability into the seven cities in the study area allows us to identify where the more vulnerable populations are located. As Table 8 depicts, Union City, Alameda, and Oakland have the largest populations that fall within the "high" score for social vulnerability.

2.5 Adapting to Rising Tides – Equity and Sea-Level Rise Survey

2.5.1 Survey Purpose and Methods

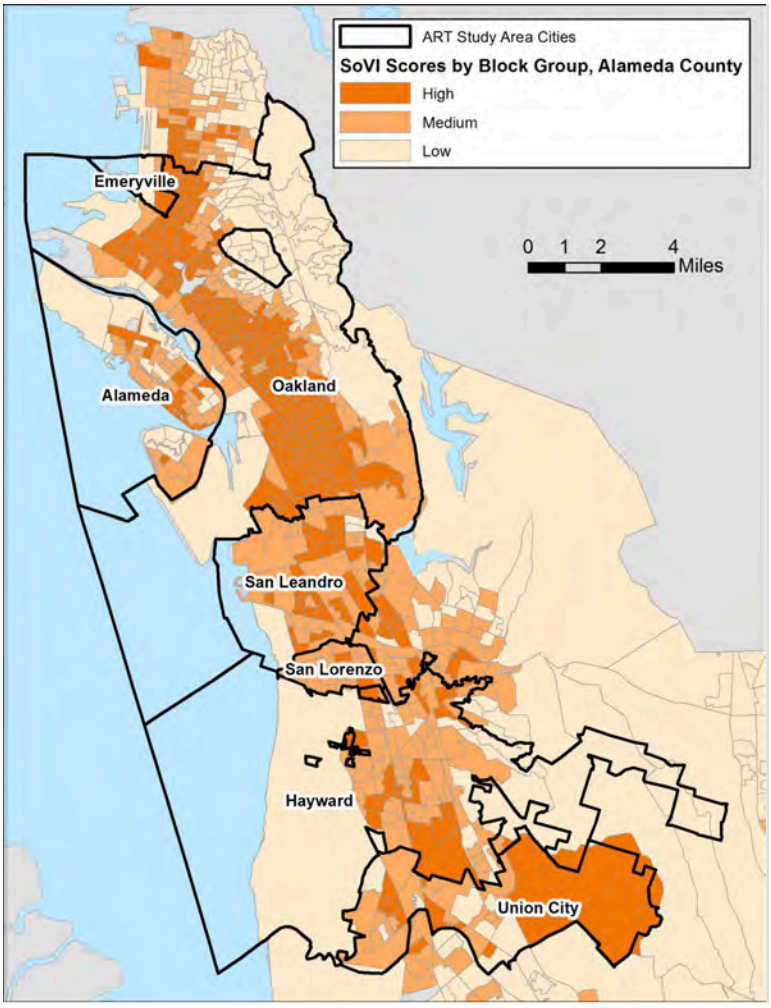
The attitudes, perceptions and beliefs of stakeholders play an important role in influencing decision-making. Surveys have proven an effective tool for gathering information about these trends and for understanding the diverse perspectives of stakeholders (NOAA, 2007). ART project staff developed and administered a survey to the ART working group, advocacy groups, local governments, community leaders and non-profit organizations. For the ART working group, a vulnerability and risk assessment survey went to asset managers in the ART study area. The survey asked mangers to assess the sensitivity, adaptive capacity and consequences associated with sea-level rise and storm events on specific assets. The final section included questions on equity and sea level rise. A separate survey that included the same equity questions was sent out to survey participants who were not assessing asset-specific vulnerability. This survey went out to a diverse range of participants across the Bay Area. This included the Oakland Climate Action Coalition, the Equity Working Group of Plan Bay Area, equity email lists, and to a broad network of non-profit and public agencies working with diverse communities across the region addressing a broad range of issues, including social and environmental justice, public health, emergency services, climate change adaptation, community engagement and community planning.

The equity and sea-level rise survey asked survey participants:

- Ways that a diverse range of practitioners define resilience in the context of equity;
- Specific equity concerns in analyzing and adapting to sea-level rise;
- Barriers to integrating equity into adaptation; and
- Major success stories that can be built upon for future sea level rise planning efforts.

Both surveys were disseminated from January to March 2012. An online survey instrument called Survey Monkey was used to distribute the survey to participants. In total, 73 participants took the survey. Of those, 53 participated in the larger vulnerability and risk survey, and 20 took the survey as a stand alone survey that just included the questions on equity.

Figire 9: Social Vulnerability Score by Block Group



2.5.2 Results

Vulnerable Populations

Recent work on planning for sea level rise and extreme storm events has begun to highlight specific populations who might be particularly sensitive to impacts. The survey asked participants to identify populations they felt would be most affected and/or disproportionately burdened by sea level rise and flooding. Respondents were also given the opportunity to write in populations that were not listed in the survey. In addition, survey participants could check as many of the populations listed as they thought relevant, so response count does not add up to total below. Response percent is percentage of total respondents who answered the question who chose that answer. This is true for all tables listed below that include response percent.

