SEA-LEVEL RISE IMPACTS AND FLOODING RISKS IN THE CONTEXT OF SOCIAL VULNERABILITY: AN ASSESSMENT FOR THE CITY OF LOS ANGELES

Prepared for the Mayor's Office, City of Los Angeles

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EXECUTIVE SUMMARY

In 2008, California's then-Governor Schwarzenegger signed the Executive Order S-13-2008 that required the California Natural Resources Agency to coordinate the development of a state Climate Adaptation Strategy. Following this executive order, the state completed its first statewide adaptation strategy in December 2009, which is being updated in 2012 (at the time of this assessment). Partially in response to the state's adaptation strategy, several regions and communities across California have initiated studies and planning processes to better understand how climate change will affect their areas and also to determine how to reduce and prepare for these impacts. This social vulnerability assessment for the City of Los Angeles makes up part of the City's overall vulnerability assessment for sea-level rise, which fulfills Milestone 2 of the City's initial adaptation planning process in 2012-2013.

Concepts Defined

For the purposes of this report, we employ the terminology used in the State of California's 2009 Climate Adaptation Strategy. ***Vulnerability*** – in the most general sense – describes a system's susceptibility to harm or change. Vulnerability is the combined result of exposure, sensitivity, and adaptive or response capacity and, as such, a function of the character, magnitude, and rate of the climate change hazard to which a system is exposed, as well as of non-climatic (social and environmental) characteristics of the system, which determine its sensitivity and adaptive capacity. This assessment focuses on the ***social vulnerability***, pointing to the factors that make certain groups of people more susceptible to harm. Thus, we describe the social and economic characteristics of coastal neighborhoods in the City of Los Angeles that are associated with lower adaptive capacity and higher sensitivity to flood events, and when possible, we reference to their potential exposure to flooding from sea-level rise. The term adaptation is often defined as any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities. In this report, we will refer to ***adaptation*** as including all those adjustments in planning, management and decision-making a government entity, business, or private citizen might make to prepare for and deal with the impacts of climate change.

Sea-Level Rise and Flood Risk from Climate Change

Sea-level rise – largely a result of warming ocean waters and melting ice caps – is among the most certain consequences of climate change, although considerable uncertainty remains over the exact extent of rise both globally and along different stretches of the coastline. Over the past century, sea level has risen by approximately 7 inches along the California coast, which is consistent with the observed global average. A set of maps created and provided by the US Geological Survey were used to inform this assessment with an initial estimate of the areas and communities that could be impacted by sea-level rise inundation or storm-related flooding as the baseline elevation increases. The maps show the estimated extent of flooding from a relatively minor storm after 16 and 55 inches of sea-level rise, representing projections for 2050 and 2100, respectively. The storm scenario is based on the January 2010 storm, which is considered "10 year flood," i.e. a flood with a 10% probability of occurring in any given year. For the purposes of this assessment, the more commonly used planning scenarios by local

communities – such as the 100- (1% chance) or 500-year flood (0.2% chance of occurring in any given year) – were not yet available.

Scientists estimate that by the end of the 21st Century, the extremely high flood levels currently associated with "century" or "100-year" flood events will occur on average once per year along California's coast. This means that a storm such as the January 2010 storm (a decadal or "10-year" storm at present and the design storm for this adaptation planning effort) can be expected to occur at least annually well before the end of the century, and probably much sooner and far more frequently.

Demographic Characteristics Indicating High Social Vulnerability

This assessment describes the elements of social vulnerability as they relate to sea-level rise flooding risks and the City of Los Angeles' residents. We provide brief snapshots of the three coastal areas within the City of L.A. that will experience the direct impacts of sea-level rise, which is followed by a description of population characteristics that indicate how and where some segments of coastal communities are more socially vulnerable to flooding than others. Characteristics presented include:

- Income and poverty
- Education levels
- Females as head of household
- Race
- Language isolation
- Age
- Housing type and age
- Physical and mental illnesses and disabilities

These characteristics are associated with a higher sensitivity and/or lower adaptive capacity to flooding and sea-level rise, and thus can inform adaptation planning.

Key Findings

First, income is one of the most important indicators of adaptive capacity. Per capita income in Los Angeles overall tends to be higher along the coast than in the interior. However, there is a pocket located around the Port of L.A. where a high proportion of the population lives below the poverty level. High proportions of the population with low education levels (e.g. those over 25 years old not graduated from high school) are also associated with lower adaptive capacity. They can be found particularly in San Pedro and Wilmington. In these same neighborhoods Census data shows that high proportions are linguistically isolated (speak English less than "very well") and are largely Hispanic.

Identifying populations that are more vulnerable due to these particular factors can inform emergency response planning for flooding, especially as sea level rises, and for developing strategies to engage community members to participate actively in the climate adaptation planning process. This might include, for example, conducting workshops and preparing other public outreach materials in Spanish and, given low education and high poverty levels, using alternative methods that do not require literacy or internet access.

Other characteristics that indicate social vulnerability presented in this assessment include housing type and control over living situation. Census data shows a high proportion of older housing, which tends to be more sensitive to flooding (lower building codes, less flood-proofing), in Venice and, again, neighborhoods surrounding the Port of L.A. These same communities have a high proportion of renters, which tend to not have the means or incentive to flood proof their homes. Segments of the population that may need special assistance in emergencies because of a lack of mobility or other disadvantages include the elderly, homeless, those with existing physical or mental illness, and those living in group quarters. An important first step to preparing special assistance for these populations in emergency situations is to document where they reside so that first responders know the extent of the need and can direct it appropriately when the time comes.

Researchers have developed different methods integrating these (and other) social vulnerability characteristics. Here, we calculate a Social Vulnerability Index (SOVI), based on a combination of population characteristics representing adaptive capacity and sensitivity. It shows relatively low overall social vulnerability along the coast in Los Angeles. Instead the highest vulnerability is concentrated in the interior of the city and county. Still, based on this SOVI measure, portions of San Pedro, Wilmington, and one census block in Venice score with relatively high social vulnerability compared to the rest of the county.

The Climate Change Community Screening Tool (CCCST), developed by the California Department of Public Health specifically for climate change impacts, results revealed clear racial disparities in terms of who is at risk of climate change impacts. The screening tool showed that in Los Angeles County, African-Americans and Latinos were at higher risk of climate change stressors than whites. They also found that, in terms of income levels, households with lower income are at higher risk from climate change stressors. The mapped results of overall climate change vulnerability from this screening tool show a much higher measure of overall vulnerability along the coast of L.A. This measure incorporates the exposure dimension of vulnerability in the cumulative vulnerability score by including risk of climate change impacts (including flooding exacerbated by sea-level rise), whereas the SOVI focuses only on sensitivity and adaptive capacity indicators. This methodological divergence partially explains the differences in results. The difference in results between the two tools highlights the importance of understanding the underlying methods and variables used to calculate integrated snapshot vulnerability in Los Angeles. Importantly, however, the underlying drivers of social vulnerability are consistent in the two approaches.

Integrated scores of vulnerability can be useful to help prioritize areas of concern for climate adaptation planning, but the review of individual characteristics can help inform the development of specific adaptation strategies.

Community Services

A number of services and supporting infrastructure are potentially at risk of impairment from short term or long term damage from flood events as sea level rises. These include impairment of drainage and treatment of wastewater and sewage, rapid emergency response, access to food and prescription

medicines, risks of salinization to coastal groundwater reservoirs, access to and functionality of energy-related facilities, transmission, and transformers, and important ecosystem services. While assessing these services is beyond the purview of this report, it is important to highlight that the interruption of these services and supporting infrastructure can have disproportionate impacts on those more sensitive to and with lower adaptive capacity for dealing with flooding as sea level rises and other climate change stressors ensue. Impairment of these services can also affect households and communities outside the current or future floodplain. Thus, an integrated approach to adaptation planning (with neighboring jurisdictions) is important to examine these critical linkages.

Recommendations

Based on this assessment we offer the following recommendations for moving forward with the adaptation process:

- *Invest in a strong foundation for climate adaptation*: Effective adaptation to climate change in a region entails building on regional, local and other efforts over time. Investing in a strong foundation in the early stages of the process can help support adaptation efforts in the future. Elements of such a foundation will require actions beyond technical and structural solutions, involving policy changes, creative financing, capacity building among key staff and decision-makers, and effective public engagement.
- *Define clear adaptation goals:* Most adaptation planning processes to date in the US have been undertaken without clearly defining what "success" would look like. Goals could focus on both procedural and outcome intentions. Strategies flow more clearly from identified goals.
- *Develop clear prioritization and selection criteria for choosing among possible adaptation strategies:* Such criteria would help with prioritization when budgets, timelines, technical considerations, and social concerns and political feasibility inevitably place constraints on preferred solutions.
- *Update the vulnerability assessment as better flood risk models and maps become available*
- *Expand partnerships in developing adaptation options:* Much adaptation that addresses social vulnerability and public concerns requires close collaboration with the affected groups and extending the network of adaptation stakeholders to include those already working on increasing community resilience in the face of disasters.
- *Incorporate more detailed community-based information as it becomes available*
- *Coordinate adaptation with neighboring communities beyond the city borders*

This social vulnerability assessment serves as first step for incorporating on-the-ground conditions into climate adaptation planning for the City of Los Angeles. Adapting to climate change is a continual process, and just like climate change science, social vulnerability information should also be updated regularly to place adaptation planning and implementation on the most up-to-date informational foundation. This report describes existing vulnerabilities and inequalities that can be addressed now and in the future regardless of the extent of climate change. In other words, reducing social vulnerabilities has benefits independent of climate change that can support a socially equitable and prosperous city.

1. INTRODUCTION: GOAL, PURPOSE AND AUDIENCE OF THIS STUDY

1.1 PURPOSE AND GOAL

The purpose of this study is to contribute social science-based information and knowledge about population segments at risk to sea-level rise impacts as part of the City of Los Angeles' climate adaptation planning process. The goal of this report is to assess social vulnerability to coastal flooding within the City of Los Angeles, focusing solely on sea-level rise and related flooding during extreme events. Information about social vulnerability, in combination with an assessment of physical risks to infrastructure, helps prioritize support (both for disaster response and long term adaptive responses) on those least able to help themselves. Thus the adaptation process is likely to be smoother, not resulting in extensive losses during disasters or the disorderly abandonment of the coast. Moreover, by including consideration of social vulnerability and the populations who could be disproportionately affected by climate change as adaptation options are developed, it is more likely to prevent socio-political tensions in implementing adaptation options.

The timeline for conducting this assessment was from May through June 2012. Thus, this report constitutes a first, rapid assessment of social vulnerability based on pre-existing information from secondary data sources, such as City and County planning documents, other assessments related to vulnerable segments of the city (and some cases county's) population, newspaper articles about past floods, Census 2010 data when available, American Communities Survey Census 2006-2010 data, and Census 2000 data when it provides information at a higher resolution[1]. These data and information sources were compiled and synthesized to provide a first social vulnerability assessment for the City. It does not constitute technical, primary research due to the timeline of the project. Yet, it aims to show the value of incorporating social vulnerability into climate adaption planning for the City. In addition, this report also points to additional information or processes that may be useful in developing a more sophisticated assessment. Adapting to climate change is a continual process, and – just like physical climate change science – this type of information should be updated regularly as adaptation planning continues in the future and as additional information becomes available.

1.2 CONTEXT AND AUDIENCE

In 2008, California's then-Governor Schwarzenegger signed Executive Order S-13-2008 that required the California Natural Resources Agency to coordinate the development of a statewide Climate Adaptation Strategy. Following this executive order, the state completed its first statewide adaptation strategy in December 2009,[2] which is being updated in 2012 (at the time of this assessment). Partially in response to the state's first adaptation strategy,[3] several regions and communities across California have initiated studies and planning processes to better understand how climate change will affect their areas and determine how to reduce and prepare for these impacts.[4] This social vulnerability assessment for the City of Los Angeles is part of the overall vulnerability assessment, which fulfills Milestone 2 of the City's initial adaptation planning process in 2012-2013.

This social vulnerability assessment is one element of the City's adaptation planning process. Established phases, with an end date of April 2013, include:

Milestone 1: Develop existing conditions & policy review report

Milestone 2: Develop sea-level rise vulnerability and risk assessments

Milestone 3: Develop sea-level rise adaptation measures and a sea-level rise adaptation plan

Milestone 4: Adopt a first sea-level rise Adaptation Plan

The impacts of climate change are disproportionately distributed across populations – harming some segments of the population more than others. Some populations, especially those who experience social inequalities, are less able to prepare for, respond to or recover from a disastrous event than others.[5] To reduce the most severe impacts to these populations, adaptation strategies can be strategically developed addressing the existing conditions and social vulnerabilities within a community and region. Such strategies can only be developed by knowledge of the socially vulnerable, which is how this assessment aims to serve the city.

Disproportionate impacts of climate change are a long-standing concern among researchers, community organizations, and governments as climate adaptation efforts increase. The State of California has supported several studies to help better identify and understand social vulnerabilities to climate change. The California Office of Environmental Health Hazard Assessment (at the request of the California Environmental Protection Agency) has published a report[6] about environmental justice indicators in California, focusing only on heat and air quality impacts associated with climate change. With support from the California Energy Commission, the Pacific Institute published a statewide assessment of how sea-level rise could affect coastal communities in 2009[7] and then more broadly across other climate change impacts in 2012,[8] both of which included a range of environmental justice indicators. The California Department of Public Health recently completed a study developing a climate vulnerability screening tool that indicates social vulnerability (in terms of sensitivity, adaptive capacity and exposure) to impacts of flooding from sea-level rise, increased heat events, and poor air quality conditions (from increasing ozone in hot, polluted air basins). They piloted the tool in counties of L.A. and Fresno, therefore results of this work is also included in the discussion of this assessment. These studies apply slightly different methods, but utilize many of the same indicators to identify populations at risk.

Social vulnerability and the unequal burden of climate impacts is also a growing concern of governments and communities at the local and regional levels as these entities begin adaptation planning. In California this type of social vulnerability analysis has also been conducted as part of the adaptation planning processes in San Luis Obispo,[9] Fresno Counties[10] and the San Francisco Bay Area.[11] Aside from California-based studies, the assessment methodology has also been applied nationally and internationally, most of which has been developed for disaster response planning and assessments (e.g. Emrich and Cutter, 2008; Martinich et al. 2012).[12] These use indicators of social vulnerability based on US Census data about the characteristics of populations within a given area.

2. ADAPTATION AND VULNERABILITY: DEFINING KEY CONCEPTS AND OUR RESEARCH APPROACH

2.1 KEY CONCEPTS AND DEFINITIONS

The effects of climate change even in just one location, such as Los Angeles will differ widely because of the regional differences in the nature of expected climate change (whether it is sea-level rise, higher temperatures, or patterns of extreme events) and because of the differences in existing conditions of the affected systems within the given regions. Together, the physical changes in climate, the condition of the interacting natural and human systems, and whatever measures are taken to prepare for, and minimize the risks will determine the ultimate impacts.

For the purposes of this report, we employ the terminology used in the California's 2009 Climate Adaptation Strategy.[13] We first distinguish climate change impacts from vulnerabilities. A ***climate change impact*** is an effect of climate change on the structure or function of a system. Potential impacts are those that may occur without considering adaptation. By contrast, ***vulnerability*** – in the most general sense – describes a system's susceptibility to harm or change. Vulnerability is the combined result of exposure, sensitivity, and adaptive or response capacity and as such a function of the character, magnitude, and rate of climate change to which a system is exposed, as well as of non-climatic (social and environmental) characteristics of the system, which determine its sensitivity and adaptive capacity. This assessment focuses on the ***social vulnerability***, pointing to the factors that make certain groups of people more susceptible to harm. Thus, we describe the social and economic characteristics of coastal neighborhoods in the City of Los Angeles that are associated with lower adaptive capacity and higher sensitivity to flood events, and when possible, we reference to their potential exposure to flooding from sea-level rise.

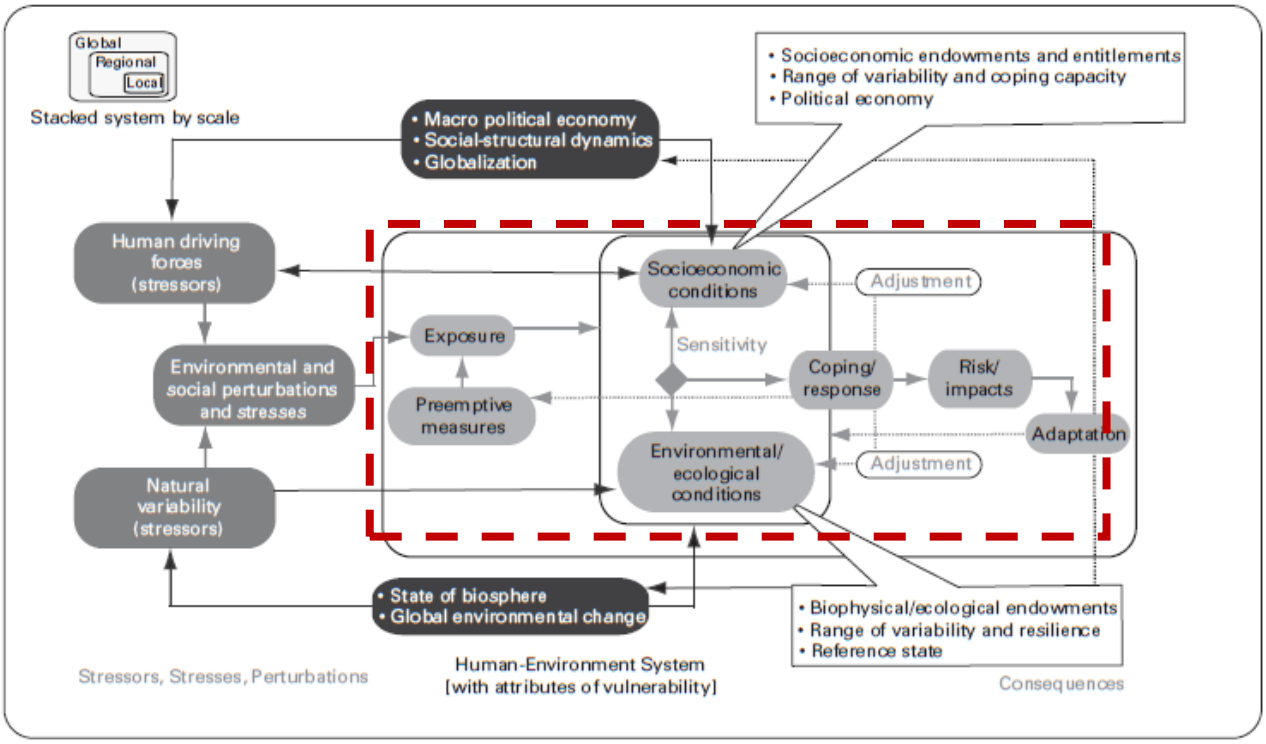


FIGURE 1: VULNERABILITY OF COUPLED HUMAN-NATURAL SYSTEMS (DASHED RED BOX, ADDED BY AUTHORS, HIGHLIGHTS CORE ELEMENTS OF FOCUS IN THIS ASSESSMENT (SOURCE: KASPERSON, KASPERSON, AND TURNER 2009)[14]

First, ***exposure*** is the nature and degree to which a system experiences a stress or hazard.[15] Examples of stresses that are familiar to coastal portions of the city include coastal flooding from storms, flooded roadways, impaired drainage backing up storm water into streets and homes, erosion of beaches and hillsides damaging beachfront property and recreational facilities. Many of these may be exacerbated by climate change. The levels of exposure from a stressor often are not distributed evenly across a geographic space or across populations (e.g., coastal areas will experience storms more, but extreme heat less than those inland). It is also important to note that climatic hazards can be one-time extreme events or slow creeping problems that are more chronic in nature, which – if not addressed – can eventually lead to a disastrous situation (e.g., a heavy precipitation event combined with an increase of sea level and high tides could create a disastrous flood or cause cliffs to fail compared to the hard-to-perceive slower changes in sediment movement and average sea-level rise). Thus, how exposure is distributed across space and populations, and the nature of the climate perturbation, are important for understanding local level vulnerability. The section on climate change projections summarizes the best available science at present on what climate changes and perturbations the county may be exposed to in the future.

The second dimension of vulnerability is ***sensitivity***, which refers to the degree to which the system is impacted by a given stressor, change or disturbance.[16] The effect may be direct (e.g., a single story home in low-lying coastal area with no flood-proofing) or indirect (e.g., climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).[17] Thus, the sensitivity of a system is not just the result of

climate-stresses, but also influenced by non-climatic stresses. For example, those with existing illnesses may be more sensitive than healthy adults to water-borne bacteria that may spread during flooding. People already under significant amounts of stress for health, economic, or psychosocial reasons may be more susceptible to additional climate-related health stresses.

The third dimension of vulnerability is ***adaptive capacity***. This term encompasses the ability to cope with extreme events, to make adaptive changes, or to transform more deeply, including the ability to moderate potential damages (negative consequences) and to take advantage of opportunities (beneficial consequences) that may arise from climate change. While there are a number of ways to measure and evaluate adaptive capacity (and the scientific community does not agree on just one), this concept relates to the degree to which the system can adapt in order to deal with a stressors or change. Adaptive capacity can be assessed on any level of organization, from the individual to the national or international level. In this report we focus on the individual, neighborhood, and community (i.e. municipality) levels. The factors that tend to increase adaptive capacity include economic resources, highly functional institutions, adequate infrastructure, availability of technological options and capacities, sufficient information and high levels of education and skill among decision-makers and stakeholders, significant social capital among stakeholders, and equity in the access to these resources and capacities. These definitions of exposure, sensitivity and adaptive capacity illustrate why in this report we focus extensively on the social characteristics of the city's population and economic sectors[18].

Adaptation is frequently defined as any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.[19] Strictly speaking, this broad definition includes mitigation actions, i.e., actions to reduce the causes of climate change. Many experts indeed view mitigation as the ultimate adaptation. Many others view them as separate sets of actions but both as equally necessary and complementary to each other. Mitigation thus limits the pace and ultimate degree of climate change by reducing the causes, thus making it possible for natural and social systems to adapt, while adaptation addresses the consequences of change that could not be avoided. For individuals familiar with disaster preparedness and management, "mitigating" potential impacts from disasters are among the actions one might take to prepare for and adapt to climate change. To avoid unnecessary confusion, in this report, we will refer to ***adaptation*** as including all those adjustments in planning, management and decision-making a government entity, business, or private citizen might make to prepare for and deal with the impacts of climate change.

Finally, ***resilience*** is the ability of a system to absorb some amount of change, including shocks from extreme events, bounce back and recover from them, and, if necessary, transform itself in order to continue to be able to function and provide essential services and amenities that it has evolved or been designed to provide.[20] In light of the potential risks from climate change, resilience has become a highly desirable outcome of adaptation for many. If adaptive actions can help a system be better prepared, able to bounce back faster and better from an extreme event, or deal with relative ease with changing conditions, continue to learn from such events and adjust over time, and provide the goods, services, functions and amenities that are desirable, then adaptation may be considered successful.

2.2 Methods to Assess Vulnerability

We use the three dimensions of vulnerability to reveal the different ways that communities are vulnerable to sea-level rise and related flooding during extreme events. Assessing potential direct effects on livelihoods, such as people's safety, health and well-being, and the ability to economically support them, can reveal first-order effects of climate change. Also contributing to social vulnerability is the ability of communities (or segments of populations) to collectively respond to a problem. Therefore, which groups have power – and which do not – and therefore can mobilize and obtain political attention also reveals insight into the social vulnerability in an area.

This assessment draws on publicly available reports, plans, and data repositories available from local (municipal and county), state and federal sources, peer-reviewed research papers, and phone conversations with representatives from coastal neighborhood councils and other organizations and researchers vested in assisting vulnerable populations.