Table 10: Potentially Vulnerable Populations

Populations	Response Count	Response Percent
Low income people	51	75%
Persons with limited mobility or with a disability	41	60%
Seniors over 75	33	49%
People of color	32	47%
Households with no vehicle	28	41%
Households with limited English proficiency	26	38%
Renters	21	31%
Institutionalized populations (People in hospitals, nursing homes and prisons)	12	18%
Total who answered question	68	

Three populations stood out as the greatest concern to survey participants: persons with limited mobility or with a disability, low income populations and seniors over 75. Some participants highlighted the need for more information to identify sensitive populations. Others emphasized that all people exposed to a climate impact will be greatly affected.

Priority considerations for integrating equity into sea-level rise planning

Survey participants provided a wealth of information and ideas to consider for addressing equity in the context of sea level rise. Issues related to this topic were broad and covered diverse areas. The table below describes the primary areas of concern for survey participants.

Of these areas of concern, flooding of critical infrastructure and/or neighborhoods in low income communities, economic effects and public health were the rated highest. However, most areas were rated relatively high. The issues that were raised most consistently can be broken into two broad categories: engaging vulnerable populations and funding for climate change adaptation. The following sections will elaborate on survey responses in these two areas.

Engage Vulnerable Populations

The need to create accessible and engaging educational opportunities for diverse audiences, particularly for highly affected communities, was raised consistently in survey responses. Participants noted the importance of making information relevant and accessible to local communities. Clear, accessible communication was emphasized. This includes developing easy to understa nd materials with translations for non-English speaking populations. Education and outreach materials would need to draw clear connections to relevant resources to carry out suggested actions for residents, and by doing so would empower action on the local level. One participant noted: "Leadership at the community level is necessary to motivate and inspire local action that can be embraced by the community as a whole."

Figure 11: Primary Areas of Concern for Equity and Sea Level Rise

	Response Count	Response Percent
Flooding of critical infrastructure and/or neighborhoods in low income communities (e.g. Overwhelmed flood protection channels and storm drains increase flooding in low lying areas, inundation of existing private and public infrastructure and critical facilities; structures, including shoreline protection, that are not adequately protected, elevated or flood-proofed are destroyed or damaged)	40	59%
Economic effects (e.g., Increased cost of repair and maintenance after flood events slows recovery in communities of concern, ost wages and higher productivity in the region during recovery periods; higher insurance rates due to greater flood risks)	39	57%
Public health (e.g., Health impacts of contamination from sewage distribution and treatment systems; groundwater intrusion into contaminated sites and remobilized contaminants)	34	50%
Public access, ecosystems and recreation (e.g., Loss of trails, beaches, vistas, other shoreline recreation areas and public access to shoreline over time; loss of tidal habitat which can reduce flood protection benefits of tidal marsh and mudflats to inland communities)	31	46%
Emergency preparedness and/or disaster response (e.g., Greater consequences from earthquakes due to elevated groundwater levels; poor quality and quantity of emergency response services in communities of concern)	28	41%
Transportation justice (e.g., Disruption to key transportation services for disadvantaged communities)	27	40%
Disaster recovery (e.g., Increased cost of repair and maintenance after flood slows recovery in communities of concern; disadvantaged communities bear disproportionately high burden of effects; longer duration or disruption of access to goods, particularly in low income communities)	26	38%
Institutional/Governance (e.g., Greater demands on agencies to plan for and manage infrastructure/resources; building codes and land use policies and practices inadequate to address sea level rise impacts)	26	38%
Effects on community services (e.g., Longer duration or disruption of access to services particularly in low in communities)	25	37%
Total who answered	68	

Multiple survey participants also noted that accessible communication should include explaining decision-making processes and specific ways community members can participate. Meeting accessibility was also raised consistently, both in providing childcare and transit accessible locations, and also in scheduling community meetings during times and locations when working people can attend. Survey participants also suggested that outreach and education extend to school-aged children and educators. Bringing communities to the shoreline for recreation and education was emphasized. One participant said: "It is critical to bring communities to the shoreline and other impacted areas to make the issue of sea level rise tangible and pertinent."

Specific suggestions included field trips, science projects, geo-caching, community mapping, training students in emergency response, summer camps, block parties and neighborhood barbeques. Educational opportunities could involve local partners and community groups as well as government agencies working collaboratively.

Responses also emphasized the need to partner with local community groups and leaders on climate change and sea level rise issues. Working at the neighborhood level has a number of benefits in improving collaborative relationships between community groups and government entities. Survey participants strongly emphasized the importance of planners reaching out to vulnerable groups through community organizations. In addition, participants noted the need for better communication between government agencies and community organizations on equity issues. A wide range of community groups were mentioned as potential resources, such as: faith-based organizations, senior centers, hospices, youth organizations, libraries, recreation centers, homeowners association, school PTAs, police and fire stations, local business districts, parks, sports groups and local interpretive centers. Using community resources such as these allows managers, decision-makers and local leaders to dialogue, collaborate with and collect feedback from local residents, provide forums to educate the public, and to conduct outreach in places where local people already spend time.