The following section summarizes the threat of sea level-rise and the resulting growing risks from flooding during high tides and storms. Then the ocean-bordering coastal communities within the city limits are introduced in brief snapshots, providing basic geographic, demographic, and economic characterization of the areas of particular interest for this study. This is followed in Section 5 with a detailed description of the demographic characteristics that indicate one or more of the dimensions of social vulnerability. This section relies largely on data from the US Census (from 2010 where available, and also American Community Survey 2006-2010), and then summarizes these characteristics in two vulnerability indices that provide an integrated view of social vulnerability. Section 6 offers some recommendations for incorporating social vulnerability into an ongoing adaptation planning process, how the future assessments can be expanded to represent existing community concerns and other climate change-related stressors (increasing heat events, decreased water supply, fire, and landslides), and adaptation options that go beyond technical or infrastructure changes, such as governance and building staff and leaders' capacity.

3. Geography and Sea-Level Rise Projections for the City of Los Angeles

3.1 Expected Impact of Sea-Level Rise in Los Angeles

Sea-level rise – largely a result of warming ocean waters and melting ice caps – is among the most certain consequences of climate change, although considerable uncertainty remains over the exact extent of rise both globally and along different stretches of the coastline. Over the past century, sea level has risen by approximately 7 inches along the California coast, which is consistent with the observed global average. While an oceanographic oscillation of currents (Pacific Decadal Oscillation) in the Pacific Ocean has suppressed sea level from rising along the West Coast of the United States since the 1980s, scientists currently see this phase coming to an end, and thus agree that sea-level rise will resume a pace consistent with the global average in coming decades.[21] A National Research Council study released in June 2012, commissioned by California, Oregon, Washington and several federal agencies, concludes that sea level along California's coast will rise up to 9 inches by 2030, 1.5 feet by 2050, and 4.5 feet by 2100.[22] The rate of sea-level rise over the next several decades, thus, is expected to be four to eight times larger than the total rise over the entire 20th century.

Along the coast of Los Angeles (both city and county), sea-level rise could lead to the following impacts:

- Increased erosion of already retreating coastal bluffs and of beaches either naturally retreating or maintained in place by sand replenishment, increasing the risk of cliff failures and damage to the Pacific Coast Highway and other critical roads along the coast;
- Coastal flooding with higher storm surges and flood elevations during coastal storms, potentially inundating valuable transportation, commercial, energy, wastewater, and residential infrastructure in low-lying areas;
- Permanent inundation of the few remaining or restored coastal wetlands in the county
- Reduced capacity to absorb runoff and drain it away from inland areas as sea-level rise elevates the coastal groundwater levels; and
- Salt water intrusion into coastal groundwater basins through which freshwater is delivered to serve local residents.

3.2 Design of Floods Used in This Assessment

A set of maps created and provided by Patrick Barnard (USGS) were used to inform this assessment with an initial estimate of the areas and communities that could be impacted by sea-level rise inundation or storm-related flooding as the baseline elevation increases. The maps show the estimated extent of flooding from a relatively minor storm after 16 and 55 inches of sea-level rise, representing projections for 2050 and 2100, respectively. The storm scenario is based on the January 2010 storm, which is considered "10 year flood," i.e. a flood with a 10% probability of occurring in any given year.

For the purposes of this assessment, the more commonly used planning scenarios by local communities – such as the 100- (1% chance) or 500-year flood (0.2% chance of occurring in any given year) – were not yet available.[23] A previous assessment (Heberger et al. 2009),[24] which used the 100-year flood scenario with sea-level rise of 16 and 55 inches, was based on a simplified inundation model that was not considered adequate by leaders of this project. However, a recent scientific study (Bromirski et al. 2012)[25] showed that while wind and waves are not expected to increase due to climate change, the storm surge will increase due to sea-level rise alone, causing the height and inland extent of floods to increase and thus have much larger impacts (i.e., more damage to infrastructure and putting more people at risk of flooding) than have been experienced historically. Another study by Tebaldi, Strauss, and Zervas (2012)[26] modeled how sea-level rise could affect storm surge, found that extreme water levels along the coast that are considered to be 100-year events are expected to become 10-year events within the next 40 years due to the expected increase in the base elevation (sea level) alone.

Bromirski et al. (2012) and Cayan et al. (2012) estimate that by the end of the 21st Century, these extremely high water levels that are currently considered "century" or "100-year" flood events will occur on average once per year along California's coast.[27] This means that a storm such as the January 2010 storm (a decadal or "10-year" storm at present) can be expected to occur at least annually well before the end of the century, and probably much sooner and far more frequently.

Finally, the National Research Council (2012) confirms these SLR projections and expectations of impacts on flooding (and concurrent coastal erosion and cliff failures). Thus, the finding on the extent of future flooding reported here should be considered a conservative estimate of minimum impacts. As sea-level rise driven flood risk maps are refined for the coast of Los Angeles in the future, including for higher flood risk levels – such as the 100-year and 500-year flood –, the extent of exposure to flood risk along the city's shoreline can be expected to expand considerably. Thus, the actual extent of flooding-exposed areas – and thus areas of concern with regard to social vulnerability – will be considerably larger. We therefore show maps of population variables contributing to social vulnerability that are outside the current or future 10-year flood risk zone to allow for a broader perspective and expect that the information presented in this report for populations currently residing outside the 10-year flood risk zone (at current or future sea level) will still be useful for future adaptation planning.

4. SNAPSHOT OF COASTAL NEIGHBORHOODS OF L.A.

The City of Los Angeles borders the coast in three different sections (Figure 2). These include Pacific Palisades, Venice/Playa del Rey, and San Pedro/Wilmington/Port of L.A. This section provides brief descriptions of each community, including the number of people living in each area and other defining characteristics. The primary infrastructure and services of concern that could be at risk from SLR and flooding are also briefly discussed to illustrate how their impairment would put populations at risk.[28] While the three communities within city limits are the primary foci of this assessment (because they are directly within city bounds), attributes of neighboring coastal neighborhoods and communities are also discussed (see Section 6) highlighting where coordination may prove useful and effective for preparing for and adapting to sea-level rise.

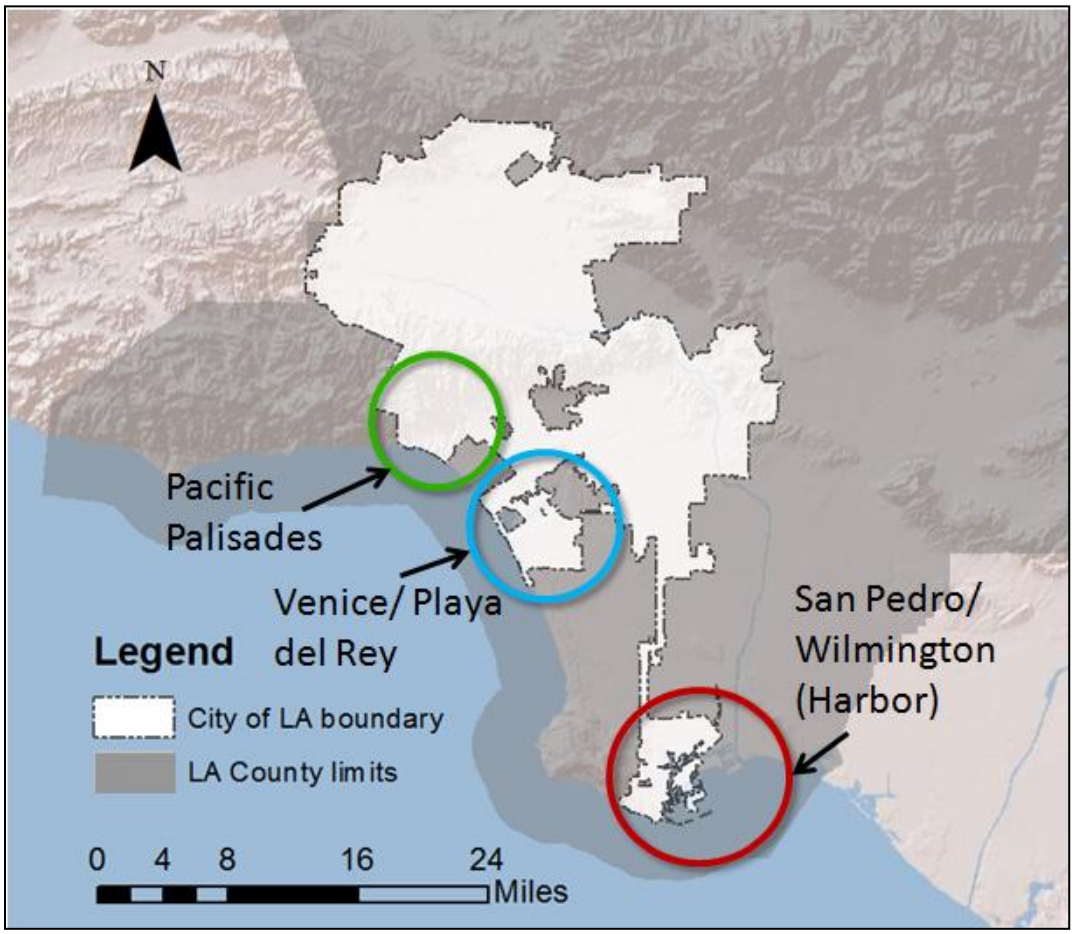


FIGURE 2. REGIONS IN THE CITY OF LOS ANGELES (WHITE) THAT TOUCH THE COAST AND THAT ARE DIRECTLY EXPOSED TO SEA-LEVEL RISE AND COASTAL STORM–RELATED FLOODING. AREAS WITHIN LOS ANGELES COUNTY THAT ARE OUTSIDE CITY LIMITS ARE SHADED GRAY.

4.1 PACIFIC PALISADES

Pacific Palisades is the most northern coastal community located within the City of Los Angeles, situated on Santa Monica Bay, just south of Malibu and northwest of Santa Monica. This portion of the city's shoreline is approximately two miles long.[29] The community covers an area of 23,451 acres and has

approximately 27,000 residents and 9,400 homes, residential units and business.[30] For the most part, the population residing in this community is very wealthy, though there is also one mobile home park. The risks to the transportation routes and how they could affect the residential population is already a major concern in this area in terms of sea-level rise, flooding and wildfire.

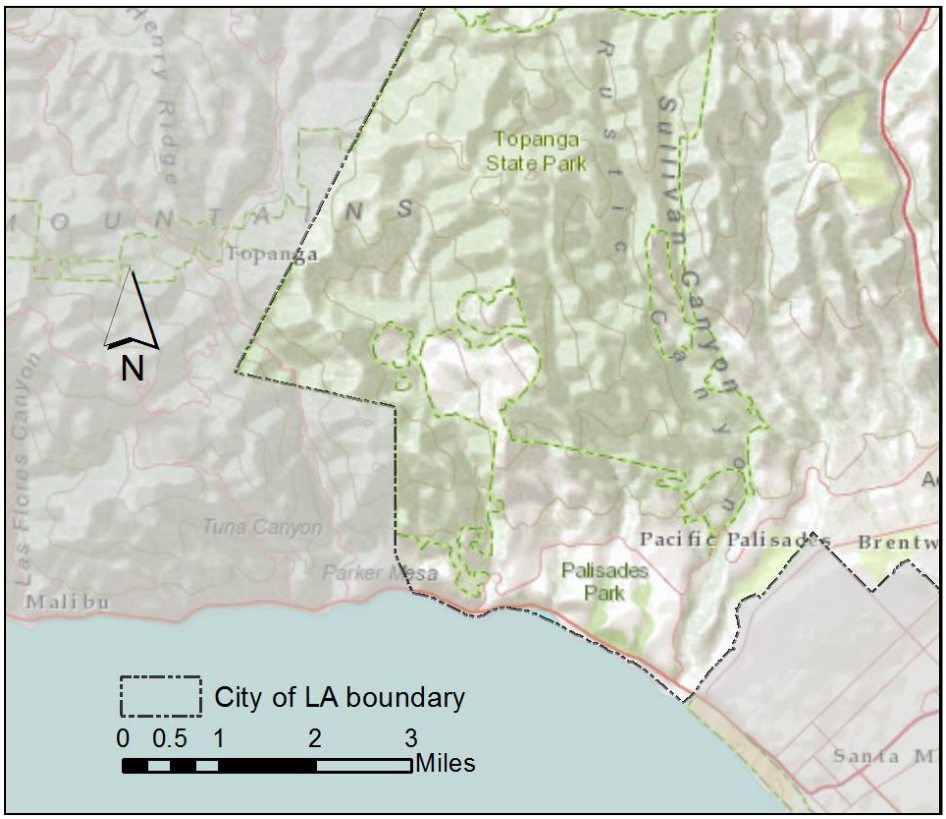


FIGURE 3: THE BOUNDARIES OF PACIFIC PALISADES (DOTTED LINES) INDICATE THE CITY OF LOS ANGELES' DIRECT JURISDICTIONALRESPONSIBILITY. PACIFIC PALISADES IS LOCATED SOUTHWESTOF MALIBU WITH SANTA MONICA AS ITS SOUTHERN NEIGHBOR. PACIFIC COAST HIGHWAY (IN RED ALONG THE COAST), WHICH ALREADY FLOODS FREQUENTLY DURING HEAVY STORMS AT CURRENT SEA LEVEL, IS A CRITICAL ACCESS ROUTE FOR GETTING IN AND OUT OF THE COMMUNITY.

Pacific Coast Highway runs along the community's coastline between the beach and several parking lots (for public beach access) lined on the landward side by residents on coastal bluff (Figure 4 and Figure 5). The beach has a long history of erosion challenges, and in efforts to maintain a desirable beach width, several breakwaters have been built, many along Will Rogers Beach. The shoreline has gotten dangerously close to the Pacific Coast Highway in some areas (see left portion of Figure 6 and Figure 7). In attempts to protect the Pacific Coast Highway from erosion, rip rap (rocks) have been placed along the highway's seaward base, which has exacerbated the sand loss and erosion of the beach. The Pacific Coast Highway already floods frequently when extreme high tides coincide with large storms.[31] The highway serves as a critically important infrastructure given that residents rely on this for evacuating the area, and tourists and recreationists rely on it for access to the public beach. For some residents, the highway is the only evacuation route (and thus the only emergency responder route to access

residences). The alternative emergency services access into -- and evacuation routes out of – the community are narrow, windy (i.e. slower), and few (i.e. easily congested).

FIGURE 4: THE PACIFIC COAST HIGHWAY IN PACIFIC PALISADES, SHOWING ITS LOCATION WEDGED BETWEEN THE SHORELINE AND THE HILLSIDE. MOST PORTIONS, LIKE THIS ONE, HAVE PARKING LOTS ALONG THE BEACH FOR PUBLIC ACCESS TO THE SHORE (SOURCE: GOOGLE MAPS)

FIGURE 5: PACIFIC COAST HIGHWAY LIES BETWEEN AN ERODING HILLSIDE (RETAINING WALL SHOWN ON THE RIGHT IN THE PHOTO) AND THE BEACH AT THE SOUTHERN PORTION OF THE CITY LIMITS ALONG PACIFIC PALISADES' STRETCH OF COASTLINE (SOURCE: GOOGLE MAPS).

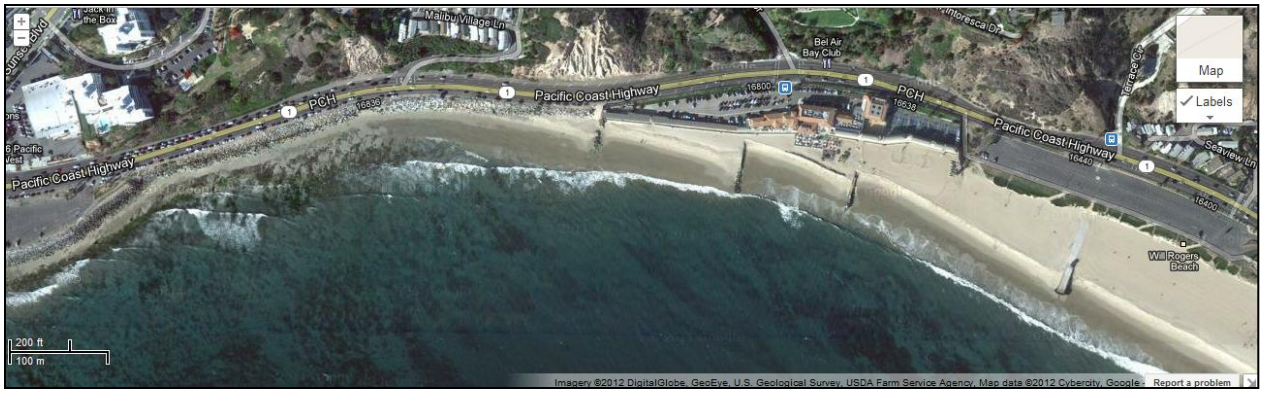


FIGURE 6: BREAKWATERS BUILT ALONG THE SHORELINE TO PREVENT EROSION OF THE DESIRABLE WILL ROGERS BEACH IN PACIFIC PALISADES. THE PACIFIC COAST HIGHWAY IS THE ONLY EVACUATION ROUTE FOR SOME COASTAL RESIDENTS FROM THESE SHORELINE AREAS (HIGHWAY HIGHLIGHTED IN YELLOW). SOURCE: GOOGLE MAPS

FIGURE 7. EXTENT OF FLOODING ALONG THE SHORELINE OF PACIFIC PALISADES IN A 10-YEAR FLOOD WITH SEA-LEVEL RISE OF 16 INCHES (ORANGE) AND 55 INCHES (RED). SOURCE: BARNARD USGS 2012.

4.2 VENICE AND PLAYA DEL REY

Venice and Playa del Rey are the communities in the central portion of where the City of L.A. touches the coastline (Figure 8). Marina Del Rey, a commercial and residential development in the unincorporated part of L.A. County, is nestled in between Venice and Playa del Rey. Venice, the northern of the two communities, is located just south of Santa Monica Venice has a low-lying topography.

Originally a marsh, this area is already highly susceptible to flooding even at current sea level. Playa del Rey is located south of Marina del Rey, and bordered on the east by the community of Westchester (and Loyola Marymount University) and the Los Angeles International Airport, and on the south by the City of El Segundo.

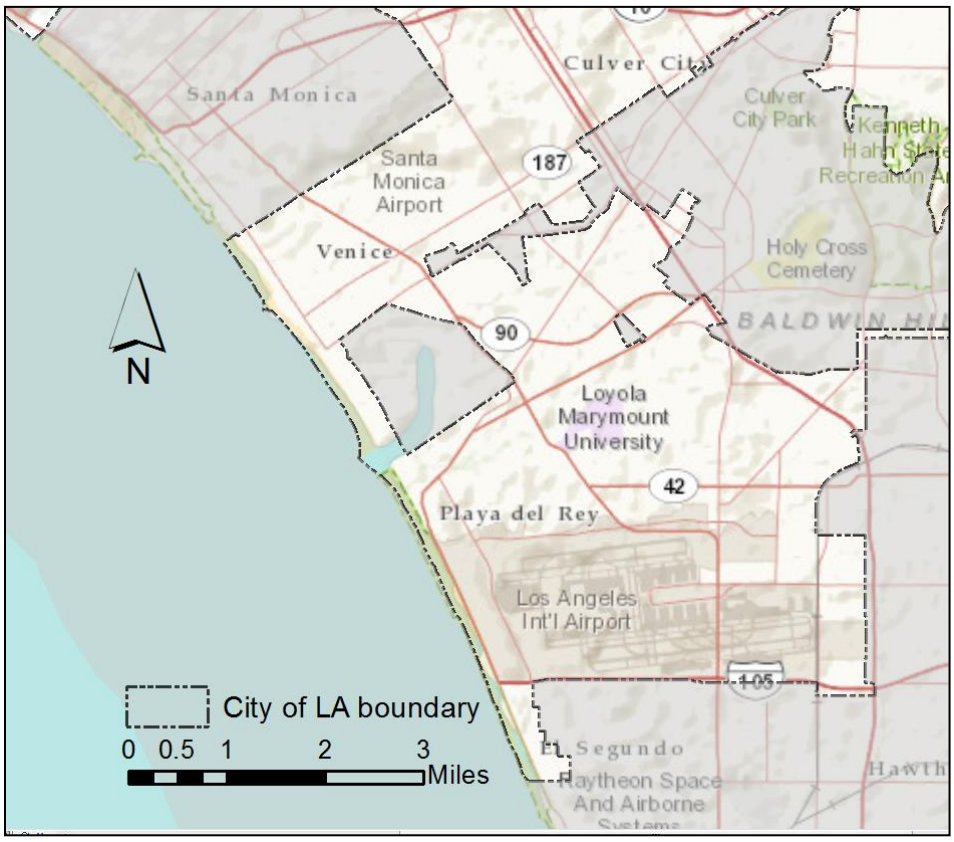


FIGURE 8: COMMUNITIES OF VENICE AND PLAYA DEL REY CONSTITUTE ANOTHER SECTION OF WHERE THE CITY OF LOS ANGELES TOUCHES THE COAST ALONG SANTA MONICA BAY. GRAY AREAS DENOTE AREAS OUTSIDE THE CITY'S JURISDICTIONAL BOUNDARIES.

The Ballona Creek (a flood control channel) and the Ballona Wetlands make up the northern border of Playa del Rey. Environmental groups have spent several decades protecting and restoring these wetlands (now a project under the auspices of the California Coastal Conservancy). These are the last remaining coastal wetlands in the Los Angeles Basin, all of which could be flooded by a 10-year storm by 2050 (Figure 9). The southern-most tip of the City of L.A.'s jurisdiction is marked by the Hyperion Wastewater Treatment Plant. Just south of Hyperion is an oil refinery, also right on the coast, though outside the bounds of the City of L.A. (in El Segundo).

The population of Venice in 2008 was approximately 40,885 people.[32] The area is home to a diverse population that ranges from high to low income. The socioeconomic status changes from block to block. The gentrification of the area is a common complaint and concern for some community members, as is gang violence. Playa del Rey is home to an estimated 11,317 people (as of 2008).[33] Several segments of population are of concern in Venice (homeless, disabled, institutionalized or group homes, and low

income) (Section5). Tourism is a large part of Venice's economy – viewed by some as "the second largest tourist attraction in California, after Disneyland."[34] Many middle and low income residents work in the industry and will therefore be economically impacted if sea-level rise takes a toll on the area's tourism.

Both Venice and Playa del Rey are highly exposed to flooding already and will be even more so as sea level rises (Figure 9). A high number of people and businesses are located in areas potentially exposed to flooding from sea-level rise, and flooding will be experienced outside the areas shown in the sea-level rise map because of the poor drainage during storms in Venice. The coastal area has a history of excessive flooding during storms coinciding with high tides, largely from drainage problems in low lying areas. Power outages are a concern for community members given that aging utility lines are buried underground and could directly be exposed to, and affected by, salt water. Already during heavy rainfall, water collects in utility basins causing potential public health hazards when they are not drained regularly (e.g. potential breeding ground for bacteria and disease vectors, such as mosquitoes). Many homes in low-lying areas already use sump-pumps in their basements or garages to cope with the frequent flooding.[35]

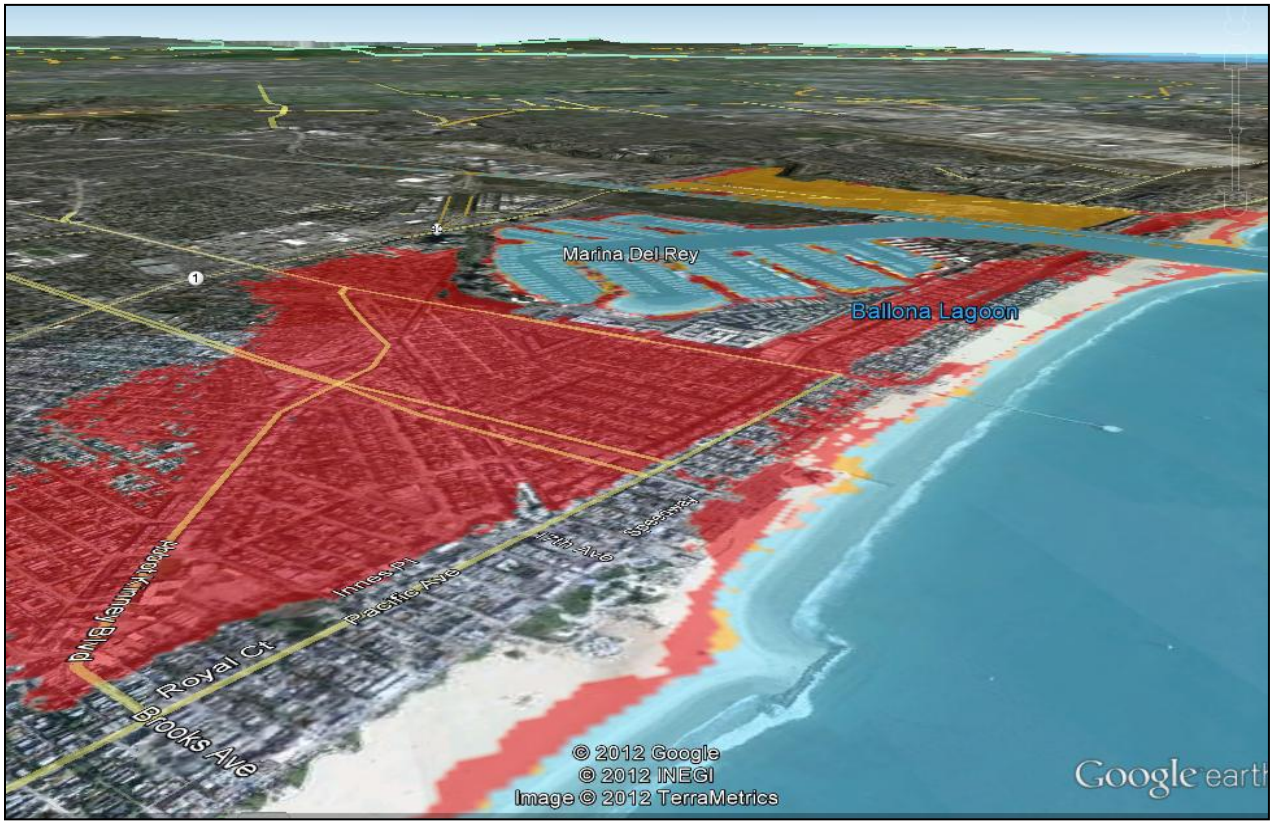


FIGURE 9. EXTENT OF FLOODING IN VENICE FROM SEA-LEVEL RISE (ORANGE REPRESENTS 16 INCHES AND RED REPRESENTS 55 INCHES OF SEA-LEVEL RISE), AS MODELED BY USGS (BARNARD 2012)[36] UNDER A 10 YEAR STORM. ADDITIONAL LAND WOULD BE AT RISK OF FLOODING DURING A 100 YEAR STORM. LARGE PORTION IN ORANGE COVERS BALLONA WETLANDS

An economic study conducted by San Francisco State University and the California Department of Boating and Waterways in 2011 on the economic impacts of sea-level rise on California beaches included a focus on Venice Beach.[37] Storm damage in Venice Beach is estimated by the study to increase with sea-level rise by nearly 640% compared to historical flood damage. The study estimates that flooding from a 5 ft. sea-level rise could result in a total of over $15 million in damages to structures and contents by 2050, and in and nearly $52 million in damages in 2100.[38] The majority of damage is expected to be from flooding damage to residential structures.

Venice

100-Year Coastal Flood Impacts (millions of 2010 dollars)

Scenario	Baseline	1.0 m Sea-Level Rise		1.4 m Sea-Level Rise		2.0 m Sea-Level Rise	
	2000	2050	2100	2050	2100	2050	2100
Residential Structures	3.0	5.6	14.6	6.5	24.1	8.7	43.8
Residential Contents	1.3	2.5	6.4	2.9	10.5	3.8	19.0
Total Residential Damages	4.3	8.1	21.0	9.4	34.6	12.5	62.8
Commercial Structures	0.8	1.3	3.3	1.7	5.1	2.0	9.1
Commercial Contents	1.9	3.1	7.1	3.9	11.4	4.8	23.2
Total Commercial Damages	2.7	4.4	10.4	5.6	16.5	6.8	32.3
Institutional Structures	0.0	0.0	0.1	0.0	0.2	0.0	0.5
Institutional Contents	0.0	0.1	0.1	0.1	0.3	0.1	0.6
Total Institutional Damages	0.0	0.1	0.2	0.1	0.5	0.1	1.1
Total Flood Damages	**7.0**	**12.6**	**31.6**	**15.1**	**51.6**	**19.4**	**96.2**
Sea Level Rise Impact							
Damages Beyond Baseline	–	5.6	24.6	8.1	44.6	12.4	89.2
% Increase From Baseline	–	80%	351%	116%	637%	177%	1,274%

TABLE 1: ECONOMIC DAMAGES CAUSED BY 100- YEAR FLOOD EVENT WITH SEA-LEVEL RISE IN VENICE SOURCE: KING, MCGREGOR, AND WHITTET (2011)[39]

Based on the King et al. 2011 analysis, 24% of the beach area erodes with approximately 6 feet (2.0m) of sea-level rise, a small percentage compared to other beaches that may experience up to 100% of the beach eroding (e.g. Ocean Beach and Torrey Pines State Beach). Their economic estimates suggest that, "combined local and state spending losses amount to $608 million at Venice Beach following a 2.0m sea-level rise by 2100." This estimate is based on the modeled reduction in annual beach goers due to the reduced size (and thus carrying capacity) of the beach.[40] The study also reported that using beach replenishment (nourishment) to maintain the existing beach width would cost over $7 million annually. And costs for adding protective seawalls estimated for Venice Beach could amount to as much as $68 million, which would cost an estimated $2 million per year to maintain.[41]

4.3 San Pedro, Wilmington, and Port of L.A.

San Pedro, Wilmington and the Port of L.A. make up the southernmost part of the city's coastline. The Los Angeles Harbor is protected from direct wave action by a breakwater extending out from Cabrillo Beach at the point of San Pedro. San Pedro, the most directly location exposed to the coast, is situated between the Los Angeles Harbor (and port) to its east, Palos Verde Hills to its west, Wilmington to the north, and the Pacific Ocean to the south (Figure 10). San Pedro covers approximately 12 square miles and has an estimated 86,012 residents (as of 2008).[42] Wilmington, just north of the Port, is approximately 9 square miles and has a population of 54,512.[43] Over 85% of the population is Hispanic/Latino, whereas the neighboring community of San Pedro is home to a population of just over 40% Hispanic/Latino.[44] Cabrillo Beach is one of the few publicly accessible beaches in the area and is a popular destination for families because the breakwater shelters the beach from direct wave action. The breakwater also prevents tidal circulation and, as a result, the beach on the harbor side has very poor water quality.[45] Alternatively, Cabrillo Beach on the open ocean side outside the breakwater has good water quality.

Wilmington is highly exposed to several environmental hazards and has a much lower per capita income compared to San Pedro. It is situated directly behind (i.e., to the north of) the Port of L.A. with an oil refinery to its west. Both San Pedro and Wilmington already flood during heavy rain events. Even if rain events remain the same, with sea-level rise, the drainage problems can be expected to be exacerbated, affecting these areas more often and severely and extending flooding to areas further inland than historically experienced. This is particularly problematic because residents in the new flood zones may be unprepared, unfamiliar with the risk, and without necessary flood insurance to assist them in recovery. In addition, none are likely to have made structural adjustments (flood proofing) to their homes.

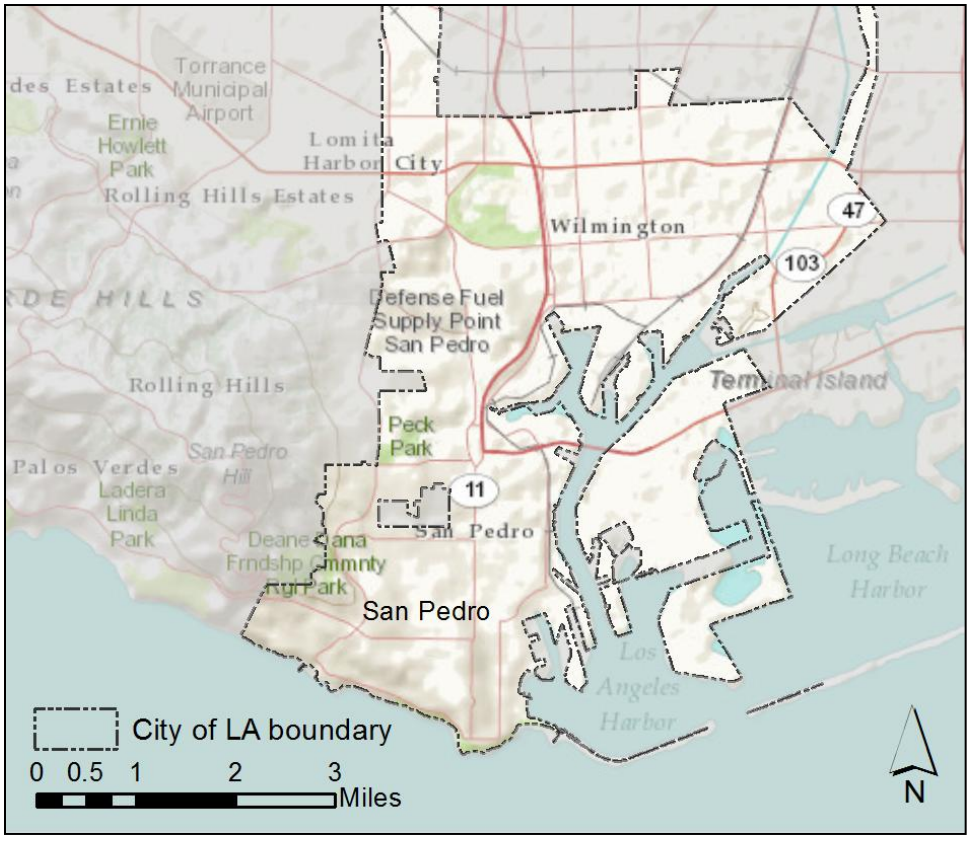


FIGURE 10: SAN PEDRO, WILMINGTON, AND THE PORT OF L.A. MAKE UP THE SOUTHERN COASTAL AREA IN THE CITY OF LOS ANGELES.

4.4 Infrastructure and Critical Services of Concern

As referred to briefly in the above community descriptions, in addition to direct exposure from coastal flooding and storm surge with sea level-rise, residents and employees of coastal communities may be at risk of and affected by flooding through infrastructure impairment. If floods damage, destroy or temporarily interrupt infrastructure, residence would be without critical services (emergency response, electricity outages, communication outages, and lack of water supply or treatment). Impairment of such services disrupts daily life of residents but also jeopardize their safety, health and well-being which can result in the flooding event turning into a disaster. In the community snapshots we briefly refer to several critical services and infrastructure at risk from sea-level rise within the communities. Other infrastructure of concern includes sea water barriers in the county (but outside city limits) that – if compromised – could lead to salinization of groundwater basins, which hold the city's water supply.[46] Other infrastructure and services at risk from flooding include wastewater treatment and drainage infrastructure, transportation routes, ports, the Los Angeles International Airport, and underground utilities.

5. Differential Vulnerability among Populations

This section presents basic statistics about the general makeup of the city population to provide essential background, but then focuses the specific population characteristics in the three coastal portions of the city and their implications of risks for flood events as sea-level rises.

5.1 Population Overview

The City of Los Angeles, which is the largest city in Los Angeles County, is 469 square miles. According to the 2010 Census, the total population is 3.8 million people, making it the largest city in California. With an average of 8,092 people per square mile, the population density within the city varies widely from highly dense urban areas in the interior to less densely populated, more secluded areas in the Santa Monica Mountains. Based on the 2010 Census of its residents, 48.5% are Hispanic/Latino, 28.7% are White non-Hispanic/Latino, 11.3% are Asian American, 9.6% are African American, and less than 1% is Native American or Pacific Islander. Just over 10% of the population is 65 years and over and 6.6% is under five years old. Nearly 40% were foreign born and 60% speak a language other than English at home. Of its residents over 25 years old, 73.7% have graduated from high school, which is slightly lower than the state's average (80%).[47]

According to the American Communities Survey from 2006-2010, the homeownership rate found that in the city is much lower than statewide at 38.9% (state 57.4%). Yet the median value of an owner-occupied housing unit is higher in L.A. with $553,900 (compared to the $458,500 statewide). Average per capita income is $27,620, which is slightly lower than the statewide average of $29,188. The percentage of the population living below the federal poverty level is an estimated 19.5%, which is significantly higher than the proportion of people living below poverty level statewide (13.7%). The actual proportion of people living in poverty is much higher given that the threshold at which the federal poverty level is defined is a very low standard of living, at just over $11,000/year for an individual (or just over $22K for a family of four) and living expenses in L.A. are quite high. The National Economic Development and Law Center found that it takes at least $54,000 or more for a family of four to be self-sufficient in Los Angeles, which means that a much higher proportion of the city's population are struggling to make ends meet in Los Angeles than is reported by the Census.

5.2 Demographic Characteristics

5.2.1 Poverty

Lower income often correlates with lower access to the necessary resources to prepare for or evacuate in the case of a disaster, or to invest in actions required to adapt to climate change (e.g. moving out of a flood plain, elevating living space in one's house above a given flood elevation or purchase sump pumps to cope with floods). The Census 2006-2010 estimated median family income in the city to be $53,312.[48] However, incomes tend to be much higher along the coast than in the interior portion of the city and county (Figure 11). The Rolling Hills portion of the County (Palos Verdes Peninsula, outside the City of L.A.) has the highest average per capita income ($128,000) along the coast, while areas in San Pedro and Wilmington are closer to $13,000 per year as the lowest income areas along the coast (Figure 11). In 2010, based on Census data and the federal poverty level threshold, is the geographic distribution of

poverty was highly variable across the city (Figure 12).[49] As of April 2012 the U.S. Bureau of Labor Statistics reports that out of a total labor force of 1.9 million in the City of Los Angeles, an estimated 12.2% (231,658) are unemployed.[50]

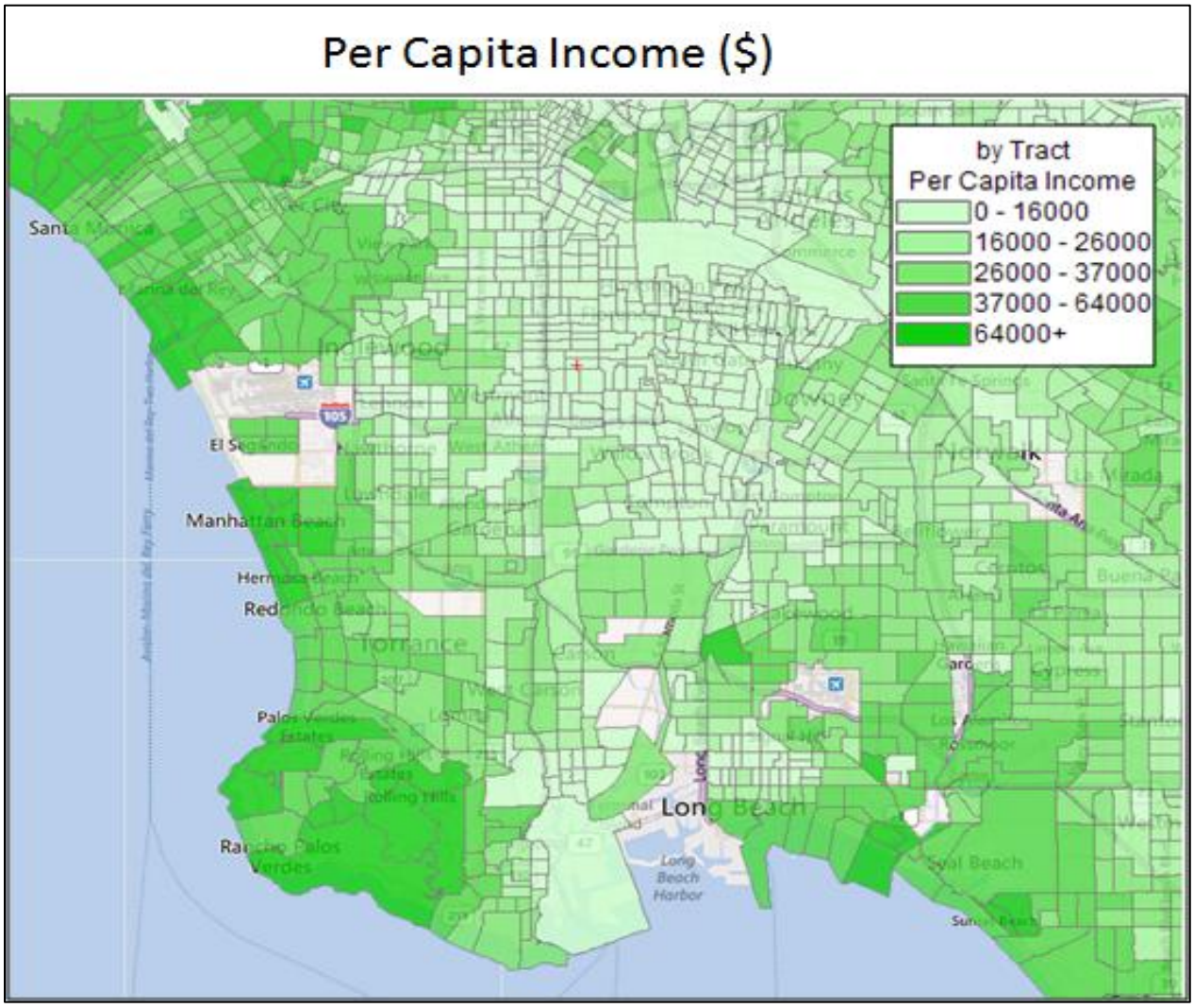


FIGURE 11: AVERAGE PER CAPITA INCOME TENDS TO BE HIGHER ALONG THE COAST AND LOWER IN THE INTERIOR PORTION OF THE CITY. THE EXCEPTION IS THE AREA AROUND THE PORT OF L.A. WHERE A LARGE PORTION OF HOUSEHOLDS FALL BELOW THE FEDERAL POVERTY THRESHOLD. (SOURCE: AMERICAN COMMUNITY SURVEY CENSUS 2006-2010, EPA EJVIEW 2012[51])

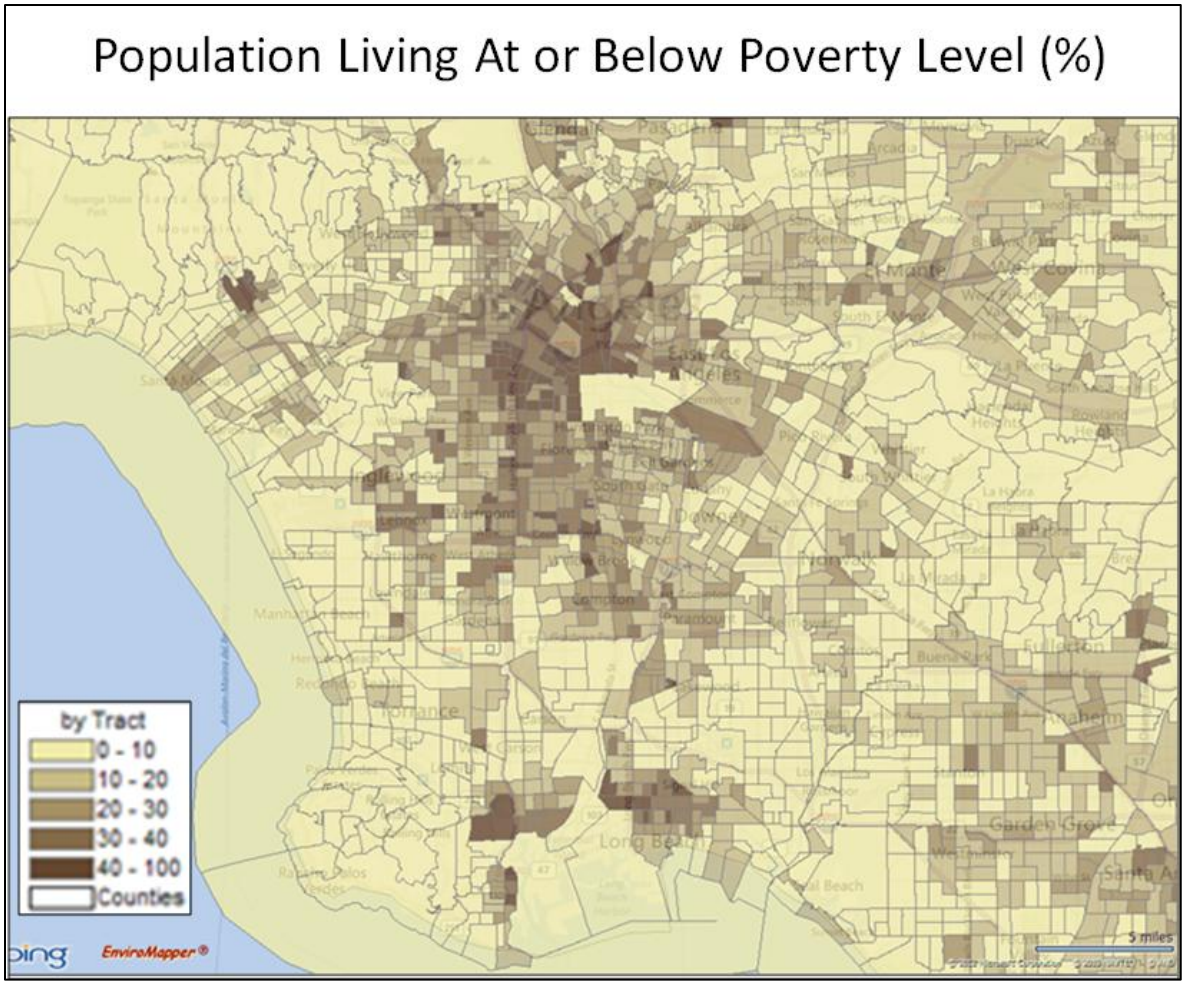


FIGURE 12. PERCENTAGE OF PERSONS LIVING AT OR BELOW THE FEDERALLY-DEFINED POVERTY LEVEL BY CENSUS TRACT ($17,500 FOR A FAMILY OF THREE). (SOURCE: AMERICAN COMMUNITY SURVEY CENSUS 2006-2010, EPA EJVIEW 2012[52])

What emerges from these two income-related maps (Figure 11 and Figure 12) is that the highest concentration of low income and poverty is in the central portion of the city and county, with the addition of the communities surrounding the Port of L.A. The 2006-2010 American Community Survey Census estimates that over 76% of the census tract population on the west side of Wilmington lives below the federal poverty level. Some residents counted as "low income" in L.A. County may include student populations, especially in areas adjacent to Los Angeles's many universities and colleges (e.g. UCLA in Westwood, USC southwest of Downtown Los Angeles, Loyola Marymount in Westchester, and Cal State Northridge). Detailed empirical work would be required to ascertain whether these student populations are truly low-income or have access to their parents' funds and so would have relatively high adaptive capacity to recover from a major flood event. However, during a disaster because they often live away from their families, students rely largely on their college or university to inform them of how to respond and where to go. Not all may have cars to leave at-risk areas.

In addition to students, low-wage labor employees in the service industry are particularly prevalent throughout the city, but especially in popular tourist destinations, including Venice Beach. Income is one

of the most important indicators of lower adaptive capacity, and can be addressed through special needs-related programs or by creating opportunities for low-income populations to make a better living (e.g., through education and training programs, providing a living wage, diversifying the economy). In many low income communities, active community-based organizations have strong relationships with the people in these neighborhoods and can provide a voice to express their needs and represent them in adaptation processes. Inviting representatives from these organizations or from the communities themselves can be useful to developing adaptation strategies that reduce impacts of sea-level rise on the most social vulnerable.

5.2.2 Lower Education Can Undermine Adaptive Capacity

Some studies have found that lower educational attainment correlates with lower adaptive capacity to deal with extreme events. The connection between education and the ability to deal with disasters and change may link to lower income, a lower capacity to obtain and understand emergency preparedness and response information, lack of access to health care, and various types of insurance, and some degree of disenfranchisement from society. Figure 13 shows the distribution of individuals (in percent) in each Census tract over 25 years old that have not graduated from high school. As of 2012, in terms of education, 73.7% of the city's population 25 years and older were high school graduates (compared to 75.9% countywide, and 80.7% statewide).[53] People with less education thus require a different level of attention and assistance from public agencies than those with greater resources of their own.