Survey participants also emphasized the need to learn from past mistakes. In examples like Hurricane Katrina, equity issues were not sufficiently considered in disaster response planning, which increased the number of people in harm's way and slowed recovery for many communities. One participant explained how the need for learning from past environmental disasters fits into a larger framework for engaging and educating local communities.

> *There is a need for positive, solution oriented education and outreach, and a strong commitment to remaining engaged for the long term, as well as stepped up public education about infrastructure vulnerabilities, and about neighborhoods that are particularly vulnerable. There also needs to be better public education about lessons learned from Katrina and other major environmental disasters.*

Another component to engaging and educating the public was emphasizing the full participation of community members in planning for sea level rise and extreme storm events. As one survey participant noted, "One of the biggest challenges to addressing equity issues in this context is to ensure that local communities are engaged and responsible for the decisions that are made in response to sea level rise and storm events." Early engagement in decision-making processes was noted as a being a significant factor for meaningful community participation. Survey participants noted the importance of existing local

planning efforts considering equity, including transportation, disaster preparedness, and land use planning efforts. Sensitive populations, such as those identified in this survey, should be given special consideration in these efforts. Interagency coordination on equity issues was also mentioned, including the need to develop coordinated responses, and to establish better collaboration among agencies. Finally, a small number of survey responses noted that a policy response was needed for prioritizing equity in agency mandates and planning efforts.

Funding Climate Change Adaptation Planning

Funding research and planning on climate change adaptation for sea level rise is a high priority for people in the San Francisco Bay Area. Survey participants raised concerns about the need to fund: planning for vulnerable populations, supporting community engagement and protecting critical assets that provide important services and access for diverse populations in the region. One survey participant said:

> *Agencies need to invest in continual community participation throughout the process, from research to planning to implementation. This means leveraging funding sources that local governments are eligible for to bring additional funding to community stakeholders to participate in the process.*

In a time of limited funding and slow economic recovery, finding ways to fund adaptive measures for critical facilities, infrastructure and communities that will be affected by sea level rise and storm events is a difficult challenge. An important strategy for making funds stretch farther is to work collaboratively and to leverage existing community resources to reach wider and more diverse audiences. Vulnerable populations, such as the ones identified in this survey may require extra assistance in evacuating during an emergency, or additional resources to deal with rising waters in their neighborhoods and homes.

Funding community engagement was also identified as an important priority. Community engagement can mean partnering or leveraging resources to work with community organizations, neighborhood groups, non-profit organizations or other entities. Many community groups can play key roles in engaging residents, educating vulnerable populations, supporting community planning efforts and providing valuable leadership and insight to community decision-making processes. This can include developing information on sea-level rise and disaster preparedness for local residents, advocating for socially vulnerable populations in planning and, if relevant, sharing past experiences from disaster response that can inform planning efforts. Funding opportunities suggested by survey participants include participation grants to organizations who want to get involved in a decision-making or planning process, regional funding for park protection, funding to reduce damage to private property, identifying funding sources for protection and relocation, and funding for infrastructure improvements in vulnerable communities.

2.5.3 Resilience and Equity

Survey participants were asked how they would envision a resilient, socially just response to the community impacts of sea level rise and storm events. Responses included a broad range of constructive ideas to consider. They emphasized the importance of prior planning for vulnerable populations and protection of critical infrastructure, the need to engage the public and improve our understanding of the existing condition of critical flood protection structures, the need to integrate planning for sea level rise and

storm events with other climate change impacts, and an ecologically-based response that links environment, social equity and public health. In addition, the importance of community-based emergency preparedness was frequently mentioned so that all neighborhood residents would know what to expect and how to respond in an emergency.

Protecting vulnerable populations from sea level rise was highlighted as being another priority for community resilience. Investing in a community planning effort to develop a Climate Adaptation Plan was emphasized. Such a plan would include multi-stakeholder engagement, an inventory of community assets and needs, community-based implementation of actions, and adaptive management practices. One participant noted:

> *A resilient, socially-just response to the community impacts of sea level rise would include an open flow of information, communication and dialogue starting very early in the process of adaptation planning.*

Specific guidance given by survey respondents included: preventing development in low-lying areas, developing a Climate Gap Neighborhood Action Plan for vulnerable communities, improving the levee protection system, involving fire and police officers in community planning, low-impact development (LID) and green infrastructure to improve flood capacity and reduce storm water runoff, and wetland restoration to protect communities. Survey respondents also suggested training community members in disaster preparedness.

2.5.4 Discussion

The results of this survey provide a rich resource on major issues related to equity and sea level rise in the San Francisco Bay Area. Survey participants represented a broad range of people and perspectives, from city planners and social justice advocates to educators and emergency managers. Participants raised important issues about the need to create opportunities for meaningful engagement in vulnerable communities, and guidance on how to do so.

Survey respondents represented two groups, with some overlap between them. The first group included members of the ART working group, which includes local, state and federal governments and agencies. The second group included local experts, organizations and agencies working specifically on social and environmental justice, advocacy, climate change and sustainability. While these groups may be perceived as holding different perspectives on the issue of sea level rise, climate change adaptation and equity, their perspectives had a great deal in common, in particular the need to engage local community members, identify and fund community-based adaptation, and build resilience by protecting vulnerable communities.

The education, outreach and engagement of stakeholders were consistent themes in survey responses. This came through from feedback on making planning and decision-making accessible to diverse audiences, clearly communicating the implications of climate change impacts on communities, bringing community organizations and leaders to the table and investing in education of all ages. In addition, the important role of funding for climate change adaptation was raised consistently. Survey respondents provided a number of suggestions for potential sources of funding, and ways to allocate funding that can improve equity outcomes for communities.

3. Tools for Understanding Equity in Planning for Climate Change

The following section summarizes three examples of planning processes or projects that integrate equity into decision-making. In the first example, San Luis Obispo and Fresno counties commissioned studies of social vulnerability to help them in identifying climate change adaptation options. In the second example, the Plan Bay Area long-range regional planning effort led jointly by the Metropolitan Transportation Commission and the Association of Bay Area Governments used an analytical approach to quantify equity to inform integrated land use and transportation planning in the San Francisco Bay Area. The third example highlights projects that engaged local communities, and specifically recognized the needs of vulnerable populations.

3.1 Integrating Social Vulnerability into Adaptation Planning--Fresno and San Luis Obispo Counties

As described in the previous section, social vulnerability studies can be used to inform a larger planning process by identifying sensitive populations and communities. Two examples of how this approach was used within adaptation planning are Fresno and San Luis Obispo counties. The studies were conducted to provide a picture of social systems susceptible to climate impacts and were part of a larger project led by the Local Government Commission and the GEOS Institute. Major findings were utilized in workshops that engaged local governments (including elected leaders, public health officials, citizens, planners and land managers) in developing adaptation strategies. Separate workshops addressed natural systems and socioeconomic systems in 2009-2010. The studies examined communities and populations, economic activities and services and infrastructure. Researchers analyzed these factors for their exposure, sensitivity and adaptive capacity to climate-related impacts. Climate risks that were found to affect different populations in San Luis Obispo County are shown below.

Table 12: Climate Risks to Populations Across Different Components of Vulnerability in San Luis Obispo County

Populations	Response Count	Response Percent
Exposure	Floods	Floodplain residents
	Heat	Outdoor workers
	Drought	Farmers, water users
	Wildfire	Homes at wildland-urban interface
Sensitivity	Heat	Infants, elderly
	Air pollution	Asthma sufferers, children
	Drought	Farmers
Adaptive Capacity	Floods	Institutionalized populations, low-income residents
	Heat	Low-income residents
	Sea-level rise	Coastal residents, structures and facilities

From: (Moser and Ekstrom, 2010)

Researchers considered exposure of floodplain residents to flooding from gradual sea-level rise as well as from extreme storms. A number of populations were identified as particularly at risk within the floodplain. For example, students and institutionalized populations would be particularly disadvantaged in a disaster. For students, this is due to lack of a vehicle and (in some cases) long distances from family members, particularly for foreign students. For institutionalized populations (including prisons and hospitals), many are reliant on others for evacuation or support during a disaster (Moser and Ekstrom, 2010).

The study found that populations and individuals with reduced adaptive capacity include those with lower educational attainment, linguistic and cultural isolation, limited mobility and renters. High rates of poverty experienced by these populations combined with other demographic factors mentioned above reduced their capacity to cope with and adapt to climate impacts. In contrast, community organizations, social relations, religious communities and other forms of strong community relationships enhanced disaster preparedness and ultimately, community resilience. Many community groups provide spiritual, emotional and physical support to members in times of need. These groups can improve social networks, reduce isolation and build preparedness for communities exposed to hazards (Moser and Ekstrom, 2010).

In San Luis Obispo and Fresno counties, addressing social vulnerability in the assessment phase of the planning process allowed planners and community members to clearly identify the specific climate change adaptation needs of different populations within both counties. The projects also developed opportunities for more collaboration and coordination across jurisdictions by involving a diverse constituency in the planning processes, and through selection of adaptation strategies that promote these connections.

The studies of existing and future stressors on social systems in San Luis Obispo and Fresno counties enabled workshop participants to identify their highest priorities for adaptation and communities of special concern within the two counties. The workshops also had the positive effective of opening up the conversation about climate change for communities that had not previously engaged on this subject (Moser and Ekstrom, 2011). In San Luis Obispo County, findings from the social vulnerability study informed recommended strategies. Adaptation considerations were categorized based on their relevance to socioeconomic systems, species and ecosystems. Socio-economic interventions included targeted education and outreach on emergency preparedness in especially vulnerable communities, and consideration of cultural and linguistic needs during planning activities. Local governments will consider the results of this project during general plan updates, greenhouse gas emission inventories and creation of climate action plans. In particular, the county is moving ahead with a climate action plan that will consider most, if not all, of the strategies laid out in the project report (Koopman, et al., 2010).