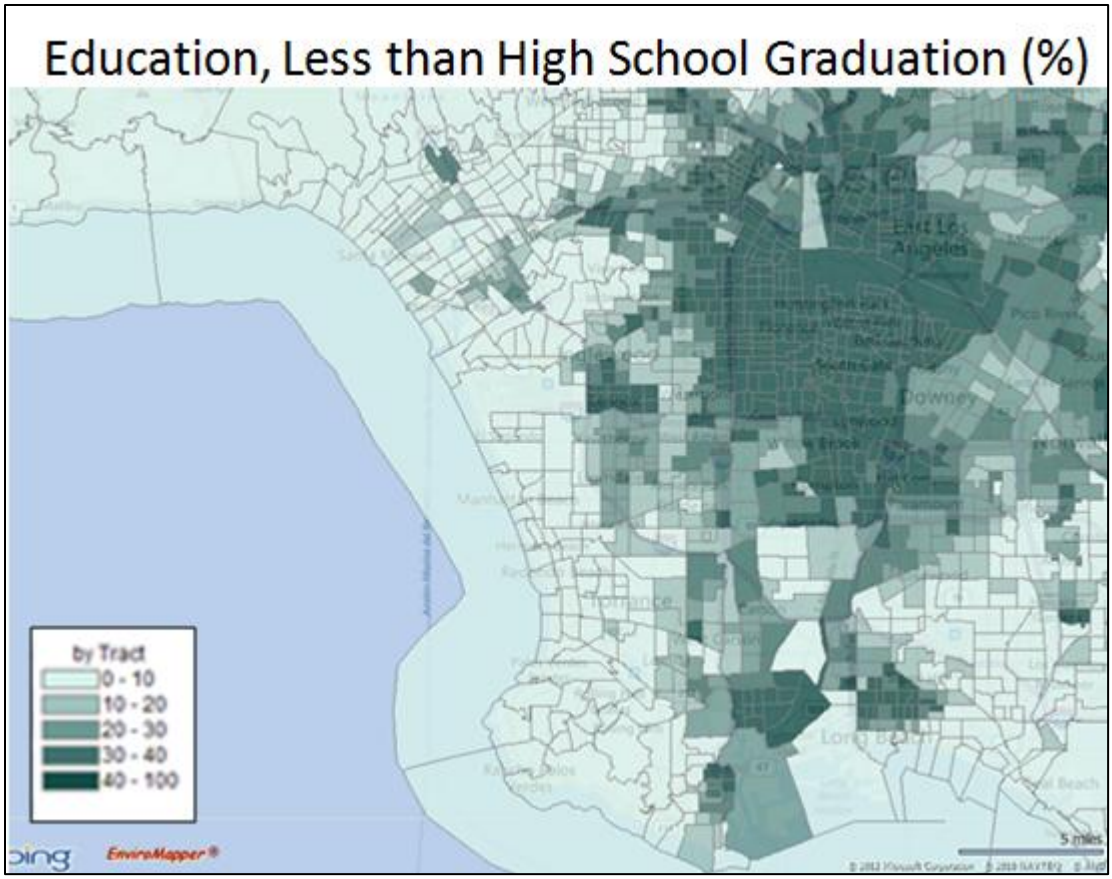


FIGURE 13: PERCENTAGE OF PEOPLE OVER 25 YEARS OLD THAT HAVE NOT GRADUATED FROM HIGH SCHOOL. (SOURCE: AMERICAN COMMUNITY SURVEY CENSUS 2006-2010, EPA EJVIEW 2012[54])

One segment of the population, often closely aligned with the spatial distribution of low income, involves women as head of the household. Women's capacity to prepare for flooding, cope with or evacuate during flooding or an associated hazard during a large storm, and recover afterward is particularly impaired when they are the sole providers for their household, especially when they have children.[55] Evacuating during a flood can be especially difficult for those who have young children. Figure 14 shows that majority of single women with children reside in the interior of Los Angeles, but there are some higher concentrations in San Pedro and Wilmington.

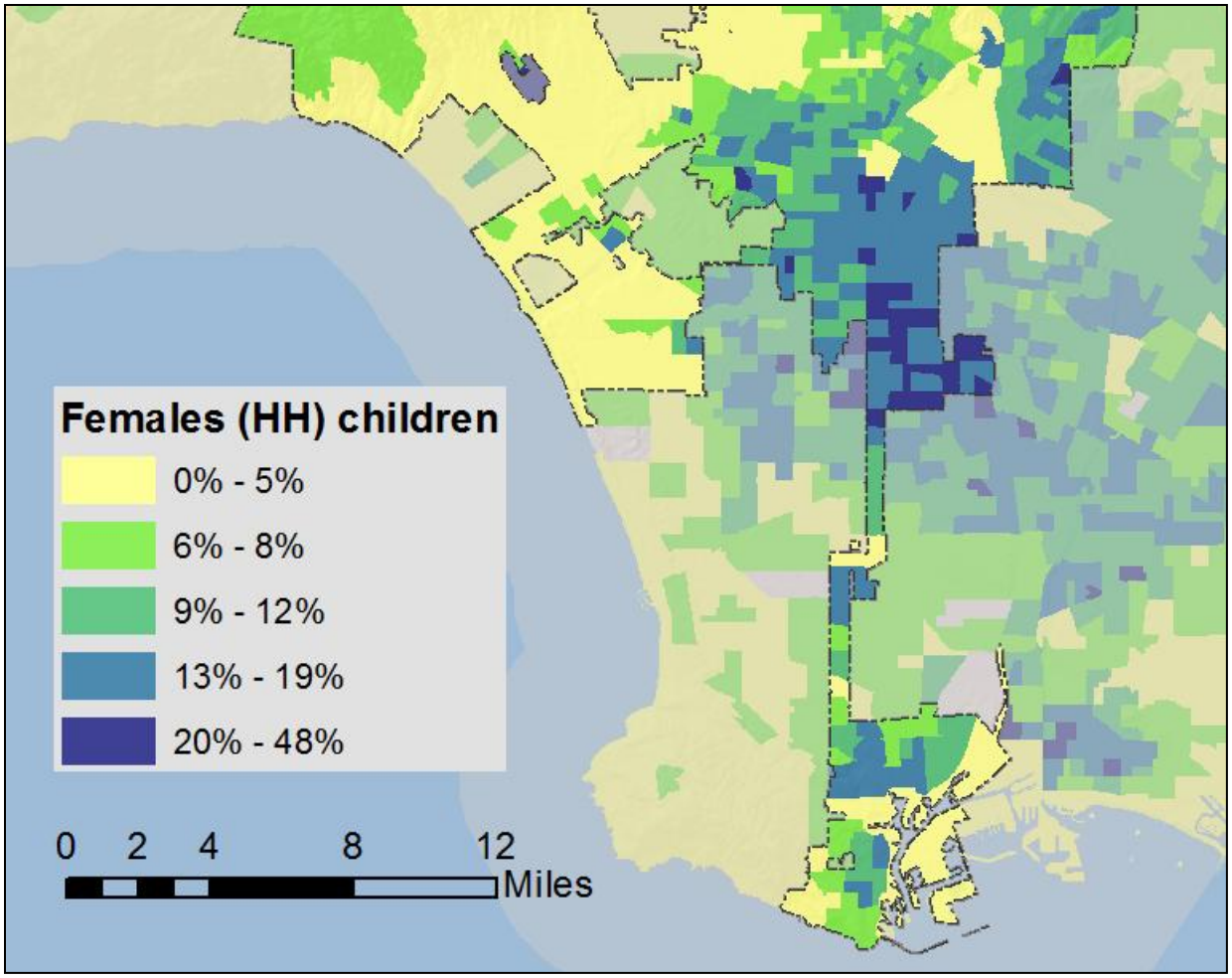


FIGURE 14: PROPORTION OF THE POPULATION WHO ARE FEMALE HEADS OF HOUSEHOLD AND WHO HAVE CHILDREN (SOURCE: CENSUS 2010 DATA).

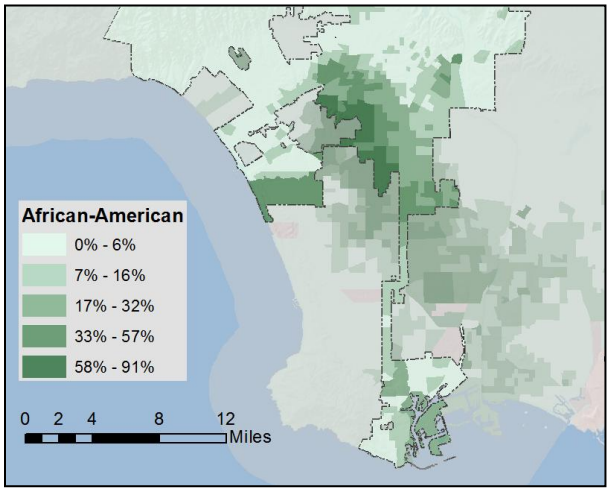
5.2.3 Race and Environmental Injustice in Adaptive Capacity

Studies of public health and vulnerability to disasters repeatedly indicate that minority populations tend to have lower capacity for responding to disasters and adapting to climate change than non-Hispanic whites.[56] This was true particularly in New Orleans after Hurricane Katrina that African Americans were less likely and able to evacuate and were then hit hardest in terms of trying to rebuild their lives in the aftermath of the disaster. Recent failures of emergency response in San Pedro and Wilmington during the January 2010 flood also demonstrate the importance of assistance during flooding events to be designed to the particular needs of different demographic groups in the community. In 2010 many residents in the San Pedro and Wilmington communities were flooded out of their homes and needed shelter. The American Red Cross opened a shelter in a local home for the elderly, but the flood victims did not know about the shelter and those who did were not comfortable going there. Since very few came to the shelter, it was closed pre-maturely based on the assumption that no one needed assistance. Instead, the flood victims who were mostly of Latino descent, many of whom were undocumented and did not speak English, went to a local non-profit social services agency (the Toberman Settlement

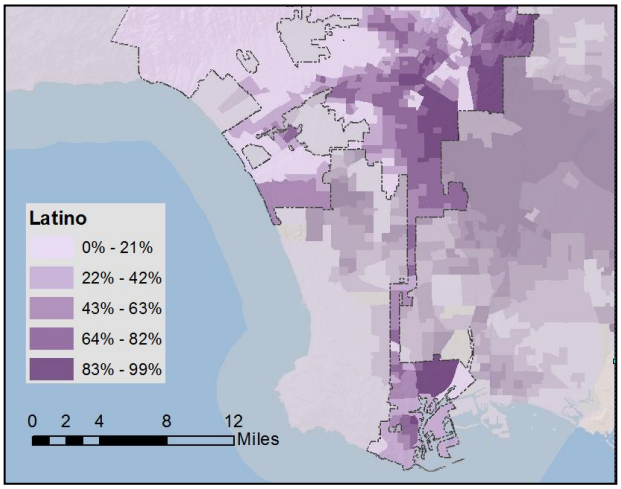
House/Neighborhood Center) that is set up to work with the Latino community. However, this center was not prepared to accommodate flood victims. The experience shows the value – and necessity – for emergency response planers to do important work to get to know and understand the community, in order to be better able to meet the needs of the population.[57]

Figure 15 (A, B, C and D) shows the distribution of African American, Hispanic/Latino, Asian American, and Pacific Islander/Native American segments of the population. In coastal communities within the City of Los Angeles, there are very high concentrations of Latino/Hispanic populations residing in the eastern portion of San Pedro (closest to the inner Harbor/Port) and throughout Wilmington, as well as some small areas of Latino populations in Venice and El Segundo. African Americans are mainly concentrated in the interior of Los Angeles, but some higher concentrations (compared to the rest of the coast) reside in San Pedro, Wilmington and Long Beach (the latter outside of the City of Los Angeles' boundaries).

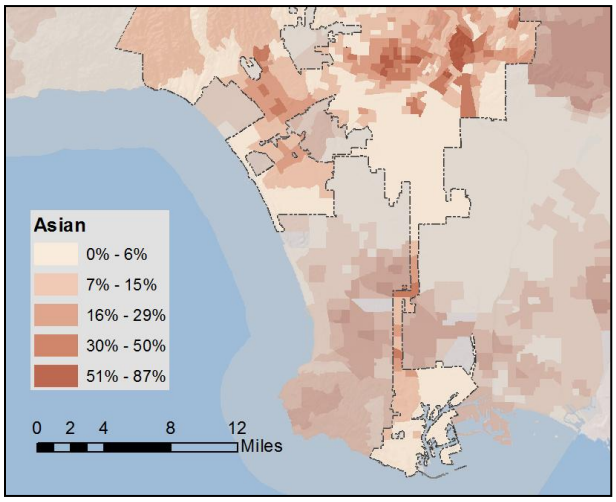
A. Percent African American



B. Percent Hispanic/Latino



C. Percent Asian



D. Percent Native American/Pacific Islander

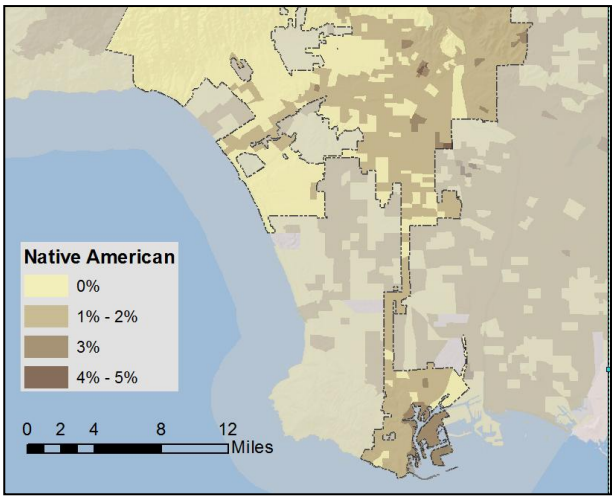


FIGURE 15: THE GEOGRAPHY OF RACE IN LOS ANGELES BY PERCENTAGE OF THE TOTAL POPULATION. THE BOUNDARIES OF THE CITY OF LOS ANGELES IS INDICATED BY THE BLACK DASHED LINE (SOURCE: CENSUS 2010).

Other studies have shown that the likely reason for the correlation between race and lower adaptive capacity is the disproportionate amount of poverty and lower incomes among African Americans and Hispanics compared to White/non-Hispanic segments of the population. Also, in minority populations where English is not the first language spoken, linguistic proficiency can also play a role, as noted above in the January 2010 flood response in San Pedro. Other factors, such as individuals and families being tightly embedded in social networks within a community, may compensate to some extent, and could either increase or decrease adaptive capacity (see below).

5.2.4 Inadequate Language Skills and Cultural Isolation Reduce Adaptive Capacity

Immigrants born outside the United States and/or individuals not fluent in English may be culturally and linguistically isolated. Among other social and economic disadvantages, this cultural and linguistic isolation can make it difficult to access or receive important information for preparing for and responding to weather- and climate-related emergencies. These linguistic and cultural differences of the Latino flood victims in San Pedro and Wilmington in January 2010 raise clear environmental justice concerns.

Between 2006 and 2010 an estimated 39.6% (1.5 million) of the city's population was foreign born compared to the county's 35.6% and the state's 27.2%.[58] The Census estimates show that of the foreign-born population, 73% have been here for at least ten years, giving them time to get settled, learn the language, and build a community support network. The remaining 27% should be of greater concern to emergency and adaptation planners. Of the foreign-born population, nearly 60% (just under 900,000) are not U.S. citizens.[59] Of the population 5 years and over, the Census estimates that in the 2006-2010 period, 59.6% of the city's population (approximately 2.2 million individuals) spoke a language other than English at home, and approximately 30% speak English less than "very well".

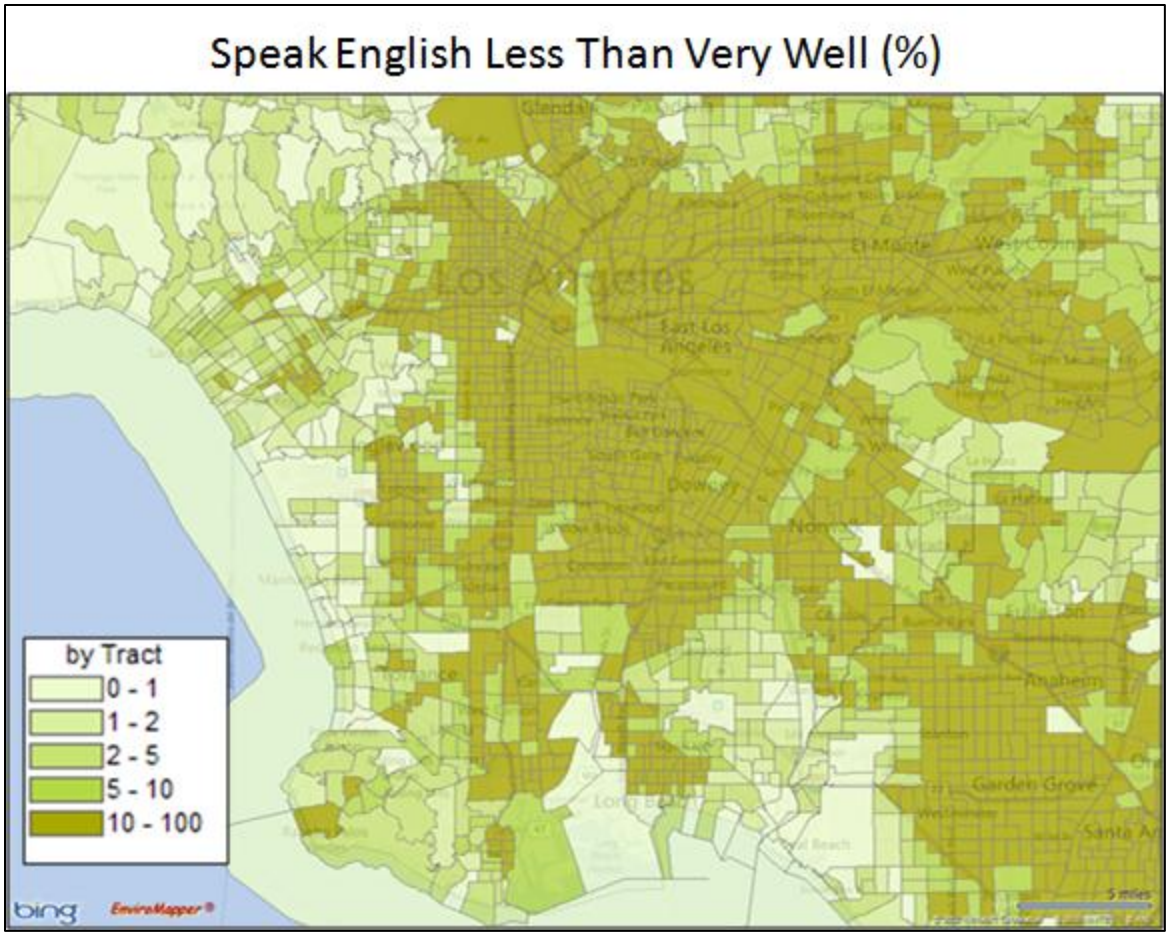


FIGURE 16: PERCENTAGE OF THE POPULATION (PER CENSUS TRACT) THAT SPEAKS ENGLISH LESS THAN VERY WELL. THE BOUNDARIES OF THE CITY OF LOS ANGELES IS INDICATED BY THE BLACK DASHED LINE.. (SOURCE: AMERICAN COMMUNITY SURVEY CENSUS 2006-2010, EPA EJVIEW 2012[60])

It is important that adaptation planning not neglect these populations and provide them with the necessary information, services, and engagement opportunities in their native language or with translators. Many who are not fluent in English may also be more shy to be proactive and publicly engaged in planning processes, so may require specific attention to be reached at all. During major rain or flooding events, especially as the sea rises, these individuals may require essential information in the language most familiar to them.[61] After disasters, non-native speakers may require special assistance working through difficult-to-understand disaster assistance applications and bureaucratic procedures. Relatively new arrivals in the community may not yet be socially connected and thus be easily forgotten, not noticed, and less familiar with available services. To begin to address the need to better prepare the San Pedro and Wilmington communities for such emergencies, the non-profit organization *COPE Preparedness* ran an all-Spanish language emergency preparedness workshop in July 2012.[62] Given that many residents do not have access to computers, outreach includes working with community organizations, such as *United Way* to get the message out through children (who will then help deliver those messages to their parents) at Boys & Girls Clubs and the *YMCA*, and through fliers targeting those who can read.

5.2.5 Limited Mobility of the Elderly Limit Coping Capacity in Disasters

Age can play a role in coping and adaptive capacity as well. Infants and the elderly are less able to protect themselves from extreme conditions (e.g. in extreme heat or flood events) and may rely on others for special assistance in times of flooding. For example, the elderly are considered to be more vulnerable than the younger adults in emergency situations because of possible mobility challenges and may be less connected to email or other typical public outreach tools that inform residents about preparing for disasters. Cooler summers and better air quality also attract older populations to coastal communities all along California's coastline, including in Los Angeles. Thus, there are higher concentrations of elderly along the coast throughout the county's shoreline, especially in Pacific Palisades within the city boundaries, and also in Palos Verdes and Malibu (Figure 17).

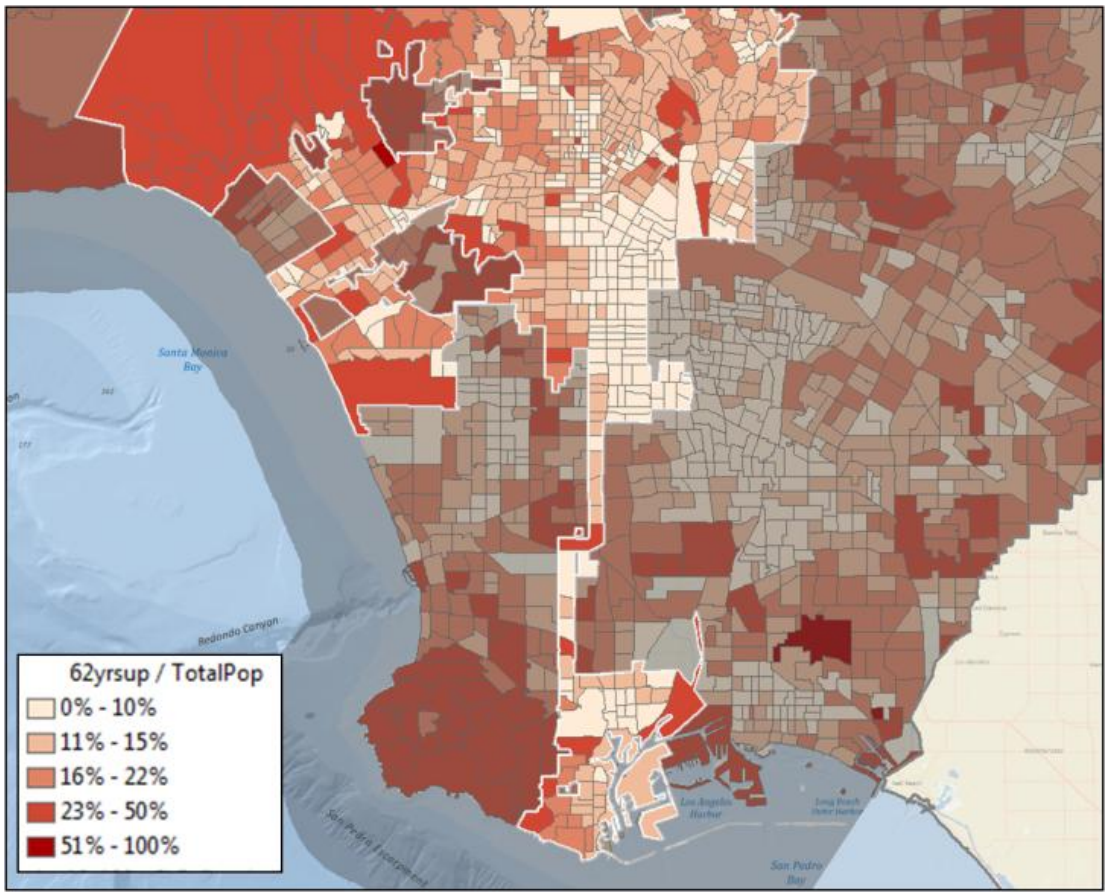


FIGURE 17: MAP SHOWING CONCENTRATION OF PEOPLE 62 YEARS AND OLDER (SOURCE: CENSUS 2010). ELDERLY POPULATIONS ARE ATTRACTED TO COASTAL LIVING BECAUSE OF THE COOLER SUMMER TEMPERATURES AND BETTER AIR QUALITY.