3.2 Measuring Equity: Plan Bay Area's Equity Analysis Framework

Plan Bay Area is developing a state-mandated regional sustainable communities strategy (SCS) for the San Francisco Bay Area. Led by Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG) and in partnership with the San Francisco Bay Conservation and Development Commission (BCDC) and the Bay Area Air Quality Management District (BAAQMD), the goal of the effort is to create a SCS on requirements laid out in 2008 Senate Bill 375[3] for development of an integrated land use and transportation plan for the region with the goal of reducing per-capita greenhouse gas emissions.

Regional agencies are evaluating ten performance targets for Plan Bay Area. These include specific targets for climate protection (reducing per-capita emissions), adequate housing, healthy and safe communities, open space and agricultural preservation, equitable access[4], economic vitality and transportation system effectiveness. These performance measures were evaluated across five alternative land use scenarios, that reflect varying levels of concentrated housing and job growth around transit centers in the inner urban core of the Bay Area. In December 2011 project staff presented a preliminary analysis of how the five alternative scenarios achieve the performance measures. The public process for review of this analysis is ongoing, and regional agencies adopted a preferred scenario in May 2012.

Equity is a central component of the overall planning process because Plan Bay Area leaders recognize that it promotes improved access and quality of life for residents of the San Francisco Bay Area (Kirkey, 2011). As part of this effort, the Equity Working Group was created to advise on major equity issues for the region such as housing, affordable transportation and access to livable wages. Members of the working group include leaders from non-profit organizations, advocacy groups and government agencies. Some agencies and organizations represented include local governments, the National Coalition for Asian Pacific American Community Development, Urban Habitat, regional agencies and the Bay Area Health In-

[3] SB 375, or the Sustainable Communities and Climate Protection Act of 2008, enhances California's ability to implement AB 32. It requires that that State's 18 metropolitan planning organizations develop "Sustainable Communities Strategies" to establish greenhouse gas emission targets for 2020 and 2035 through integrated land use and transportation planning.

[4] The performance target for equitable access is to decrease the share of low-income and lower-middle income residents' household income consumed by transportation and housing by 10%.

equities Initiative. In addition to its advisory role, the Equity Working Group is developing an equity analysis framework to support the assessment of different land use scenarios in addition to the ten adopted performance targets described above.

The working group's analysis focused on identifying communities of concern and applying equity-related performance measures for evaluating different scenarios, and then comparing results or likely outcomes for communities of concern across the region (MTC, 2011). The Equity Working Group utilized a demographic and spatially based approach[5] to define communities of concern within the San Francisco Bay Area as they pertain to the planning and investment decisions under consideration in the Plan Bay Area process. Across census tracts, communities of concern are those that have (1) four or more of the factors listed in Table 13, or (2) communities that have concentrations of both low-income and minority populations at or above the thresholds described in Table 13 (One Bay Area, 2011). A concentration threshold (i.e., the percentage of population in a census tract with a specific demographic factor) describes the level at or above which that demographic factor is considered a characteristic of a potential community of concern.

Table 13: Factors for communities of concern

Factor	% of Regional Population (in nine counties)	% of Concentration Threshold
Minority	54%	70%
Low Income (<200% of Poverty)	23%	30%
Limited English Proficiency	9%	20%
Zero-Vehicle Households	9%	10%
Seniors 75 and over	6%	10%
Population with a Disability	18%	25%
Single-Parent Households	14%	20%
Cost-Burdened Renters	10%	15%

Source: MTC (2012)

Using an analytical approach, 305 out of 1,405 census tracts in the San Francisco Bay Area have been identified as communities of concern. Current analysis of the five Plan Bay Area scenarios for equity-related performance measures show mixed results. Table 14 depicts how the five scenarios perform under five equity measures chosen by the Equity Working Group. These metrics incorporate housing cost and income forecasts, transportation cost, displacement risk, non-commute and commute travel time.

The first measure, housing + transportation, is the share of average household income spent on the combined the cost of housing and transportation. These numbers represent a percent change of 0.7%

[5] Census tract data based on the American Community Survey 2005-2009

to 13.1% from the base year of 2005 (One Bay Area, 2011). The measure for displacement risk links new development in each scenario to the probability that current residents will be affected by changes in the housing market. Cost-burdened renters paying more than 50% of household income on rent were identified as at-risk for displacement is new housing in desirable areas drives up cost. In the scenarios analyzed, displacement risk is significantly higher for communities of concern than for the remainder of the region. Vehicle miles travelled (VMT) density is a measure of VMT per day per square kilometer of developed area (One Bay Area, 2011). It is used to forecast increased exposure to a variety of risks such as noise, collisions and emissions due to heavy traffic on major roadways in close proximity to communities of concern. Commute and non-commute travel time do not show significant variation between communities of concern and the remainder of the region. This is, in part, due to the fact that travel times reflect a variety of choices travelers make abut where, when and how to travel. Travel times are influenced by congestion, but also by individual choices to take less expensive modes that take longer (such as walking, biking or taking transit) or costlier modes (such as driving).

Table 14: Equity Analysis of Plan Bay Area Scenarios

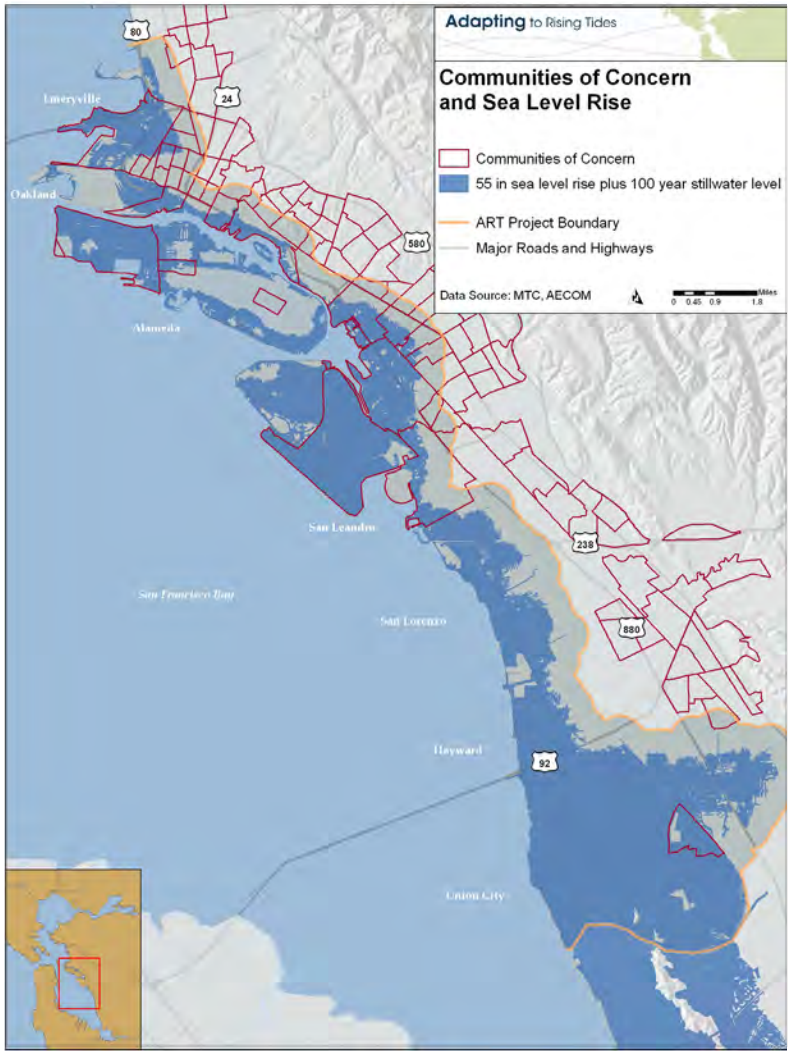
	1. Housing + Transportation		2. Displacement Risk		3. VMT Density		4. Non-Commute Travel Time		5. Commute Time	
	House-holds < $38k/yr (2010)	House-holds > $38k/yr (2010)	COC*	Remainder of Region	COC	Remainder of Region	COC	Remainder of Region	COC	Remainder of Region
Base Yr.	77%	41%	n/a	n/a	n/a	n/a	12.2	12.5	25.4	27.1
Scenario										
1	77%	43%	38%	10%	2,900	1,000	12.8	13.1	28.5	28.7
2	84%	44%	40%	10%	3,100	1,000	12.9	13.1	27.6	28.7
3	85%	44%	35%	7%	2,900	1,000	12.7	12.9	27.3	27.7
4	85%	44%	35%	7%	3,000	1,000	12.7	12.9	27.4	27.8
5	85%	44%	30%	7%	2,800	1,100	12.5	12.8	27.3	27.8

Source: MTC (2012)

During this iteration of Plan Bay Area, the ways that sea-level rise and climate change may cause disproportionate burdens for communities of concern were not addressed explicitly. However, it is reasonable to assume that certain climate change-related issues will negatively affect many of the performance metrics. For example, Figure 15 below depicts communities of concern within the area affected by the projected ART 100-year stillwater elevation sea level rise scenario.

The Equity Working Group took an analytical approach to characterizing communities of concern and developing performance metrics for development of a sustainable land use and transportation plan for the region. These quantitative targets can help to shape policies and planning priorities for the region

Figire 15: Communities of Concern within the ART 55" plus 100-year Flood Inundation Area



Source: MTC, AECOM

that improve equity conditions. The use of quantitative metrics also introduces a challenge because these metrics can prove inflexible and incapable of fully capturing the complex factors that affect struggling communities. Other factors that might be important determinants of Communities of Concern could include educational access and attainment, community and family support and relationships, and histories of community engagement and organizing. Addressing such issues with this assessment methodology could add greater richness and complexity to equity analysis in future planning and community engagement efforts. The Plan Bay Area process illustrates that raising equity issues proactively within an integrated region-wide planning effort encourages greater collaboration across agencies, non-profit organizations and community groups.