Special attention and services are needed to meet these communication and mobility challenges, as well as pre-existing health conditions that may inhibit the responsiveness of infants and older residents to emergency warnings.

5.2.6 Housing Type and Control over the Living Situation Affects Adaptive Capacity

Home Ownership vs. Renting

Housing also tends to be a factor in people's ability to prepare, respond to, recover from flood events and adapt to sea-level rise. Home ownership versus renting indicates, again, income distribution. However, with regard to adaptive capacity, it also indicates how much control individuals have over their housing, e.g., to make structural adjustments to their home for flood protection.

In 2010, the Census estimated that there were a total of 1.4 million housing units in the city.[63] The median price of a house sold in between 2006-2010 was $553,900, although this varied considerably by section of the city with higher prices typically found along the coast. There were an estimated 814,305 renter-occupied housing units citywide (61.8% of all housing currently in use),[64] though with considerable variation: the interior portion of the city had the highest concentration of renters and much higher home ownership along the coast, especially in Pacific Palisades and other wealthy coastal areas outside of the City of L.A. (but within L.A. County). San Pedro and Wilmington have areas with very high proportion of renters (over 80%), as does Venice (between 45-80% for the area potentially flooded, see Figure 9). Other very high concentrations of renters along the coast can be found in Long Beach.

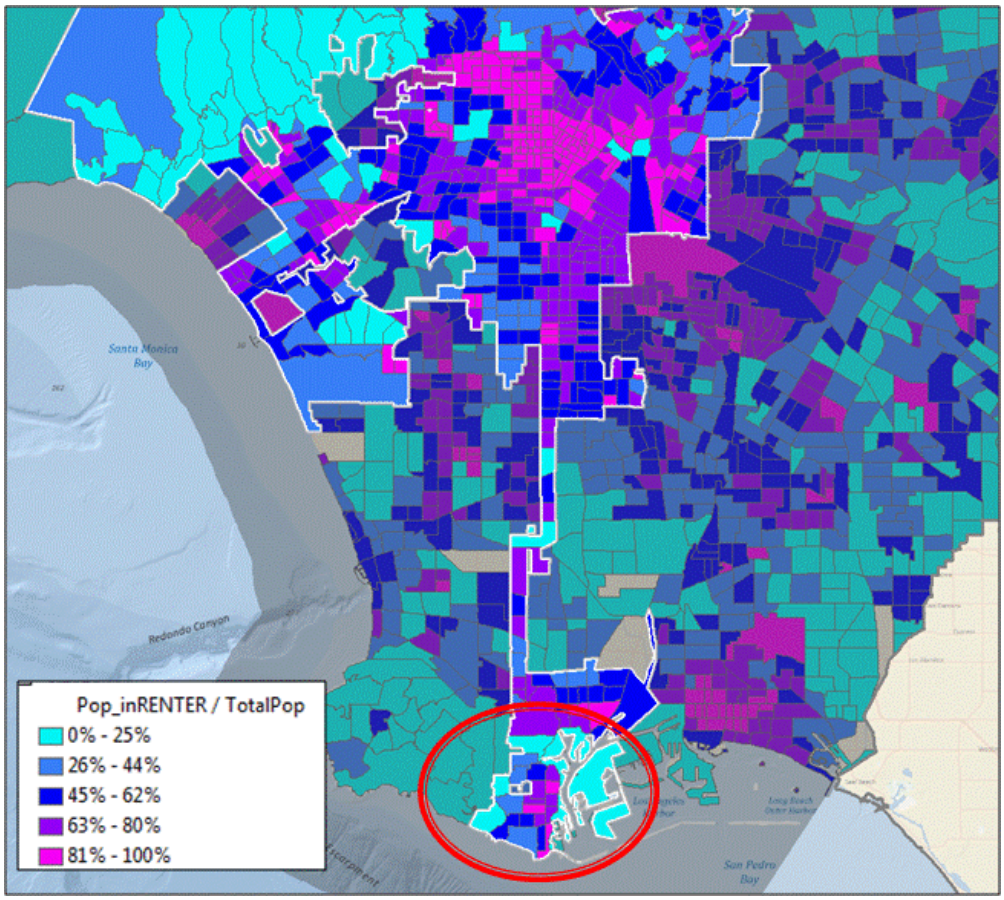


FIGURE 18: PERCENTAGE OF HOUSING UNITS IN USE THAT ARE RENTED. AREA SUURROUNDING THE PORT (CIRCLED IN RED) HAS A PARTICULARLY HIGH CONCENTRATION OF RENTERS (SOURCE: CENSUS 2010)

Mobile Homes

Another population that is of special concern includes those living in mobile homes because of those homes' sensitivity to flooding and potential inability of families living in those homes after the event (due to low income). The sensitivity of mobile homes is related to the manner in which they are constructed and to the lower degree of anchoring to the ground, which increases the risk of damage, dislocation, and debris-related damage in case of floods and storms. A rent-controlled mobile home park in Pacific Palisades, *Palisades Bowl*, is located along Pacific Coast Highway. By the same token that sensitivity to floods is high during storms (less stable construction and anchoring), long-term adaptation may be easier for structures that can be elevated and moved more easily, as long as road access and sewage is still functional. Thus, this type of housing requires locally targeted emergency response and long-term plans.

Homeless Population

Another population that is at major disadvantage during a disaster or other hazardous event includes those people without a permanent home. Homeless individuals living in coastal areas could be directly exposed to flood events because of living in the streets or in a parked vehicle. Very little information is usually collected to document the location and living situation of this population, making it difficult for emergency response during a disaster to find and help this population. Public education and awareness campaigns or emergency preparations as pre-disaster planning often do not reach this population, and the homeless do not have adequate means to move to new unfamiliar locations. According to representatives from the Venice Beach Neighborhood Council, Venice has a particularly high concentration of homeless residing in that coastal community.[65] This segment of the population is also of particular concern given that they may not be able or willing to evacuate during a disaster, or go to shelters.

Del Playa (just south of Venice and Ballona Creek), as part of the Westchester/Playa Neighborhood Council, has demonstrated a growing concern about homeless individuals living in the streets and in vehicles. In collaboration with several government and non-governmental organizations, they conducted a survey of the homeless population over the course of one evening in September 2010.[66] They found 48 individuals, mostly white, male and less than 60 years old. Of the thirteen interviewed, the survey reported that 54% had serious health issues, 33% had mental health issues, and 33% reported to have substance abuse issues. Over half the interviewees were homeless because they had lost their housing. Most slept in either a vehicle or on the street. Organizations and community-based programs working with the homeless can be a vital resource in disaster preparedness, response and recovery to make sure those without permanent housing receive the assistance they need. This will be especially problematic for residents as sea level rises and flooding events extend further inland into new areas not prepared for such events.

Age of Housing

Another condition of concern is that the age of housing indicates a potential sensitivity to flooding and sea-level rise. Newer housing tends to be designed to deal with historical climatic conditions. Older

housing, especially when owners do not have the income to make their homes flood-proof, can be more susceptible to flooding. Figure 19 shows the distribution of housing built before 1950.

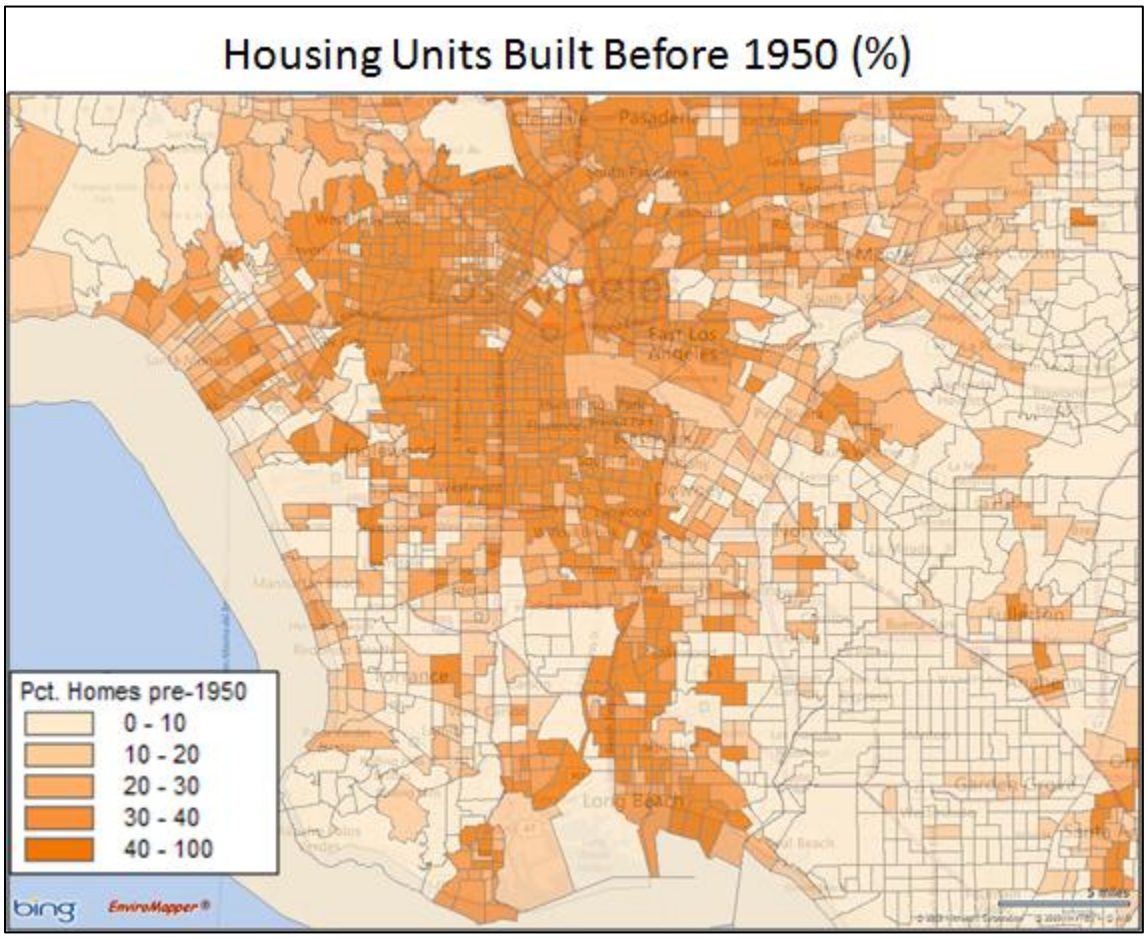


FIGURE 19: PERCENTAGE OF HOUSING UNITS BUILT BEFORE 1950 (SOURCE: AMERICAN COMMUNITY SURVEY CENSUS 2006-2010)

OF SPECIAL CONCERN: UNDOCUMENTED IMMIGRANTS AND INSTITUTIONALIZED POPULATIONS

Age of housing may also point to the prevalence of flood insurance policies although such data can be directly obtained from the Federal Emergency Management Agency and the National Flood Insurance Program (NFIP).[67] While compliance with NFIP requirements is historically lacking, homes that no longer have a mortgage are less likely to be insured under the flood insurance program. Thus, vulnerability of these older homes may also be increased because of the lack of insurance coverage which could help home owners rebuild after damage.

5.2.7 OF SPECIAL CONCERN: INSTITUTIONALIZED, HEALTH IMPAIRED, AND DISABLED POPULATIONS

Three additional populations are of special concern in the City of Los Angeles' coastal communities: the institutionalized populations, those with pre-existing health issues, and disabled populations.

Institutionalized Populations

Institutionalized populations (such as in prisons, hospitals, senior citizens homes, kindergartens, schools and colleges) are reliant on institutional emergency provisions, the facility's response measures during times of disaster for support, and the institution's long-term plans. The Federal Correctional Institution, *Terminal Island*, a low security facility for male inmates is located right along the coast at the entrance to the Los Angeles Harbor. It has a population of nearly 1,200 prisoners and is managed by the Federal Bureau of Prisons. Other organized group residences located in potential future flood areas include several group sober/rehabilitation and elder care homes in Venice Beach.[68] San Pedro also has several nursing homes for the elderly, two of which are located in low-lying areas near the harbor (*Harbor Tower* and *Harbor Terrace*). These group homes may be at higher and increasingly frequent risk of flooding as sea level rises, demanding appropriate preparatory measures from these institutions to address the particular vulnerability of their residents. A recent federal study published by the Office Health and Human Services Department of nursing home emergency preparedness found that they often have inadequate emergency plans for disaster response and recovery. Gaps identified in the report included lack of reliable transportation contracts, need for improved coordination with local emergency management, and lack of support for nursing home residents during disasters, especially for those needing long term care.[69] The concern for nursing home residents and other populations living in group homes has increased recently in Venice. The Venice Neighborhood Council in June 2012 discussed the need for emergency responders to know the locations of these group homes in and around Venice.[70]

Mentally and Physically Impaired

Populations with physical and mental disabilities are of special concern for disaster planning and emergency response. People with physical and mental illnesses can have a greater sensitivity to high levels of stress during disasters. Permanent relocation for adaptation purposes may be equally stressful. Existing illnesses or disabilities may impair individuals' mental and/or physical abilities to respond to extreme events and make it especially difficult to recover. Facilities providing services for those with mental health issues and physical disabilities need to have a plan that is coordinated with the local emergency response, have pre-determined shelters to go to during a disaster, and ensure that emergency response is educated about the special needs of these populations (e.g. they may require more personnel and special assistance during an evacuation). It is important for emergency responders to know where these people reside, whether they live on their own or rely on a group living facility. The *Disability Rights Legal Center* in Los Angeles cites the city as having approximately 800,000 residents with some degree of disability.[71] Although the US Census from 2006-2010 collected information about disabled populations, we could find no readily available data for the City or County of Los Angeles to confirm this large number reported by the *Disability Rights Legal Center*. The City General Plan documents that 546,374 individuals ages 16-64 years have disabilities, making up 16% of the citywide population (in 2000).[72] As many as 22% of the adult population (16 to 64 years old, 546,374 persons) lives with a disability and does not live in an institutionalized home or in group living quarters. Nearly one quarter of disabled adults aged 16-64 years have some type of physical limitation, which could inhibit or slow these individuals' ability to get out of the flood zone in case of an emergency. Similarly, as many as two thirds of adults over 65 years have physical limitations, and 31% of those 65 years and older have a vision or hearing limitation that may reduce their ability to act swiftly and safely in case of a

flooding emergency (further details in Table 2). Documenting where disabled persons reside would be a useful step to make sure shelters and emergency response had appropriate provisions to meet victims' needs during an emergency. Since such location data is not easily available, it is up to the City or organizations representing the interests of these populations to document through an empirical survey or some other method where the disabled live, the nature of their disability, and what needs they may have in an emergency.

The City of Los Angeles is already making some efforts in its emergency response plan to accommodate the needs of physically disabled individuals. This effort has been encouraged by the *Disability Rights Legal Center*'s lawsuit filed in 2009 against the City for having inaccessible public spaces. The lawsuit was prompted by a then-negligent emergency response plan for disabled, leaving many stranded during evacuations. Important planning for evacuation transit that can accommodate wheelchairs and making emergency shelters wheel-chair accessible are important concerns that the *Center* expressed. Even plans for assisting those disabled or with medical conditions who depend on extra medicines (and refrigeration for these), and medical instruments (e.g. dialysis, oxygen) need to be a part of emergency planning considerations.

TABLE 2: PREVALENCE OF DISABILITY BY TYPE OF DISABILITY IN CITY OF LOS ANGELES (SOURCE: GENERAL PLAN, HOUSING ELEMENT CITY OF LOS ANGELES 2009, P1-15[73], FROM CENSUS 2000)

Type of Disability	Ages 16 to 64	Ages 65+
Sensory limitation (includes vision and hearing limitations)	8%	31%
Physical limitation (includes any condition that limits physical activities such as walking, climbing stairs, reaching, lifting or carrying)	22%	66%
Mental disability (includes any physical, mental or emotional condition lasting six months or more that makes it difficult to learn, remember, or concentrate)	15%	32%
Self-care limitation (includes any physical, mental or emotional condition lasting six months or more that makes it difficult to dress, bathe, or get around inside the home)	8%	27%
Going-outside-home limitation (includes any physical, mental or emotional condition lasting six months or more that makes it difficult to go outside the home alone to shop or visit a doctor's office)	50%	54%
Employment limitation (includes any physical, mental or emotional condition lasting six months or more that makes it difficult to work at a job or a business)	68%	n/a

Source: Census 2000

5.2.8 An Integrated Perspective on Social Vulnerability

The demographic characteristics described above are well-known to the hazards and climate vulnerability research communities. Scholars of vulnerability have developed several ways to integrate multiple facets of vulnerability in a single index, as briefly described in the Introduction. Here we summarize a thoroughly vetted and widely used index, developed by the Hazards and Vulnerability Research Institute at the University of South Carolina and a recent climate change-specific index developed by the California Department of Public Health. The results differ slightly because the set of variables used and the methods to calculate the index differ, but key aspects are similar and confirm our findings.

Social Vulnerability Index

The social vulnerability index (SOVI) is a method, developed by Susan Cutter and colleagues at the University of South Carolina. It integrates 32 Census variables to create a picture of relative social vulnerability within a given region.[74] This provides an objective snapshot of where the populations reside that are associated with low adaptive capacity and high sensitivity to hazardous events. Results for the entire Los Angeles County area (Figure 21) show that overall, the highest social vulnerability is concentrated in the interior portion of the county – i.e. the center of the City of L.A. Pacific Palisades ranks as having low social vulnerability, as expected from the demographic and socioeconomic data described before. Venice Beach also ranks as low, which is not entirely consistent with on-the-ground conditions, given numerous vulnerable populations and group housing.

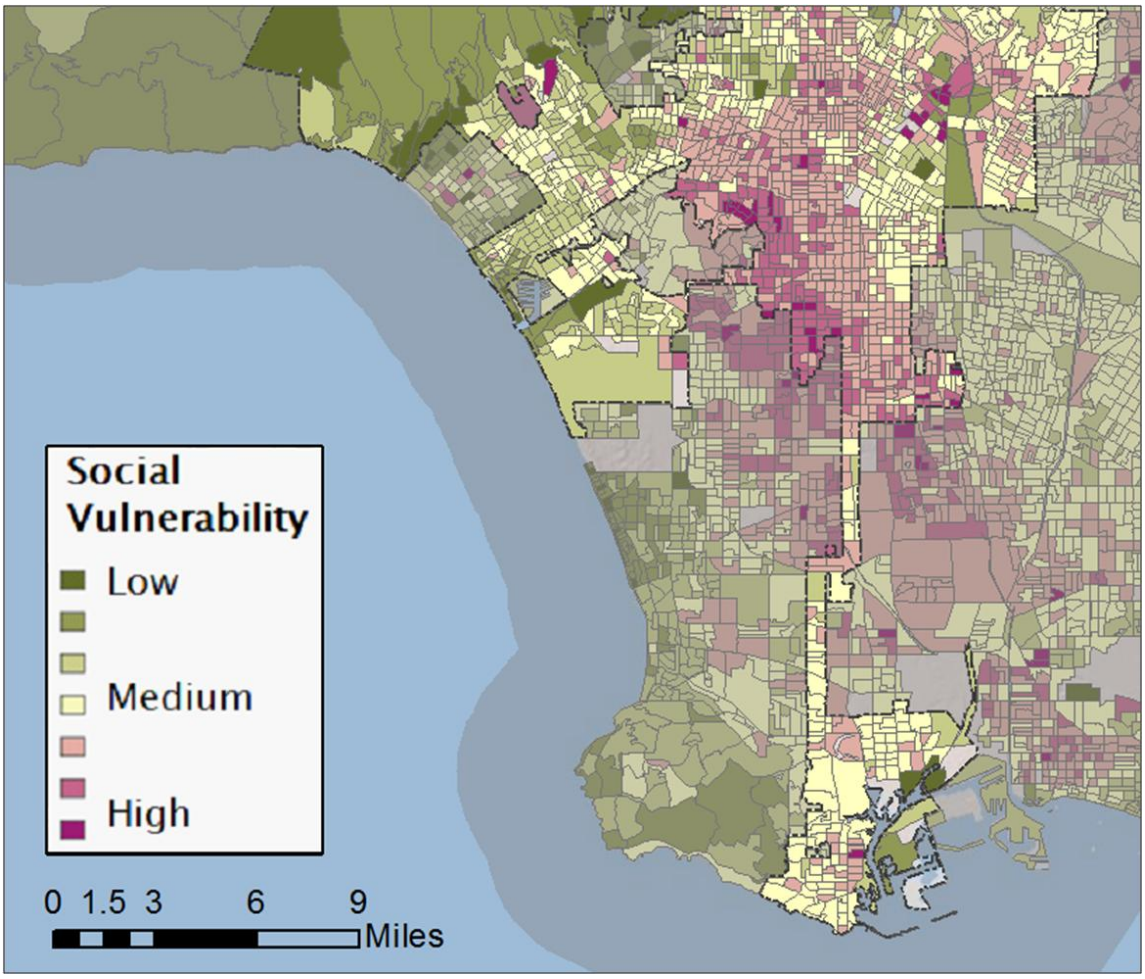


FIGURE 20. THE SOCIAL VULNERABILITY INDEX (SOVI) PROVIDES AN INTEGRATED VIEW OF A POPULATION'S SOCIAL VULNERABILITY. THE INDEX INTEGRATES 32 SOCIOECONOMIC AND DEMOGRAPHIC VARIABLES. (SOURCE: CENSUS 2000 DATA, INTEGRATED SUMMARY PROVIDED BY NOAA COASTAL SERVICES CENTER)[75]