3.3 Integrating Equity into Sea-Level Rise and Flood Protection Projects

Just as large-scale planning processes and research can integrate equity considerations, so can individual projects. Projects that engage and educate local communities, improve flood protection, and restore habitats can have particular benefits for disadvantaged communities. Several such projects exist in the San Francisco Bay area. The Integrated Regional Water Management Program (IRWMP) supports water supply and water quality projects that specifically benefit sensitive populations. The projects are intended to alleviate flooding and improve stormwater systems. Among project priorities are inclusion of local employment and training opportunities, focusing efforts in disadvantaged schools and areas of high risk of exposure to toxins, and providing flood hazard mapping to these communities. A number of projects have been proposed, including floodplain mapping, stream restoration and technical assistance to various disadvantaged communities across the San Francisco Bay Area.

One project-level approach to addressing equity is to engage and educate local communities and students, and to encourage participation in ecological restoration practices that improve flood protection. The STRAW Project or Students and Teachers Restoring a Watershed, is led by PRBO Conservation Science and supports watershed and restoration planning and implementation in Marin, Sonoma, Alameda, Napa and Solano Counties. The project provides scientific and technical resources to teachers and students, and provides opportunities for students in grades K-12 from local communities to participate in wetland restoration projects. The STRAW project is shifting toward greater integration of climate change research into design of future projects, and began implementing climate-adapted restoration techniques in 2011.

Community members can also participate in data collection and scientific studies to improve our understanding of how to alleviate flooding issues today and in the future. Restoration Design Group and a local non-profit, Urban Tilth, will implement one such project in Richmond, CA along Wildcat Creek and San Pablo Creek. The primary project purpose is to develop priorities for restoration and flood risk abatement in disadvantaged communities in North Richmond, which was identified as a high overall priority in the Wildcat Creek Restoration Plan. Local students from Contra Costa Community College will be hired to collect data, and school teachers and administrators will integrate the project into course credit and curriculum. The final stream design guidance will inform a larger creek restoration design project for a commercial business district in an economically depressed with high unemployment (IRWMP 2011). A similar project has been proposed for the mapping of floodplains with a focus on disadvantaged communities across the San Francisco Bay Area. This project is led by the San Francisco Estuary Institute in collaboration with a number of local partners. This analysis will focus on identifying flood prone areas in low-lying disadvantaged communities. Outputs will be used in State and federal flood inventories, local planning and research efforts and green infrastructure objectives (IRWMP, 2011).

There are other examples of project-level integration of sea level rise and equity. These projects often illustrate themes such as engaging communities, improving mapping and technical capacity, collaborating with local partners, improving flood protection and/or flood flow capacity and community participation in ecological restoration.

3.4 Decision-Support Tools

Tools that help us analyze and understand the spatial patterns related to community and social change can also support assessments of social vulnerability in a planning context. These decision support tools provide frameworks for data management and analysis, and ready-to-use, locally relevant information. Table 16 below lists some of the tools available that integrate socio-economics and equity into climate change vulnerability analysis and adaptation options.

Table 16: Decision Support Tools to Support Equity Analysis and Socio-economic Considerations

Tool Name	Description	Website
Social Vulnerability Index	Analytical index of demographic factors at the census tract level to understand social vulnerabilities.	http://webra.cas.sc.edu/hvri/products/sovi.aspx
HAZUS	Allows users to examine potential economic losses, physical damage and social impacts from floods and other hazards.	http://www.fema.gov/plan/prevent/hazus/
CRISTAL	Decision support vulnerability assessment tool that runs in excel, focusing on community livelihood.	http://www.iisd.org/cristaltool/
Spatial Trends in Coastal Socioeconomics	Provides reports of census data for planners.	http://coastalsocioeconomics.noaa.gov/
Coastal County Snapshots	Provides county snapshots of demographic trends, critical infrastructure and land use information for planners.	http://www.csc.noaa.gov/digitalcoast/tools/snapshots/index.html
Cal-Adapt	Web-based planning tool for climate change adaptation – depicts climate change risks for specific areas across California.	http://cal-adapt.org/

The Social Vulnerability Index (SOVI) uses existing demographic data to identify social vulnerability trends in communities. The eleven factors considered in SOVI include gender, age, race, occupation and renter/owner. SOVI is an additive model that uses these factors to create an index of social vulnerability for the United States (Cutter, 2003). The National Oceanic and Atmospheric Administration (NOAA) worked with the University of South Carolina to produce a SOVI dataset for all US Census Block Groups in Coastal US states.

Another tool, FEMA's HAZUS, allows users to calculate potential monetary losses from floods and other hazards, including providing an understanding of physical damage, economic losses and social impacts (FEMA, 2011). These two tools offer established methodologies for analyzing social and demographic trends as they relate to vulnerability and coastal hazards. CRISTAL, or Community-based Risk Screening-Adaptation and Livelihoods, is a decision support tool that provides an accessible methodology for understanding social vulnerability. Running in Excel, the tool focuses on creating linkages between climate-related risks and community livelihood.

Other tools provide information and reports to help planners better understand spatial distribution of different demographic and social trends. NOAA's Spatial Trends in Coastal Socioeconomics also provides resources for understanding social aspects of vulnerability. It provides quick reports and census data for coastal planners to use in analyses. NOAA's Coastal County Snapshots also allows users to choose a county and receive a broad array of demographic information about the county, such as income, population and elderly population, as well as information about critical facilities and land use.