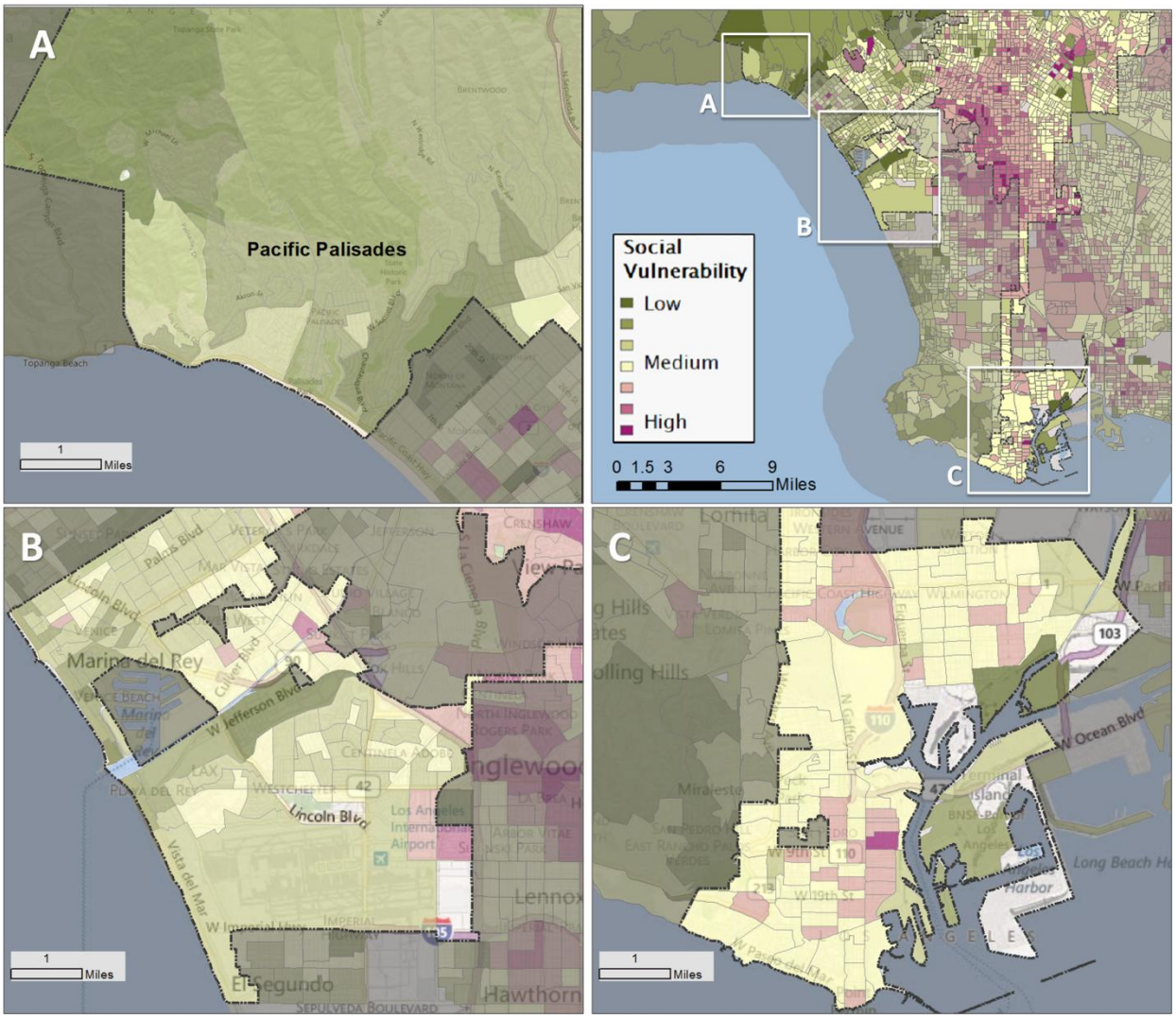


FIGURE 21: THE SOCIAL VULNERABILITY INDEX (SOVI) IN THREE SHORELINE COMMUNITIES IN THE CITY OF LOS ANGELES. PACIFIC PALISADES ("A" UPPER LEFT), VENICE AND PLAYA DEL REY ("B" LOWER LEFT), AND SAN PEDRO AND WILMINGTON SURROUNDING THE PORT OF LOS ANGELES ("C" LOWER RIGHT). (SOURCE: CENSUS 2000 DATA, INTEGRATED SUMMARY PROVIDED BY NOAA COASTAL SERVICES CENTER)[76]

COMMUNITY VULNERABILITY TO CLIMATE CHANGE SCREENING TOOL

The California Environmental Health Tracking Program in the California Department of Public Health developed and piloted a different index of social vulnerability to identify vulnerable communities. This tool is particularly useful for the City's adaptation planning process because it was piloted in Los Angeles County. It takes into consideration social factors that relate to increased sensitivity and reduced adaptive capacity for flooding, heat waves, air quality, and wildfires. It includes a similar (but not the same) set of factors as the SOVI developed by Cutter and colleagues, but also incorporates layers of exposure to climate change impacts in the analysis. By contrast, the SOVI (Figure 21) only shows a combination of sensitivity and adaptive capacity, whereas the Climate Change Community Screening Tool (CCCST) also incorporates coverage of exposure to the risks from climate change, as well as risks associated with environmental justice issues (such as proximity to existing hazardous locations such as refineries and brownfields). Figure 22 shows the CCCST for L.A. County and reveals much higher vulnerability scores for coastal areas than those found in the SOVI. Based on their analysis, much of

Venice and Playa del Rey are at "high risk" as is the coastal Census tracts of Pacific Palisades (Figure 22) because it already integrates flooding risks from a 1.4m sea-level rise. The CCCST study also found clear racial disparities with African Americans and Latinos at higher risk of climate change stressors than Whites. They also found that in terms of income levels that households with lower income are at higher risk from climate change stressors. Thus, in terms of the socioeconomic variables the two indices are highly consistent with each other. The only true difference is the integration of physical risks associated with climate change, which – logically – should and does result in higher vulnerability scores.

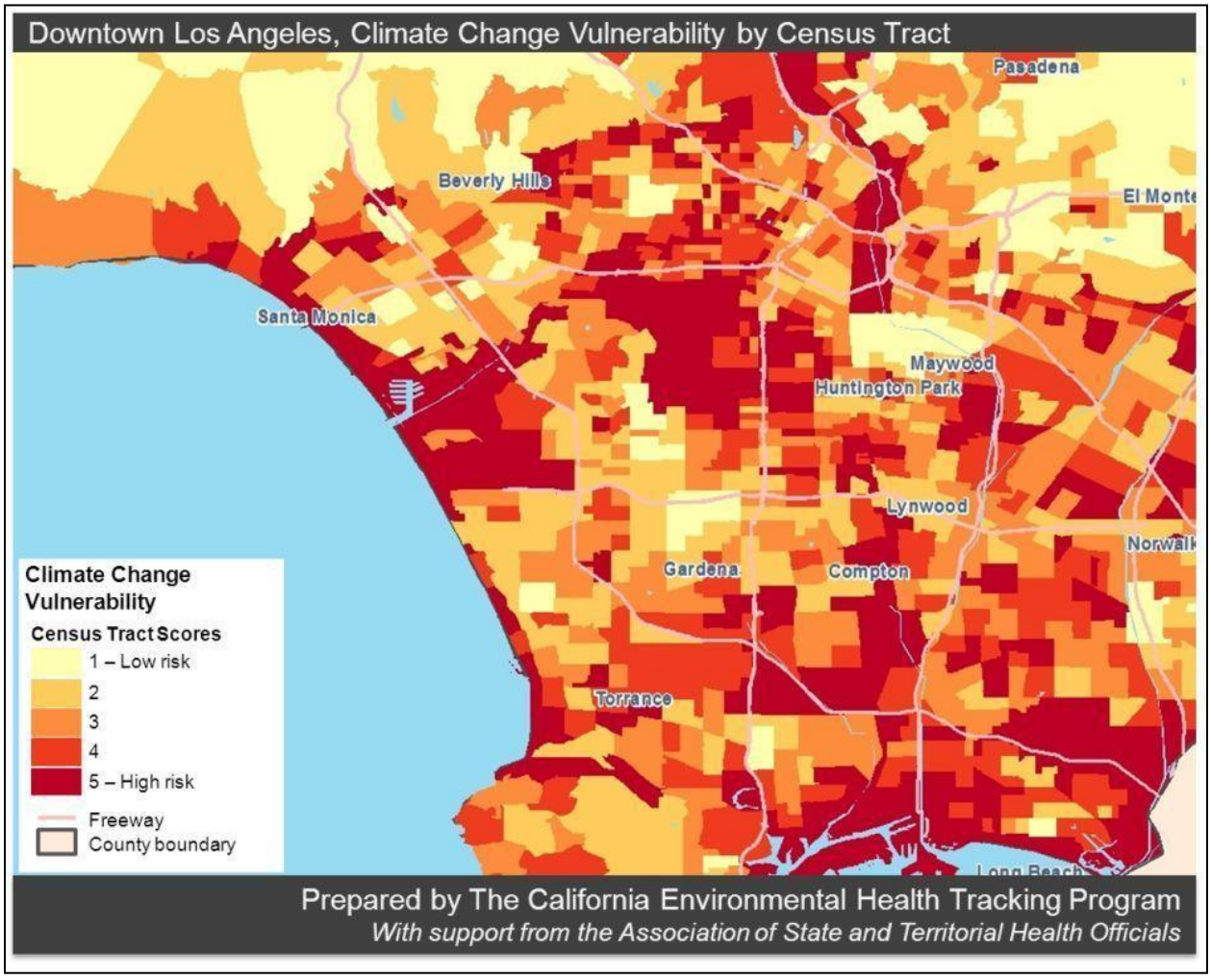


FIGURE 22: RESULTS FOR DOWNTOWN LOS ANGELES OF THE INTEGRATED CLIMATE CHANGE COMMUNITY SCREENT TOOL, DEVELOPED AND PILOTED BY THE CALIFORNIOA ENVIRONMENTAL HEALTH TRACKING PROGRAM (DPH). THIS MAP SHOWS A SET OF FACTORS COMBINED TO REPRESENT SENSITIVITY, ADAPTATIVE CAPACITY AND EXPOSURE TO A NUMBER OF CLIMATE CHANGE IMPACTS (SOURCE: CALIFORNIA DEPARTMENT OF PUBLIC HEALTH)[77]

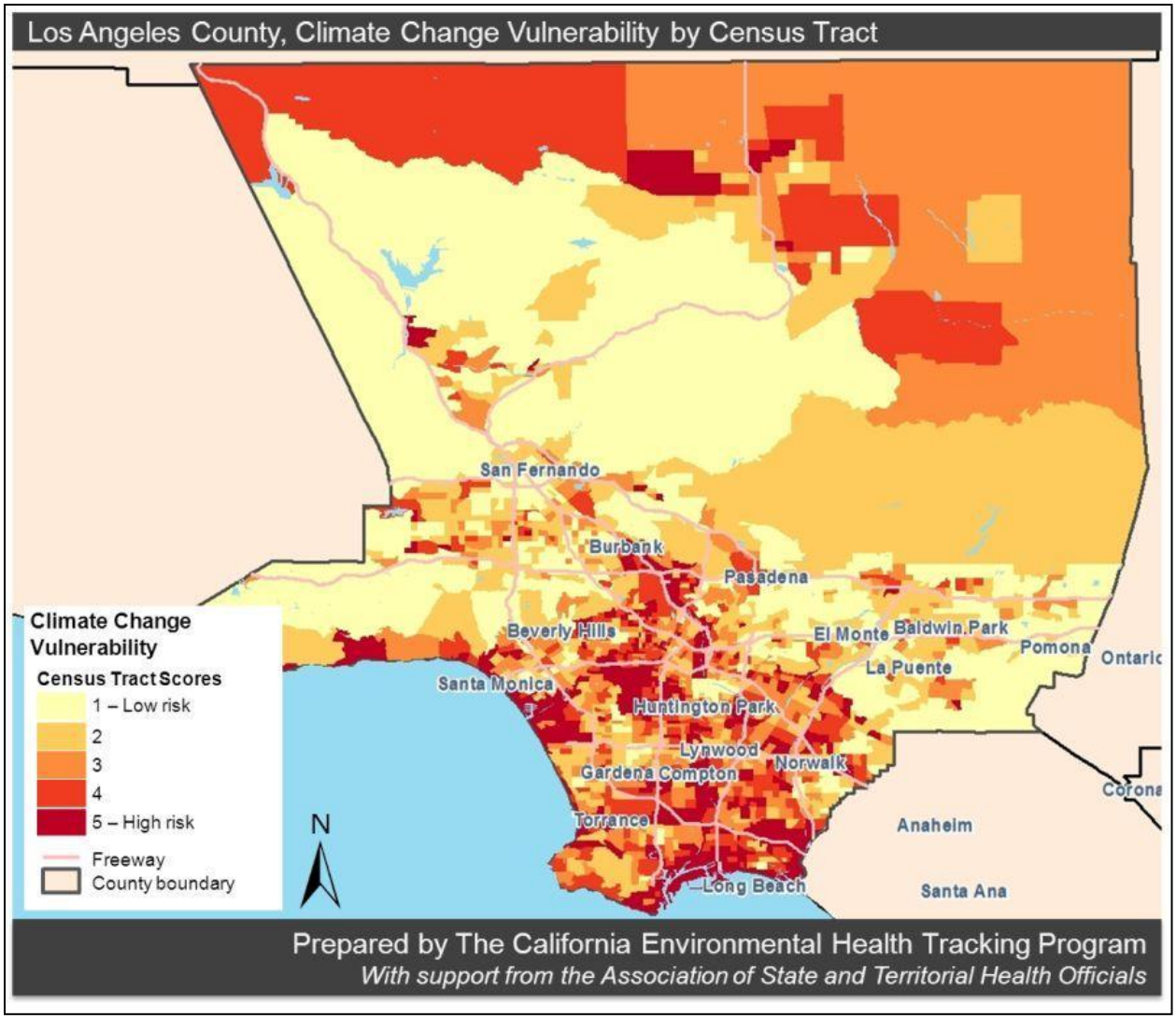


FIGURE 23: RESULTS FOR L.A.COUNTY OF THE INTEGRATED CLIMATE CHANGE COMMUNITY SCREENT TOOL, DEVELOPED AND PILOTED BY THE CALIFORNIOA ENVIRONMENTAL HEALTH TRACKING PROGRAM (DPH). THIS MAP SHOWS A SET OF FACTORS COMBINED TO REPRESENT SENSITIVITY, ADAPTATIVE CAPACITY AND EXPOSURE TO A NUMBER OF CLIMATE CHANGE IMPACTS (SOURCE: CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, SEE ENGLISH 2012)[78]VI. CRITICAL COMMUNITY SERVICES

6. CRITICAL COMMUNITY SERVICES

A number of services and supporting infrastructure are potentially at risk of impairment from short term or long term damage from flood events, erosion, and permanent inundation as sea level rises. These include impairment of drainage and treatment of wastewater and sewage, rapid emergency response, access to food and prescription medicines, risks of salinization of coastal groundwater reservoirs, and energy-related facilities, transmission, and transformers. For example, electricity outages can occur during storms when coastal flooding is at its worst. Such outages can make a flood event turn quickly into an emergency for people relying on electricity.[79] A description of these is beyond the purview of this social vulnerability assessment; however we provide a glimpse of some of the connections between infrastructure and service functionality (focus on drainage and emergency response) with particular reference to how these could exacerbate stressors to already vulnerable populations.

6.1 DRAINAGE AND FLOODING

As sea level rises storm water drainage will be increasingly impaired, leading to increased flooding during rain events. The City of Los Angeles, more than 70% of which is located on an alluvial floodplain, has a long history with flooding from infrequent albeit major storms.[80] Flash floods caused by heavy rainfall within a short period of time can cause major flooding throughout many parts of the city. Most of the land is covered with impermeable surface (e.g. asphalt) meaning that water cannot filter into the ground, but instead rushes down streets and overloading the wastewater system, where it backs up back into the city. The Safety Element of the City's General Plan refers to major storms that cause "a high magnitude of water flow" as the "most dramatic and potentially the most hazardous water activity confronting the City."[81] The region receives the majority of its rain in heavy, short-duration storms. The Safety Element says that "in a 100 year storm, 10 to 24 inches of rain may fall within 24 hours or as much as one inch of rain in a minute for a brief duration." The impermeable surfaces lining the city make these strong storms more difficult to manage because the water cannot percolate into the soil. Instead it rushes through the streets or other pathways toward the ocean. There, this increased runoff is met by higher sea levels. While wind and waves are not estimated to increase with climate change, storms as strong as those experienced historically with higher sea levels will also cause higher storm surges. Thus, more coastal flooding and intense runoff from inland areas will combine to cause more severe damage and flooding because the inundation zone will extend much farther inland.[82] Impervious surfaces also lead to higher temperatures, referred to as the urban heat island effect. Impervious surfaces and lack of shading from trees are often most prevalent in low income and minority neighborhoods, leaving the socially most vulnerable populations to experience potentially greater physical risks as well.

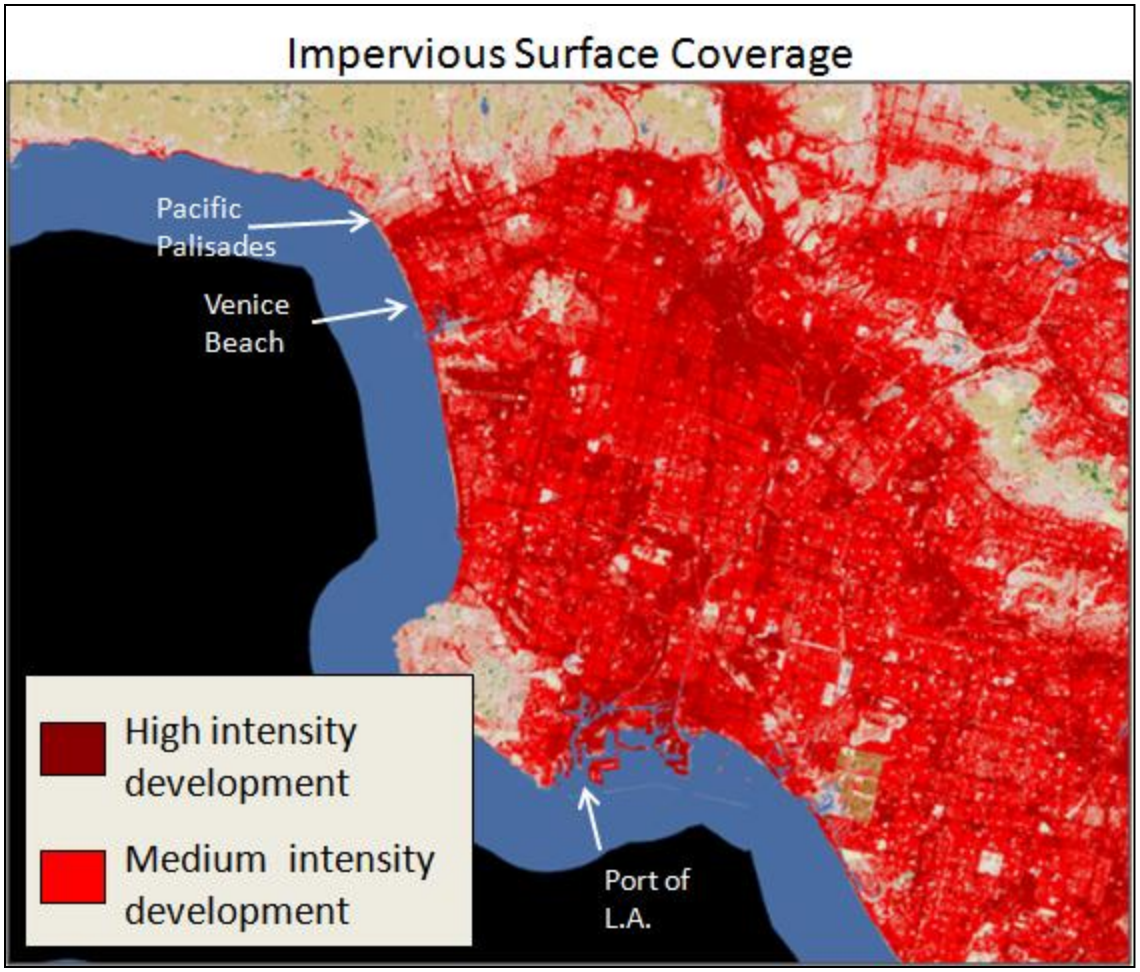


FIGURE 24: IMPERVIOUS SURFACE COVERAGE IN LOS ANGELES REGION. MUCH OF LOS ANGELES COUNTY IS COVERED BY IMPERVIOUS SURFACES, WHICH PREVENT EXCESS WATER (RAIN OR STORM SURGE) FROM INFILTRATING INTO THE GROUNDWATER AND, THUS, INCREASING FLOODING RISK. HIGH INTENSITY DEVELOPMENT IMPERVIOUS SURFACES (DARK RED) ACCOUNT FOR 80% TO 100% OF THE TOTAL COVER. MEDIUM INTENSITY DEVELOPMENT (LIGHTER RED) IMPERVIOUS SURFACES ACCOUNT FOR 50% TO 79% OF THE TOTAL COVER (SOURCE: NATIONAL LAND COVER DATABASE 2006[83]).

FEMA flood loss maps – based on historical experience – are an important additional information source, as they integrate both aspects of physical exposure (i.e., where flooding actually and repeatedly occurs, as opposed to maps based on calculated potential flood risk), sensitivity, and response capacity of affected buildings and households (e.g., building age or constructions, elevation off the ground, households' ability to take preventive measures). Such maps (Figure 25) can serve as ways to cross-check and validate other sources of information such as presented here and as a tool to prioritize flood risk management interventions.

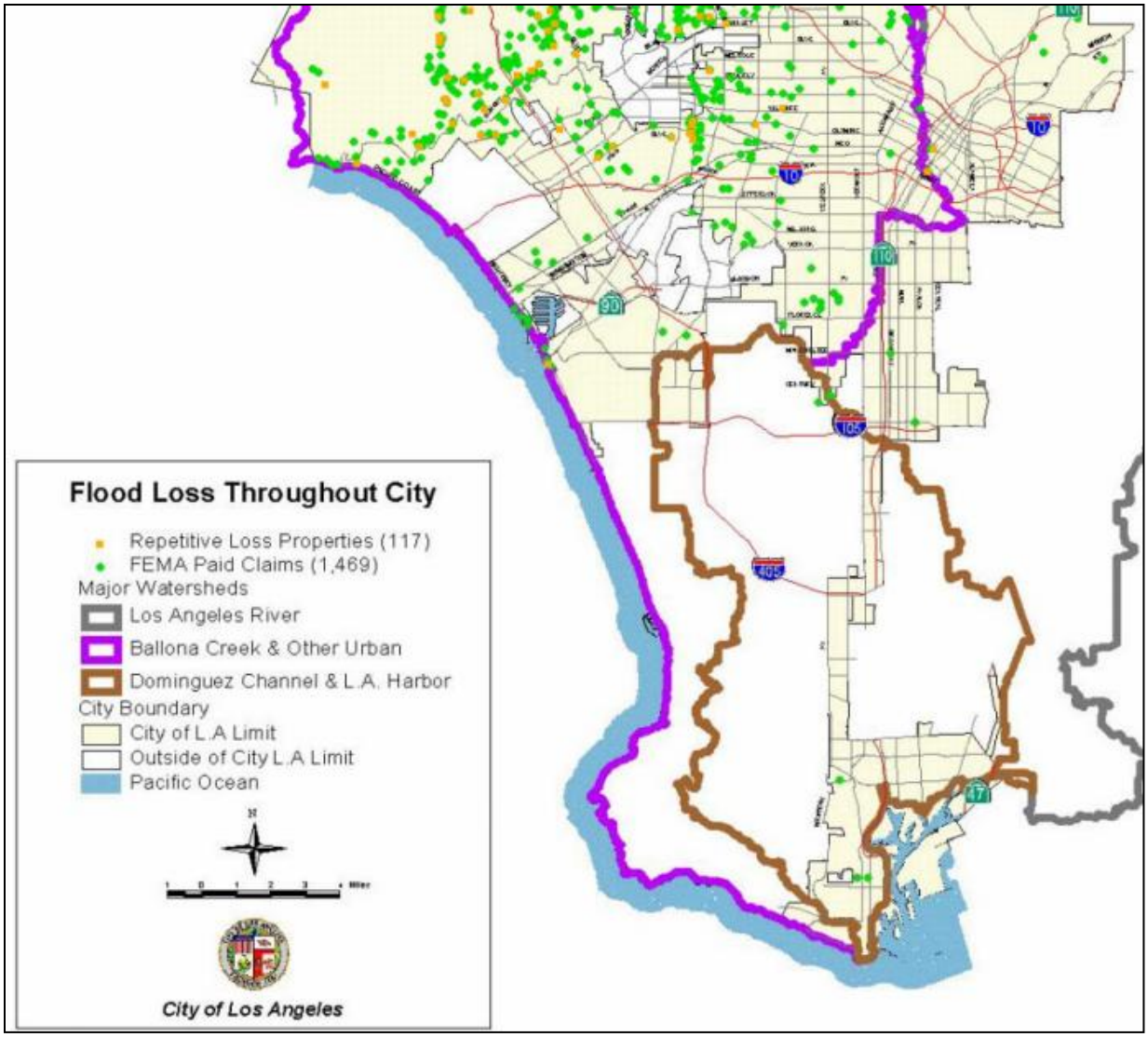


FIGURE 25: FLOOD LOSS THROUGHOUT THE CITY – REPETITIVE LOSS PROPERTIES AND FEMA PAID CLAIMS (SOURCE: CITY OF L.A.FLOODPLAIN MANAGEMENT PLAN, APRIL 2010[84]

6.2 EMERGENCY RESPONSE

Rapid emergency response is critically important during an emergency (Figure 26). Any lack of access to fire or police stations or impairment of the most direct transportation routes (due to flooding) increase the risk of additional loss of life. Flooding – even temporarily from heavy rainfall, combined with increasing sea level and coastal storm surge – can lead to increased time for emergency responders. Several important emergency routes, shown in Figure 27, are located along the coastline of Los Angeles – both within and outside City boundaries. Even areas that are outside of City boundaries can prevent emergency response from accessing the City's coastal neighborhoods. There are ten fire stations but no police stations in L.A.'s coastal areas at risk of flooding with sea-level rise. These include two fire stations in Pacific Palisades, one in Venice, one in Playa del Rey, six in San Pedro (and one emergency management service battalion).[85]

FIGURE 26: RAPID EMERGENCY RESPONSE CAN MEAN LIFE OR DEATH FOR SOME VICTIMS DURING A DISASTER. SEVERAL FIRE STATIONS ARE LOCATED ALONG THE COAST, AND IF FLOODED DURING HEAVY RAINS OR COASTAL STORMS AS SEA LEVEL RISES, THEIR ACCESS TO RESPOND TO FLOOD VICTIMS OR OTHERS IN NEED WILL BE IMPAIRED. (SOURCE: WIKIMEDIA COMMONS, AUTHOR "COOLCEASAR")

The access routes for emergency response (and evacuation of residents) can be jeopardized during flood events, especially as sea level rises. Figure 27 shows the important evacuation and emergency response routes in times of a disaster throughout L.A. County. Several "Highway Disaster Routes" run narrowly along the coast and are at risk of flooding with sea-level rise even during a 10-year storm. Moreover, these could be jeopardized as erosion (already a problem in many areas of the coast) increases as a result of sea-level rise. Flooding is the primary climate-related hazard that puts important highways at risk in Los Angeles' coastal communities (Figure 28), according to the modeled ArkStorm scenario conducted by the US Geological Survey.[86]

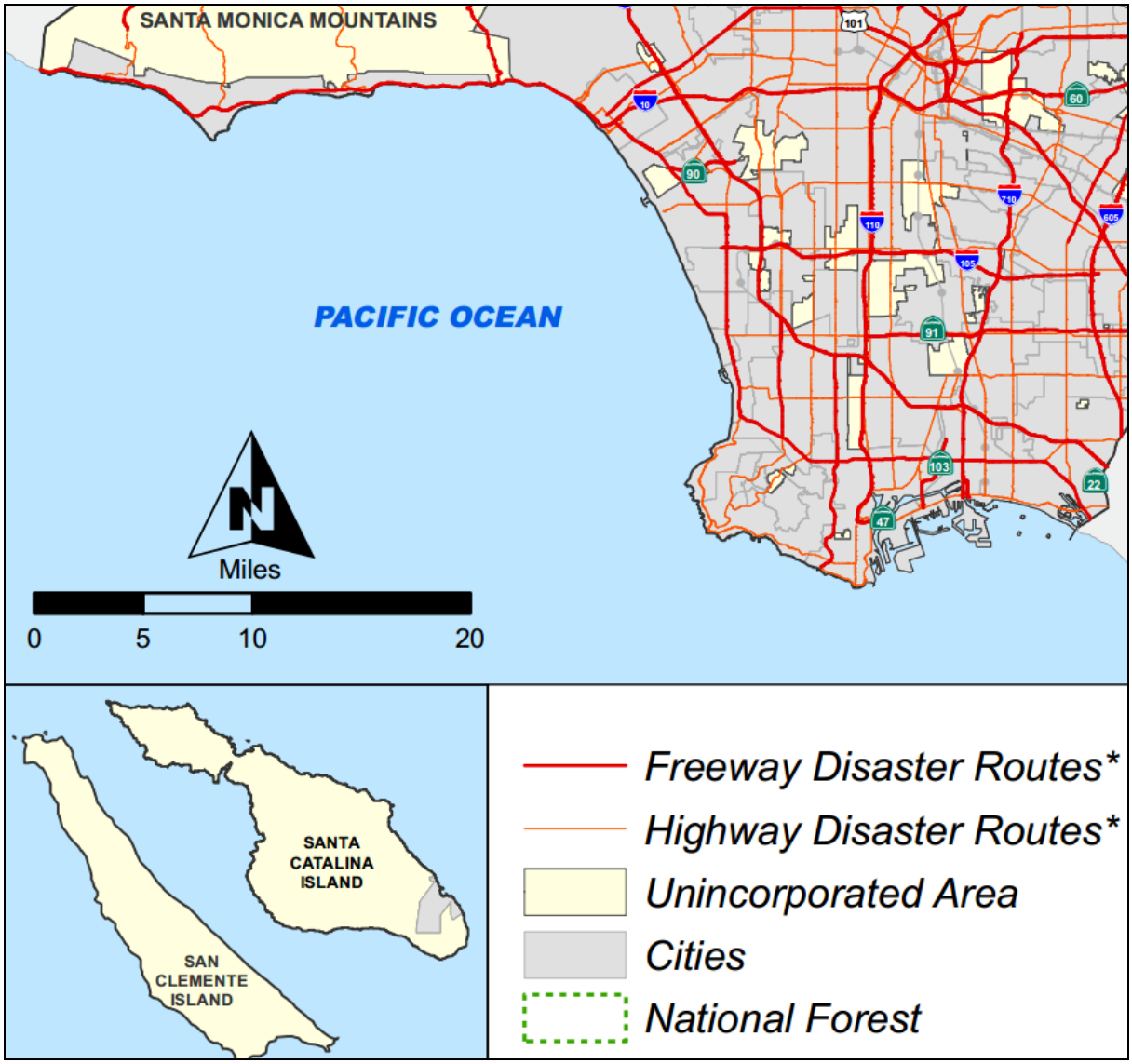


FIGURE 27. COASTAL PORTION OF DRAFT MAP OF EMERGENCY ROUTES IN LOS ANGELES COUNTY (SOURCE: LOS ANGELES COUNTY DRAFT GENERAL PLAN ACCESSED JUNE 20, 2012[87])

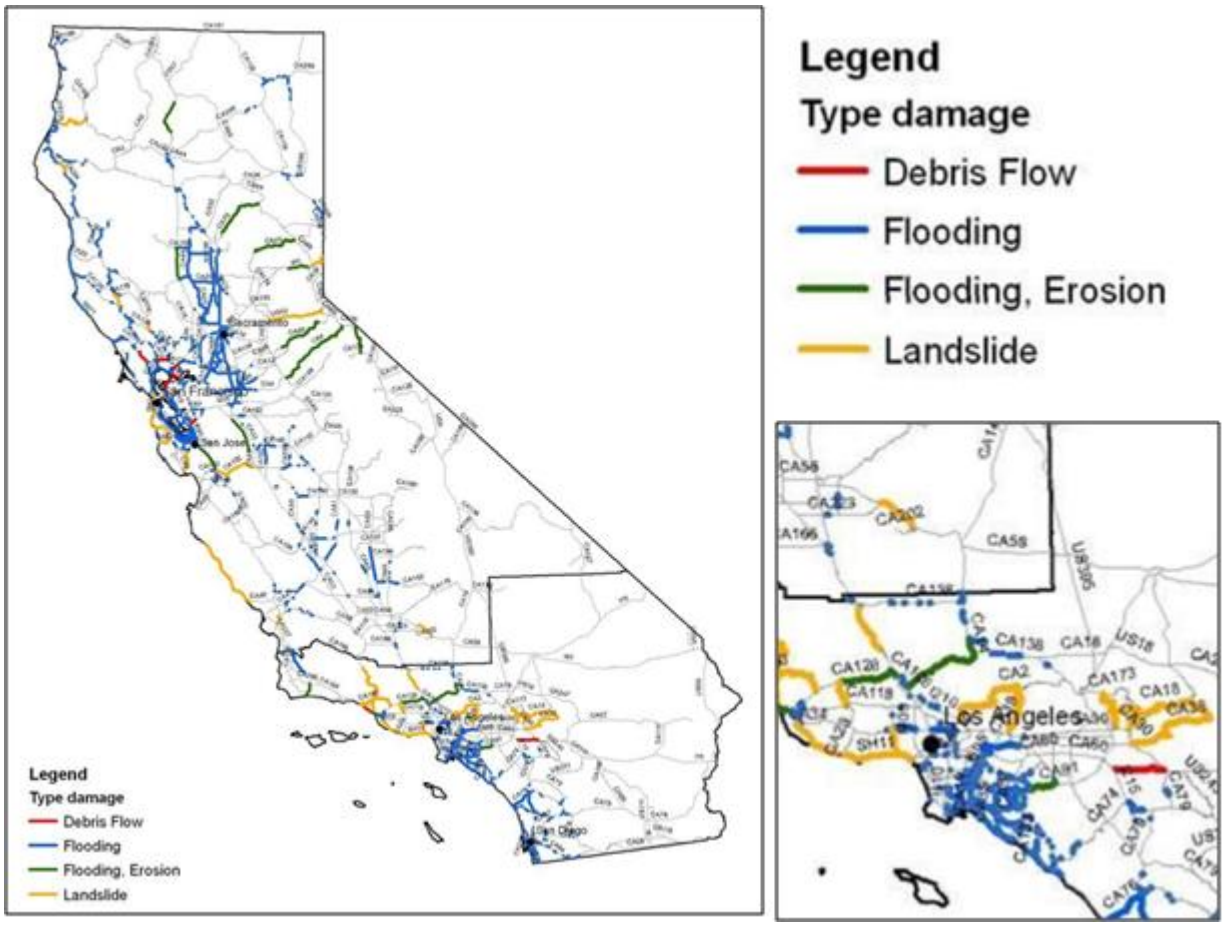


FIGURE 28. CUMULATIVE HIGHWAY DAMAGES PROJECTED FROM THE ARKSTORM SCENARIO. COASTAL LOS ANGELES COMMUNITIES ARE MAINLY AFFECTED BY FLOODING (BLUE) (SOURCE: ARKSTORM 2010 MAPS ON COPE PREPAREDNESS WEBSITE) [88]

6.3 FOOD ACCESS

Proximity to supermarkets is at least as necessary during flooding emergencies as it is during other times. People rely on supermarkets not only for food and bottled water in times of emergency, but also for prescription medicines, batteries and other critical goods. For those with limited personal mobility (e.g., lack of a personal car), i.e. poorer and disabled populations, this is particularly relevant.

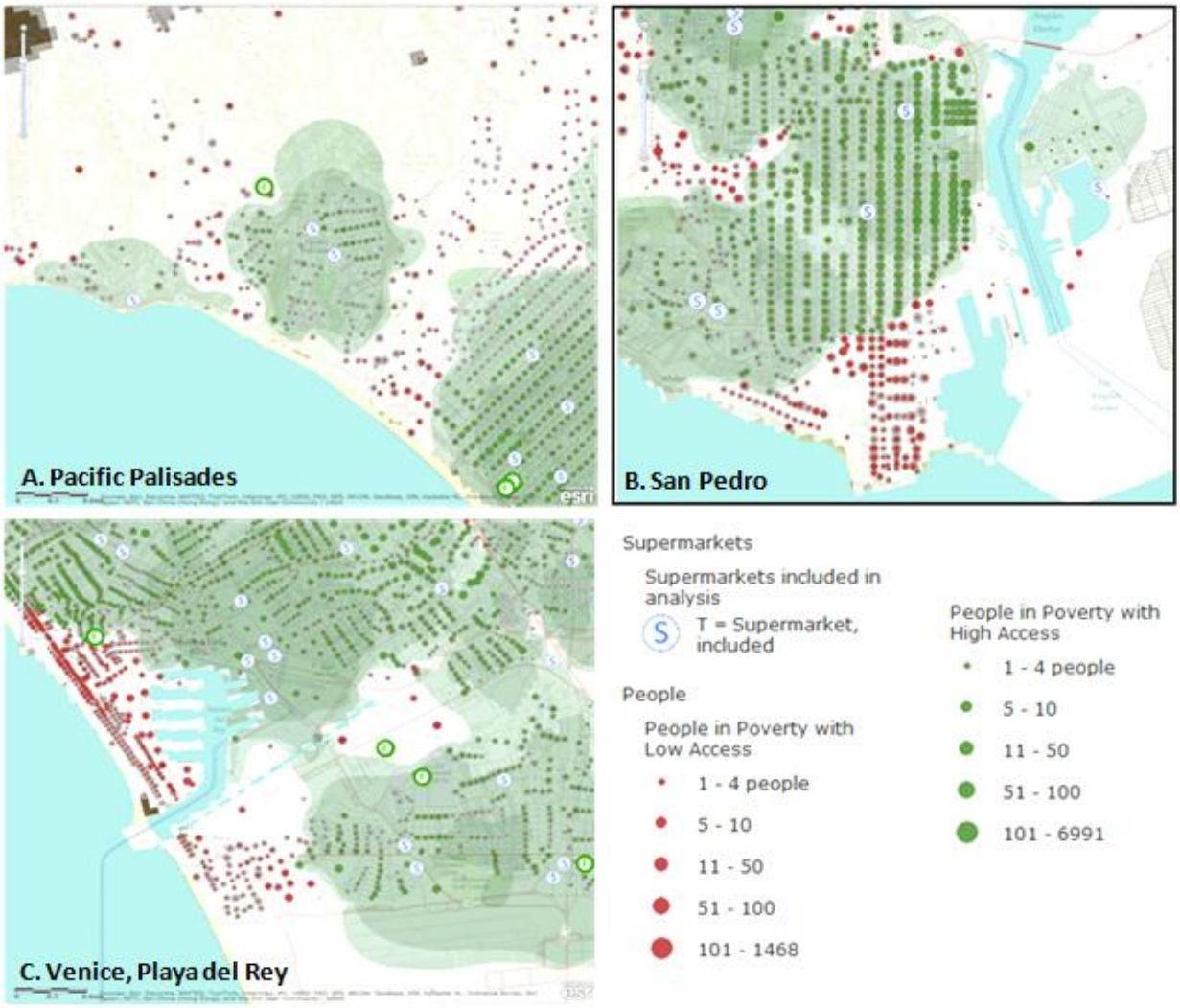


FIGURE 29: SUPERMARKET ACCESS FOR LOW-INCOME POPULATIONS IN SAN PEDRO AND HARBOR (TOP RIGHT MAP), PACIFIC PALISADES (TOP LEFT) AND VENICE AND PLAYA DEL REY (BOTTOM LEFT). GREEN AND RED DOTS INDICAT COASTAL POPULATIONS IN FUTURE FLOOD RISK ZONES THAT HAVE LOW OR HIGH ACCESS, RESPECTIVELY, TO CRITICAL GOODS, SUCH AS FOOD, BOTTLED WATER, PRESCRIPTION MEDICINES. AND OTHER EMERGENCY SUPPLIES (SOURCE: ARCGIS.COM)[89]

6.4 Beaches, Wetlands and Ecosystem Services

Coastal areas are popular destinations for the public to recreate and enjoy for swimming, relaxing, surfing, birding, hiking, sailing, canoeing, and so on. Reduction of easily accessible beaches and wildlife areas could mean some populations will no longer live within reach of accessible open space, which could create declines in well-being and quality of life for low income and minority communities that are already experiencing multiple stressors and have limited resources to travel further to alternative sites. In addition, beaches serve as important storm buffers, and wetlands also serve critical water purification functions. As discussed above in the Community Snapshots section, Cabrillo Beach, several beaches along Pacific Palisades, and Venice Beach historically all have received sand replenishment. The loss of sand at these beaches may increase markedly as sea level rises. This means that to maintain these important public beaches, the City would need to commit to more frequent beach replenishment in the future and develop the necessary financial means to do so.

Ballona Wetlands, discussed in the Venice Community Snapshot, is expected to flood regularly with 16 inches of SLR (see Figure 9 above). This area provides a unique wildlife and nature experience for urban residents, which is the only one of its kind in L.A. County. In addition to the potential threat to this resource as a recreation and educational area, the wetland also provides unique habitat for a variety of bird, plant and other species. Friends of Ballona Wetlands reports that about 300 species of birds have been cited in the wetlands, including Belding's savannah sparrows, least terns (endangered), least bitterns, great blue herons, and Canadian geese.[90] Demonstrating the ecological and social value this wetland to California, in January 2012 the state approved $6.5 million for planning a large-scale restoration of the Ballona Wetlands.[91]

7. SUMMARY & RECOMMENDATIONS

Above we have described the elements of social vulnerability as they relate to sea-level rise flooding risks and the City of L.A.'s residents. We provided brief snapshots of the three coastal areas within the City of L.A., followed by a description of population characteristics that indicate how and where some segments of coastal communities are more socially vulnerable than others. Characteristics of importance for social vulnerability included: income, poverty, education, females as head of household, race, linguistic isolation, age, housing type and age, and physical and mental illnesses and disabilities.

We integrated these characteristics into a social vulnerability index (SOVI) and compared it with another recently developed index. The two indices were developed using two slightly different methods, thus producing somewhat different results. The Social Vulnerability Index (SOVI), based on combination of population characteristics representing adaptive capacity and sensitivity, shows a relatively low overall social vulnerability along the coast in Los Angeles with some variation. In contrast, the highest social vulnerability is concentrated in the interior of the city and county. Still, based on this SOVI measure, portions of San Pedro, Wilmington, and one census block in Venice score with relatively high social vulnerability compared to the rest of the county. The second index, the Climate Change Community Screening Tool (CCCST), was developed by the California Department of Public Health specifically for climate change impacts. The mapped results of overall climate change vulnerability from this tool show a much higher measure of overall vulnerability along the coast of L.A. This measure incorporates the exposure dimension of vulnerability in the cumulative vulnerability score by including risk of climate change impacts such as heat extremes, flooding, wildfires and others (whereas the SOVI focuses only on sensitivity and adaptive capacity indicators). This difference partially explains the differences in results and highlights the importance of understanding the methods and variables used to calculate integrated snapshot vulnerability in Los Angeles.

Integrated scores of vulnerability can be useful as a first-order tool to help prioritize areas of concern for climate adaptation planning, but the review of individual characteristics that cause the overall vulnerability are more appropriate to inform the development of specific adaptation strategies. Here we provide a brief summary of findings seen in the presentation of individual population characteristics.

First, income is one of the most important indicators of adaptation capacity. Per capita income in Los Angeles overall tends to be higher along the coast than in the interior. However, there is a pocket of the population located around the Port of L.A., where a high proportion of households lives below the federal poverty level L.A. High proportions of the population with low education levels (e.g. those over 25 years old who did not graduate from high school) – also associated with lower adaptive capacity – reside in San Pedro and Wilmington. In these same neighborhoods Census data shows that high proportions of the population are linguistically isolated (speak English less than "very well") and are largely of Latino descent. This information can inform emergency response planning for flooding and sea-level rise, and for developing strategies to engage community members in active climate adaptation planning. This might include, for example, conducting workshops and preparing public outreach materials in Spanish and, given low education and high poverty levels, using alternative methods that do not require literacy or internet access.

Other characteristics that indicate high social vulnerability include housing type and control over living situation. Census data shows high proportion of older housing, which tends to be more sensitive to flood (less flood-proof), in Venice and again in neighborhoods surrounding the Port of L.A. These same communities have high proportion of renters, which tend to not have the means or incentives to flood proof their homes.

Segments of the population that may need special assistance in emergencies because of a lack of mobility or other disadvantages include the elderly, children, the homeless, those with existing physical or mental illness, and those living in group quarters. An important first step in preparing special assistance for these populations is to document where they reside so that emergency response preparations and long-term adaptation plans can be made to help these populations when the time comes.

RECOMMENDATIONS

Invest in strong foundation for climate adaptation: Climate adaptation is a complex process, involving decision-makers at all levels of government (even if the focus of adaptation is a local community), as well as in civic society and the private sector; it is not a one-time effort, but an ongoing process with periods of lesser and more intense activity; it requires periodic updates of information and scientific understanding, and including such new information in the decision-making process; and it goes far beyond technical and structural solutions, but involves policy changes, creative financing, capacity building among key staff and decision-makers, and effective public engagement. At this early stage in adaptation for most communities, including Los Angeles, it is therefore important to lay a strong foundation for such an ongoing process. Elements of such a foundation include:

- Acquisition of the best available science and developing a timeline and formal strategy for periodic updates of scientific information in planning and decision-making procedures;
- Assessing and ascertaining the capacity and willingness of local government departments, agencies, commissions, and boards to integrate information on climate change and related infrastructure and social vulnerability into their planning, budgetary, and policy decisions;

- Initiating 'soft' adaptation strategies, such as staff training, developing trusting relationships with community organizations, identifying and supporting local champions in government, business, and civic organizations, and building governance structures across sectors and jurisdictional boundaries to increase adaptive capacity, foster buy-in, and generate the necessary institutional and political support;
- Creating opportunities for periodic, meaningful public engagement that gather information about affected neighborhoods and communities' concerns, vulnerabilities, and constraints; to educate about climate change related risks; and to jointly develop strategies that are designed to meet current and future needs. Such engagement should also offer opportunities for communities to express any concerns and needs around procedural justice and equitable burden sharing and outcomes of adaptation.

Define clear adaptation goals: Most adaptation planning processes to date in the US have been undertaken without clearly defining what "success" would look like. Goals could focus on both procedural and outcome intentions. Failing to define success has several important implications, directly relevant to local decision-making: It is difficult to prioritize and justify expenditures when a goal or purpose is not identified, and it is politically difficult to sell when people cannot visualize the intended outcome (even if just a temporary outcome). It is also difficult to show that a strategy made a positive difference or to measure progress toward the desired goal. The City would therefore be well advised in not just stating a "pie in the sky" goal, but to spend concerted effort both internally and with community involvement to define desirable and feasible outcomes of adaptation. Strategies flow more clearly from identified goals.

Develop clear prioritization and selection criteria for choosing among possible adaptation strategies: A corollary to the need for a clearly defined goal is the establishment of criteria that help select options from the universe of potential adaptation strategies. Such criteria would help with prioritization when budgets, timelines, technical considerations, and social concerns and political feasibility inevitably place constraints on preferred solutions. Again, such criteria are best selected in consultation and agreement with affected stakeholder communities, as exclusion from defining *how* decisions will be made can lead to political resistance and lack of buy-in to the ones that *are* being made. That, of course, could endanger the ultimate success of the entire effort.

Updating the vulnerability assessment as better flood risk models and maps become available: As stated in this report (Section 3), the use of a 10-year flood scenario with sea-level rise was a pragmatic choice in light of the best available, most defensible physical science at this time. Ten-year floods, however, are not the common planning standards (100- and 500-year floods are benchmarks for FEMA for example). In addition, SLR scenarios may change over time, as the science advances, as will land use, the level of coastal protection, and the demographic and socioeconomic situation of coastal populations. Thus, the City would be well advised to closely track scientific developments and update the current vulnerability assessment as needed to ensure its adaptation plans and preparedness measures are up-to-date.

Expand partnerships in developing adaptation options: Much adaptation that addresses social vulnerability and public concerns requires close collaboration with the affected groups. Thus, to the extent collaborative ties are not yet established, it would be important to establish working relationships with marginalized groups or organizations that represent them (e.g. using *Emergency Network LA* to include climate change training; see Wisner and Uitto[92]), expand the network of adaptation stakeholders to include those already working on increasing community resilience in the face of disasters.

A case in point: The *L.A. County Community Resilience Project*, funded by the Center for Disease Control, is a three year project that aims to improve community resilience and disaster preparedness throughout L.A. County. This collaborative project between UCLA, the Emergency Network of Los Angeles (ENLA), and the L.A. Department of Public Health exemplifies what it may take to build the needed relationships within communities before a disaster occurs. The upcoming phase of the project will select 16 communities in the county to test out a toolkit to help communities prepare for disasters. The project includes a working group focused on vulnerable populations.[93] While the communities piloting the toolkit may not be coastal, the project could have valuable contributions to the city's and region's climate adaptation planning process.