4. Conclusion

Consideration of equity in planning for sea level rise and storm events is becoming an increasingly pressing topic as coastal flooding and related impacts begin to affect more and more communities. As historic responses to disasters show, equity and social factors can significantly increase impacts on communities. If social vulnerability is addressed in planning and policy-making, the sensitivity of these communities to hazards can be reduced, while opportunities can be created for renewal, reorganization and adaptation during difficult times.

Social inequity can undermine a community's capacity to respond and rebuild from hazards. In the case of the city of New Orleans and Hurricane Katrina, a variety of factors resulted in communities and individuals being disproportionately affected by the storm. Decades of fast urban growth in low-lying vulnerable areas and an extreme storm event, combined with these factors to cause serious devastation and hardship for individuals, families, neighborhoods and the entire region. The economic, social and environmental impacts that resulted were much greater than what would have been experienced had social vulnerability been accounted for in disaster and recovery responses. A range of factors and small changes to emergency response can influence community resilience. The most effective strategy for building resiliency is to engage local communities and to bring the wealth of local knowledge into decision making and planning.

Climate change vulnerability studies conducted in San Luis Obispo and Fresno Counties illustrate the use of participatory social vulnerability studies to identify disproportionate burdens as well as existing community strengths that could form building blocks for resiliency. Factors such as strong cultural ties, social networks and strong relationships form the basis of resilient communities. In developing a response plan, it can be just as essential for community planners to highlight these resiliency factors as it is to draw attention to vulnerability. In the second case study, the Plan Bay Area Equity Working Group, with broad representation from agencies and non-profits, developed performance measures to support equitable land use and transportation planning. The measurable targets facilitated development of concrete milestones for equity in the region to move toward continued advancement of reducing inequalities in

Equity and Sea Level Rise Planning Recommendations
Projects and programs that incorporate social vulnerability and equity in a way that will result in tangible outcomes need to include the following:

(1) Understanding exposure and impacts
Projections of the scope, timing and geographic location of the hazard or hazards that may impact the community.

(2) Social vulnerability analysis and understanding of sensitive demographics
Identification of the populations within that geographic location and the strengths and limitations of that population. The SOVI analysis conducted in Fresno and San Luis Obispo and the ART project are all examples of this type of analysis. Other tools to conduct this work include census data, GIS, county assessor data, decision support tools (see Table 16) and community input/feedback.

(3) Vulnerability of critical services, infrastructure and facilities
Understanding of the relationship between the services, infrastructure and other assets and the population within the area that are projected to be exposed to the hazard or hazards. Identify the vulnerabilities of these services and infrastructure and the potential impacts to the exposed population and how the social vulnerabilities defined above will make these populations more or less sensitive and vulnerable to the hazard or hazards.

(4) Collaborative process
Creation of a working group of people, partners and organizations representing the exposed community to help ensure that your information is accurate and your work is relevant.

(5) Community engagement
Identify ways to engage communities, as illustrated by the STRAW project, to train and employ residents and improve flood protection in urbanized watersheds to build capacity and attempt to reduce impacts.

(6) Integrated adaptation
Develop an adaptation response with the working group that is directly tied to the analysis of social vulnerability, the vulnerability of the services, infrastructure and other assets, and focuses on building resilience within the most vulnerable populations identified in the study area.

the context of land use and transportation planning. Finally, a number of projects were highlighted that engage disadvantaged communities in data collection, restoration, education and improvement of flood protection. Project-level actions that improve flood protection and involve the public can have significant sea level rise adaptation benefits, especially when they are part of comprehensive planning frameworks. In all of the case studies reviewed, analysis of social equity factors formed the basis for understanding overall community vulnerability, and clear linkages were made between efforts to reduce social vulnerability and increased resiliency.

This white paper also synthesized results from a study completed by the Pacific Institute of socially vulnerable populations within the ART study area. This study examined vulnerable populations across a range of scenarios, from gradual sea level rise to extreme events. These scenarios help to paint a clearer picture of exposure to coastal hazards and could help government officials to prioritize hazard response and planning efforts. Identifying socially vulnerable populations and individuals and integrating these findings into an overall climate change vulnerability analysis is the first step towards addressing equity in planning for sea level rise.

The ART project will continue to address equity in the vulnerability assessment as well as in communication materials and outreach to diverse stakeholders within the region. Specifically, the results from the social vulnerability analysis will be used to identify vulnerable communities and their proximity to and reliance on critical infrastructure, facilities and assets, such as emergency response facilities, ground transportation, hazardous waste sites and parks and recreation area. In addition, equity will be carried into the adaptation phase of the ART project. While project staff is still working to develop a roadmap for this portion of the project, the four overarching frames of society/equity, environment, economy and governance will continue to guide the work.

Planning that addresses social vulnerability and equity can reduce the burden communities may experience due to climate hazards. The approaches reviewed here are part of a growing suite of best practices for integrating analysis of equity issues into studies of sea-level rise vulnerability to inform adaptation and resilience.

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