More detailed community-based information: To develop adaptation options that are most strategically designed to address the communities' needs, it would be beneficial to expand on this vulnerability assessment by providing a more detailed assessment that involves affected communities. Community representatives could participate in developing adaptation options. Also, recognizing that this social vulnerability assessment will likely be expanded beyond City boundaries or to other climate impacts beyond sea-level rise and flooding, other useful resources for finding geographic data related to issues of environment justice are listed in a report published by the CALFED Environmental Justice Subcommittee.[94]

A case in point: The Pacific Institute, funded by the California Energy Commission, conducted a community-level vulnerability assessment in the City of Oakland demonstrating how working with representatives of disadvantaged groups could reveal social vulnerabilities that were grounded in the concerns and needs of the residents themselves.[95] Another model demonstrating the strength of engaging communities themselves in the adaptation process was undertaken as a partnership between non-governmental organizations and the counties of San Luis Obispo and Fresno. The non-governmental organizations provided climate projections, important coordinating and meeting facilitation, and framing for ways to think about and design adaptation options. An initial social vulnerability assessment was first conducted by outside experts, which was then used as a foundation (framing and data) from which stakeholders could provide more detailed information about the issues and vulnerabilities of their sectors.[96]

Coordinate adaptation with neighboring communities beyond the City borders: Climate change impacts on neighboring cities and unincorporated areas, as well as their adaptation responses, will inevitably affect the success of adaptation strategies implemented within the City's boundaries. This is true for sea-level rise and other climate change impacts. Therefore, expanding the planning process sooner rather than later to collaborate with those communities will help ensure that consistent science is used, and coherent and coordinated adaptation strategies are developed and chosen for L.A.'s coastline. This may help build up adaptive capacity in the region more quickly, and possibly involve cost sharing and savings for all involved.

APPENDIX A. USEFUL CONTACTS FOR FUTURE STAKEHOLDER ENGAGEMENT

The table below contains a list of people and contact information who either were helpful to us in providing information for this assessment directly, who were mentioned as being interested in future opportunities to be involved in the adaptation process, or who are involved in complementary work that could be very useful to informing/coordinating with the adaptation process led by the City of Los Angeles. This should not be considered a complete list, but these valuable contacts should be maintained or sought for the ongoing adaptation process in Los Angeles.

Name	Affiliation	Related work	Contact information
Alix Stayton	Program Manager, Emergency Network L.A. (ENLA)	ENLA and L.A. County Community Resilience Project	info@enla.org, 213-739-6888 , www.enla.org
Robin Rudisill	Venice Neighborhood Council	Knowledgeable about Venice, flooding, and community issues, and interested in working with climate adaptation planning process	wildrudi@mac.com
Lonna Calhoun	President of COPE Preparedness (www.COPE-Preparedness.org), San Pedro Neighborhood Council	Expert on working with communities for disaster preparedness; knowledgeable about San Pedro and Wilmington community needs for emergency preparedness and flooding; On 7/21/12 conducting emergency preparedness workshop in all Spanish in Wilmington; wants to be involved in future assessments of vulnerability (infrastructure or social)	Lonna@cope-preparedness.org, 310-982-1180
David Eisenman	Associate Professor of Medicine and Public Health Director, UCLA Center		310-794-2452 deisenman@mednet.ucla.edu

	for Public Health and Disasters		
Dede Audet	Venice Neighborhood Council	Very knowledgeable about the history of flooding in Venice	daudet@ca.rr.com, ddaudet@comcast.net
Darryl DuFay	Venice Neighborhood Council	Worked on the flood assessment for the community	darryldu@pobox.com

REFERENCES AND ENDNOTES

[1] Note that the 2010 Census data, while more up-to-date, often contain far less detailed information (fewer demographic variables) than the 2000 Census. This makes the tracking of social vulnerability over time more difficult.

[2] California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy*. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF

[3] According to the survey results of what motivates coastal managers and other professionals in California to begin adaptation to climate change, as reported in:

Finzi Hart, J. A., P. M. Grifman, S. C. Moser, A. Abeles, M. R. Myers, S. C. Schlosser, J. A. Ekstrom. (2012) *Rising to the Challenge: Results of the 2011 Coastal California Adaptation Needs Assessment*. USCSG-TR-01-2012. Available at: http://www.usc.edu/org/seagrant/research/climateadaptsurvey/SurveyReport_FINAL_OnlinePDF.pdf

[4] For example, Messener, S. Miranda, K. Green, C. Phillips, J. Dudley, D. Cayan, and E. Young. 2008. *Climate Change Related Impacts in the San Diego Region by 2050*. A Summary Prepared for the 2008 Climate Change Impacts Assessment, Second Biennial Science Report to the California Climate Action Team. Available at: http://www.escholarship.org/uc/item/870746sr#page-2

[5] Intergovernmental Panel on Climate Change (IPCC). 2012. *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)*. Working Group I and II Intergovernmental Panel on Climate Change. Available at: http://ipcc-wg2.gov/SREX/report/

[6] Mazur, L., C. Milanes, K. Randles, D. Siegel 2010. *Indicators of Climate Change in California: Environmental Justice Impacts*. Office of Environmental Health Hazard Assessment. Available at: http://oehha.ca.gov/multimedia/epic/pdf/ClimateChangeEJ123110.pdf

[7] Heberger, M., H. Cooley, P. Herrera, P. H. Gleick, and E. Moore. 2009. *The Impacts of Sea Level Rise on the California Coast.* California Energy Commission. Publication number: CEC-500-2009-024-F.

[8] Cooley, H., E. Moore, M. Heberger, L. Allen (Pacific Institute). 2012. *Social Vulnerability to Climate Change in California*. California Energy Commission. Publication Number: CEC-500-2012-013.

[9] Moser, S. and J. Ekstrom, 2010. *Developing Adaptation Strategies for San Luis Obispo County: Preliminary Climate Change Vulnerability Assessment for Social Systems*. Technical Report and Summary. Prepared for the Local Government Commission, Sacramento, CA. Available at: http://www.lgc.org/adaptation/slo/docs/SLO_TechnicalReport_5-7-10_final.pdf

[10] Moser, S. and J. Ekstrom, 2010. *Toward a Vibrant, Prosperous and Sustainable Fresno County: Vulnerability and Adaptation to Rapid Change*. Technical Report and Summary. Prepared for the Local Government Commission (LGC), Sacramento, CA. Available at: http://www.lgc.org/adaptation/fresno/docs/Fresno_Co_SocialSystems-draft_report_110710.pdf

[11] Refer to "Adapting to Rising Tides" project website; Available at: http://risingtides.csc.noaa.gov

[12] Emrich, C.T. and S.L. Cutter. 2011. Social vulnerability to climate-sensitive hazards in the southern United States. *Journal of Weather, Climate, and Society* 3(3): 193-208.

Martinich, J., J. Neumann, L. Ludwig, and L. Jantarasami. 2012. Risks of sea level rise to disadvantaged communities in the United States. *Mitig. Adapt. Strateg. Glob. Change*, pp1-17.; Available at: doi:10.1007/s11027-011-9356-0

[13] http://www.climatechange.ca.gov/adaptation/; see in particular the Appendix in which key concepts are defined. The State's terminology reflects common understanding in the scientific literature, especially the (social scientific) climate change literature.

[14] Kasperson, J.X. , R.E. Kasperson, and B.L. Turner II. 2009. Vulnerability of coupled human-ecological systems to global environmental change. In: *Human Footprints on the Global Environment: Threats to Sustainability*, eds. E.A. Rosa, A. Diekmann, T. Dietz, and C.C Jaeger, 231-294, Cambridge, MA: The MIT Press. (figure on page 273)

[15] Romero Lankao, P. and JL. Tribbia. 2009. Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the *Fifth Urban Research Symposium 2009*: p. 4.

[16] Romero Lankao, P. and JL. Tribbia. 2009. Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the *Fifth Urban Research Symposium 2009*: p. 4.

[17] California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy*. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[18] Kasperson, J.X. , R.E. Kasperson, and B.L. Turner II. 2009. Vulnerability of coupled human-ecological systems to global environmental change. In: *Human Footprints on the Global Environment: Threats to Sustainability*, eds. E.A. Rosa, A. Diekmann, T. Dietz, and C.C Jaeger, 231-294, Cambridge, MA: The MIT Press.

[19] California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy*. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[20] California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy*. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[21] Bromirski, P. D., A. J. Miller, R. E. Flick, and G. Auad. 2011. Dynamical suppression of sea level rise along the Pacific coast of North America: Indications of imminent acceleration. *Journal of Geophysical Research* 116: C07005, 12 PP.

[22] National Research Council. 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.* Washington, DC: The National Academies Press. Pre-publication available: http://www.nap.edu/catalog.php?record_id=13389.

[23] The 100- and 500-year floods are standard frequencies of significant flood events used by the Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP).

[24] Heberger, M., H. Cooley, P. Herrera, P. H. Gleick, and E. Moore. 2009. *The Impacts of Sea Level Rise on the California Coast*. California Energy Commission. Publication number: CEC-500-2009-024-F.

[25] Bromirski, P.D., D.R. Cayan, N. Graham, M. Tyree, R.E. Flick. 2012. Coastal Flooding-Potential Projections: 2000-2100. California Energy Commission. Publication number: CEC-500-2012-011.

[26] Tebaldi, C., B.H. Strauss, and C.E. Zervas. 2012. Modeling sea level rise impacts on storm surges along US coasts. *Environ. Res. Letter.* 7: 014032. Accessed at: http://iopscience.iop.org/1748-9326/7/1/014032/pdf/1748-9326_7_1_014032.pdf

[27] Bromirski, P.D., D.R. Cayan, N. Graham, M. Tyree, and R.E. Flick. 2012. Coastal Flooding-Potential Projections: 2000–2100. California Energy Commission. Publication number: CEC-500-2012-011.

Cayan, D. R., M. Tyree, D. Pierce, and T. Das. 2012. Climate Change and Sea Level Rise Scenarios for California Vulnerability and Adaptation Assessment. California Energy Commission. Publication number: CEC-500-2012-008.

[28] A complementary assessment is being conducted in parallel to this one that evaluates the exposure, sensitivity, and adaptive capacity of coastal infrastructure in depth (authored by ICLEI).

[29] Leatherman, S. 1989. National Assessment of Beach Nourishment Requirements – Associated with Accelerated Sea Level Rise. Published by the US EPA Office of Policy, Planning, and Evaluation. Contract

No 68-01-72-89. Accessed at: http://papers.risingsea.net/federal_reports/rtc_leatherman_nourishment.pdf.

[30] Pacific Palisades Chamber of Commerce webpage "About Pacific Palisades", Accessed at,: http://www.palisadeschamber.com/community/about-pacific-palisades/

[31] Refer to complementary ICLEI infrastructure vulnerability assessment for the City of L.A.

[32] Los Angeles Times "Mapping LA" Project: http://projects.latimes.com/mapping-la/neighborhoods/neighborhood/venice/

[33] Los Angeles Times "Mapping LA" Project: http://projects.latimes.com/mapping-la/neighborhoods/neighborhood/venice/

[34] Los Angeles Police Department (LAPD). Accessed at : http://www.lapdonline.org/get_informed

[35] Personal communication with Robin Rudisill and Dede Audet on June 18, 2012.

[36] Data received from Patrick Barnard (USGS) May 2012. For more information about the methods and project to produce the data, refer to: Porter, K, Wein, et al. 2011. Overview of the ArkStorm scenario: U.S. Geological Survey Open-File Report 2010-1312, 183 p. and appendixes. Available at: http://pubs.usgs.gov/of/2010/1312/

[37] King, P.G., A.R. McGregor, J.D. Whittet. 2011. *The Economic Costs of Sea-Level Rise to California Beach Communities*. A report from the California Department of Boating and Waterways and San Francisco State University. Available at: http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

[38] King, P.G., A.R. McGregor, J.D. Whittet. 2011. *The Economic Costs of Sea-Level Rise to California Beach Communities*. A report from the California Department of Boating and Waterways and San Francisco State University. Available at: http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

[39] King, P.G., A.R. McGregor, J.D. Whittet. 2011. *The Economic Costs of Sea-Level Rise to California Beach Communities*. A report from the California Department of Boating and Waterways and San Francisco State University. Available at: http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

[40] King, P.G., A.R. McGregor, J.D. Whittet. 2011. *The Economic Costs of Sea-Level Rise to California Beach Communities*. A report from the California Department of Boating and Waterways and San Francisco State University. Available at: http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

[41] King, P.G., A.R. McGregor, J.D. Whittet. 2011. *The Economic Costs of Sea-Level Rise to California Beach Communities*. A report from the California Department of Boating and Waterways and San Francisco State University. Available at: http://www.dbw.ca.gov/PDF/Reports/CalifSeaLevelRise.pdf

[42] Los Angeles Times "Mapping LA: San Pedro" http://projects.latimes.com/mapping-la/neighborhoods/neighborhood/san-pedro/, accessed June 2012.

[43] Population figures based on L.A. Department of City Planning in 2008; Los Angeles Times "Mapping LA: Wilmington" http://projects.latimes.com/mapping-la/neighborhoods/neighborhood/wilmington/

[44] Los Angeles Times "Mapping LA: Wilmington" http://projects.latimes.com/mapping-la/neighborhoods/neighborhood/wilmington/

[45] Heal the Bay - Beach Report Card 2012. Available at: http://brc.healthebay.org/?st=CA&f=1

[46] According to Edwards and Evans (2002): "This problem is significant because much of the water used by the nearly 10 million residents of Los Angeles County comes from ground-water sources. Although not all coastal aquifers in the region are at risk, the existing resources are vital and must be protected to maintain adequate supplies of potable water" (Edwards and Evans 2002, webpage) Edwards, B. D., and K. R. Evans. 2002. Saltwater Intrusion in Los Angeles Area Coastal Aquifers – the Marine Connection. US Geological Survey Fact Sheet 030-02. Accessed June 10, 2012 at: http://pubs.usgs.gov/fs/2002/fs030-02/.

[47] Quickfacts Los Angeles (City) accessed June 20, 2012; available at : http://quickfacts.census.gov/qfd/states/06/0644000.html

[48] Quickfacts Los Angeles (City) accessed June 20, 2012; available at : http://quickfacts.census.gov/qfd/states/06/0644000.html

Note that *median* differs from the *mean* (or average) income. Median is the midpoint in a list of values, meaning that half the population in Los Angeles lives on more than the median income and half the population lives below the median income.

[49] US Census American Community Survey (ACS). 2006-2010. Available at: Quickfacts. Los Angeles County, California. Accessed at: http://quickfacts.census.gov/qfd/states/06/0644000.html

[50] Data from U.S. Bureau of Labor Statistics, Accessed from Google Public Data website, available at: http://www.google.com/publicdata/explore?ds=z1ebjpgk2654c1_&ctype=l&strail=false&bcs=d&nselm=h&met_y=unemployed&fdim_y=seasonality:U&scale_y=lin&ind_y=false&rdim=country&idim=city:PS060500&ifdim=country&tstart=633254400000&tend=1335337200000&hl=en&dl=en&ind=false&icfg

[51] Data from US American Communities Survey Census accessed from EPA Environmental Justice Mapper "EJView". Available at: http://epamap14.epa.gov/ejmap/ejmap.aspx?wherestr=los%20angeles%2C%20california

[52] Data from US American Communities Survey Census accessed from EPA Environmental Justice Mapper "EJView". Available at: http://epamap14.epa.gov/ejmap/ejmap.aspx?wherestr=los%20angeles%2C%20california

[53] US Census American Community Survey (ACS). 2006-2010. Available at: Quickfacts. Los Angeles County, California. Accessed at: http://quickfacts.census.gov/qfd/states/06/06037.html

[54] Data from US American Communities Survey Census accessed from EPA Environmental Justice Mapper "EJView". Available at: http://epamap14.epa.gov/ejmap/ejmap.aspx?wherestr=los%20angeles%2C%20california

[55] Curtis, A., J.W. Mills, M. Leitner. 2007. Katrina and Vulnerability: the Geography of Stress. *Journal of Health Care for the Poor and Underserved* 18: 315-300. Available at: http://cretscmhd.psych.ucla.edu/nola/Volunteer/EmpiricalStudies/Katrina%20and%20vulnerability%20-%20the%20geography%20of%20stress.pdf

Morrow, B.H. 1999. Identifying and mapping community vulnerability. *Disasters* 23(1):1–18.

[56] Thomallla, F., T. Downing, E. Spanger-Siegried et al. 2006. Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters* 30(1):39-48. Available at online with subscription at: http://onlinelibrary.wiley.com/doi/10.1111/j.1467-9523.2006.00305.x/abstract

Perry , R.W. and A.H. Mushkatel. 2008. *Minority Citizens in Disasters*. University of Georgia Press: Athens, Georgia.

[57] Personal communication with Lonna Calhoun, Certified Emergency Manager, Director of COPE Preparedness (Community Outreach Promoting Emergency Preparedness), and San Pedro Neighborhood Council representative

[58] US Census. American Community Survey 2006-2010: Los Angeles County, California. Available at: http://quickfacts.census.gov/qfd/states/06/06037.html

[59] US Census ACS Factfinder, Available at: http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_3YR_S0201&prodType=table

[60] Data from US American Communities Survey Census accessed from EPA Environmental Justice Mapper "EJView". Available at: http://epamap14.epa.gov/ejmap/ejmap.aspx?wherestr=los%20angeles%2C%20california

[61] Personal communication with Lonna Calhoun, Certified Emergency Manager, Director of COPE Preparedness (Community Outreach Promoting Emergency Preparedness), and San Pedro Neighborhood Council representative

[62] For more information, see http://cope-preparedness.org/

[63] U.S. Census Bureau, 2010 Census. Accessed at: http://quickfacts.census.gov/qfd/states/06/0644000.html

[64] U.S. Census Bureau, 2010 Census. Accessed at: http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?fpt=table

[65] Personal communication with Robin Rudisill and Dede Audet on June 18, 2012.

[66] Pearson, B. 2010/11. NCWP Helps Conduct Survey of Westchester/Play Homeless Population. Newsletter of the Neighborhood Council of Westchester/Playa. Accessed at: http://www.ncwpdr.org/library/newsletters/2010-11.pdf

[67] This was not done due to the limited time for this project.

[68] Personal communication: Robin Rudisill and Dede Audet on June 18, 2012

Six "sober living " homes are noted by the Intervention America website as being located in Venice: http://soberliving.interventionamerica.org/citydirectory.cfm?state=CA&city=Venice

[69] Levinson, D.R. 2012. Gaps Continue to Exist in Nursing Home Emergency Preparedness and Response During Disasters: 2007-2010. Department of Health and Human Services, Office of the Inspector General. OEI-06-09-00270. Available at: http://oig.hhs.gov/oei/reports/oei-06-09-00270.pdf

[70] Personal communication with Robin Rudisill and Dede Audet on June 18, 2012.

[71] https://www.disabilityrightslegalcenter.org/news/news.cfm

[72] Los Angeles Department of City Planning 2009. Housing Element of the General Plan: 2006-2014. Adopted January 14, 2009. Council File No. 08-1933. And No. 08-1933-S1. Available at : http://planning.lacity.org/HousingInitiatives/HousingElement/Final/HE_Final.pdf, page 1-12.

[73] Los Angeles Department of City Planning 2009. Housing Element of the General Plan: 2006-2014. Adopted January 14, 2009. Council File No. 08-1933. And No. 08-1933-S1. Available at : http://planning.lacity.org/HousingInitiatives/HousingElement/Final/HE_Final.pdf

[74] Cutter, S. L., B. J. Boruff, and W. L Shirley. 2003. Social vulnerability to environmental hazards. *Social Science Quarterly* 84(2): 242–261.

[75] NOAA Coastal Services Center. Social Vulnerability Index (SOVI) Census 2000 Block Groups. Geospatial data available at: http://www.csc.noaa.gov/digitalcoast/data/sovi/

[76] NOAA Coastal Services Center. Social Vulnerability Index (SOVI) Census 2000 Block Groups. Geospatial data available at: http://www.csc.noaa.gov/digitalcoast/data/sovi/

[77] English, P. and M. Richardson. 2012. *ASTHO Climate Change Population Vulnerability Screening Tool*. Report prepared by the California Environmental Health Tracking Program. California Department of Public Health. Available at: http://www.ehib.org/projects/ehss01/Climate%20change%20vulnerability%20report_ASTHO.pdf

[78] English, P. and M. Richardson. 2012. *ASTHO Climate Change Population Vulnerability Screening Tool*. Report prepared by the California Environmental Health Tracking Program., California Department of Public Health. Available at: http://www.ehib.org/projects/ehss01/Climate%20change%20vulnerability%20report_ASTHO.pdf

[79] According to the Los Angeles Times, January 18, 2010, downed power lines from heavy downpours caused 44,000 Southern California Edison customers to lose power

[80] City of Los Angeles, Bureau of Engineering. 2010. Floodplain Management Plan. Prepared by the Department of Public Works. Available at: http://eng.lacity.org/projects/fmp/pdf/FMP_Final.pdf

[81] Department of City Planning Los Angeles. 1996. Safety Element, General Plan. Quote from page II-12. Available at: http://cityplanning.lacity.org/cwd/gnlpln/saftyelt.pdf

[82] Bromirski, P. D., D. R. Cayan, N. Graham, M. Tyree, and R. E. Flick. 2012. *Coastal Flooding-Potential Projections: 2000–2100*. California Energy Commission. Publication number: CEC-500-2012-011.

[83] Available from Multi-Resolution Land Characteristics Consortium (MRLC), http://www.mrlc.gov/

[84] City of Los Angeles. Bureau of Engineering. 2010. *Floodplain Management Plan. Appendix A-2.* Available at: http://eng.lacity.org/projects/fmp/pdf/FMP_Final.pdf

[85] Location of fire and police stations gathered from NavigateLA (website) of the City of Los Angeles, Bureau of Engineering, Department of Public Works. Last accessed on June 26, 2012 at: http://planning.lacity.org/

[86] Porter, K, Wein, et al. 2011. Overview of the ArkStorm scenario: U.S. Geological Survey Open-File Report 2010-1312, 183 p. and appendixes. Available at: http://pubs.usgs.gov/of/2010/1312/

[87] Map accessed at the L.A. County DRAFT General Plan: http://planning.lacounty.gov/assets/upl/project/gp_2035_2012-FIG_9-7_la_co_disaster_routes.pdf

[88] Highway hazard damage risk map from Arkstorm modeling scenario. Accessed at: http://cope-preparedness.org/wp-content/uploads/2011/01/ARkStormDataof2010-1312_text.pdf)

[89] Web map produced by "jimhe" on ArcGIS.com. This work is licensed under a Creative Commons Attribution-Noncommercial-Share Alike 3.0 United States License. Accessed at: http://www.arcgis.com/home/item.html?id=153c17de00914039bb28f6f6efe6d322

[90] Friends of Ballona Wetlands website. Available at: http://www.ballonafriends.org/habitat_wildlife.html

[91] Barboza, T. 2012. California OKs $6.5 million to plan Ballona Wetlands restoration. *Los Angeles Times* January 12, 2012. Accessed at: http://articles.latimes.com/2012/jan/21/local/la-me-ballona-wetlands-20120121

[92] Wisner, B and Oitto. J. 2009. "Life on the Edge: Urban Social Vulnerability and Decentralized, Citizen-Based Disaster Risk Reduction in Four Large Cities of the Pacific Rim" Chapter 13 in: Hans-Guenther Brauch et al., eds., *Facing Global Environmental Change*, pp. 217-234. Berlin: Springer Verlag.

[93] Working group member: Dr. David Eisenmann, UCLA, see Appendix A

[94] Jones & Stokes. 2003. Potential GIS Data Sources to Address Environmental Justice Issues in the CALFED Solution Area. June. (J&S 03-257) Sacramento, CA. Report prepared for the California Bay-Delta Authority, Sacramento, CA. Available at: http://calwater.ca.gov/content/Documents/environmental_justice/GIS_Sources_6-30-03.pdf

[95] Garzón, Catalina, Heather Cooley, Matthew Heberger, Eli Moore, Lucy Allen, Eyal Matalon, Anna Doty, and the Oakland Climate Action Coalition. (Pacific Institute). 2012. *Community-Based Climate Adaptation Planning: Case Study of Oakland, California*. California Energy Commission. Publication number: CEC-500-2012-038.

[96] Moser, S.C. and J. A. Ekstrom, 2011. Taking ownership of climate change: Stakeholder-intensive adaptation planning in two California communities. *Journal of Environmental Studies and Sciences (JESS)* 1(1): 63-74.