LA County Climate Vulnerability Assessment

Desktop Review

October 2021

Desktop Review
Introduction

1 Introduction

The County of Los Angeles (the County) adopted OurCounty: The Los Angeles Countywide Sustainability Plan in 2019. The plan set a vision for regional climate leadership and collaboration rooted in equity and resilience. Developing a countywide climate vulnerability assessment (CVA) is an important implementation step coming out of OurCounty and will inform the update to the County's General Plan Safety Element. By conducting a CVA, the County can identify the people, neighborhoods, and infrastructure systems that are most vulnerable to the worsening impacts of climate change. This analysis will serve as the foundation for adaptation planning efforts and help educate communities about the local impacts of climate change.

Over the past decade, as climate impacts have worsened in California, understanding and planning for the impacts of climate change has become an increasing focus of state, regional, and local planning efforts. To inform this CVA, a first step has been to review and summarize various existing state and county documents, sub-regional plans, and studies from external agencies. This report is organized into two parts:

Part I: Social Vulnerability Review captures methodology, indicators, and tools for understanding sensitivity, vulnerability, and adaptive capacity for populations and sub-populations in the County. The document examines frameworks, indicators, vulnerbility indices/scores, and tools commonly used to describe and measure social vulnerability that will be useful for the County's own CVA. The report first looks into definitions and existing research on social vulnerability and then examines methodologies, tools, and core indicators used for assessing vulnerability. Part III also outlines the current state of knowledge about social vulnerability in Los Angeles County, noting where there is limited data available, particularly in identifying vulnerable populations that are not easily represented through spatial analysis. This report further dicusses adaptative capacity and indictors for measuring a community's capability to adapt and respond to climate impacts.

Part II: Physical Vulnerability Review discusses sensitivity to climate hazards and examines historic impacts on infrastructure systems and critical assets. The document examines existing reports, in and around Los Angeles County, that describe climate change vulnerabilities on physical infrastructure and facilities, which can lead to disruption in critical services to people and communities. For the purposes of the CVA, this Desktop Review focuses on water, energy, transportation, emergency systems and structures, and communications infrastructure. The report identifies critical infrastructure and facilities in Los Angeles County that have already been documented as particularly vulnerable to local climate hazards.

1.1 Climate Vulnerability

Climate vulnerability is a measure of susceptibility to harm as a function of exposure, adaptive capacity, and sensitivity to climate hazards. These key terms are defined as such:

Key Terms[1]

Vulnerability: Vulnerability is the degree to which a system or sub-population is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Exposure: The nature and degree to which a system or sub-population is exposed to significant climatic variations.

Sensitivity: Sensitivity is the degree to which a system or sub-population is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise).

Adaptive capacity: Adaptive capacity is the ability of a system or sub-population to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

1.2 State and Regional Guidance Documents

Over the past two decades, California has developed various documents and tools for evaluating climate hazards, social and physical vulnerabilities, and their impacts under different climate change scenarios. These scenarios are informed by California's *Fourth Climate Change Assessment,* which downscales a set of global climate models to derive the state, regional, and local climate change impacts. These models are used to project risks facing California's residents, the built environment, and natural ecosystems. To address climate risks, the State has prepared numerous reports, best practice guides, and plans for analyzing social and physical vulnerability at a local scale, and preparing jurisdictional hazard mitigation plans. Some key State documents that serve as a foundation for this Desktop Review and the overall project include:

2012 and 2020 California Adaptation Planning Guides (APG)
California Natural Resources Agency and California Office of Emergency Management

The APG provides guidance to local governments and regional agencies to address the impacts of climate change through robust adaptation and resilience planning. The APG is organized around five categories: (1) exposure; (2) sensitivities and potential impacts; (3) adaptive capacity; (4) vulnerability

[1] IPCC AR4, 2007

scoring; and (5) outreach and engagement. Based on SB 379 requirements, the APG provides a framework for assessing vulnerability for populations, natural resources, and community assets.

These guides assist in identifying priority vulnerabilities by characterizing climate risks and assessing a community's ability to cope with climate impacts. The report includes social vulnerability as a measurement of people, rather than place, emphasizing that a population being considered socially vulnerable does not mean the population is responsble for their vulnerability. The report also notes that many of these groups face historic, and continued, systemic marginalization and oppression that affects their ability to cope and adapt to climate change.

The APG also outlines important vulnerabilities for some physical infrastructure sectors at the State level, including the emergency management, energy, public health, transportation, and water sectors. Emergency management vulnerabilities include a potential for overwhelming the system due to increased frequency and intensity of events. The energy sector vulnerabilities include the susceptibility of above ground power lines and facilities to damage, natural gas pipelines damaged in landslides and other events, and high heat weather causing disruption to energy service.

Vulnerabilities in the public health sector include increases in vector-borne diseases and extreme heat, both of which may add stress to healthcare infrastructure. The transportation sector is vulnerable to the impacts from increased storms and hazard events that can limit public transit service and damage roadways. The water sector, particularly potable water supply, is vulnerable to the impacts of drought and saltwater intrusion.

2018 State of California Hazard Mitigation Plan (SHMP)
Governor's Office of Emergency Services

The SHMP (prepared as per FEMA's State Mitigation Plan Review Guide) provides a comprehensive overview of historical and current climate hazards, the State's assets, vulnerabilities and capabilities, and offers technical assistance for preparing local climate hazard mitigation plans (LHMP). There are more than 1,250 dams within State jurisdiction as well as 11 seaports, 170,000 road miles, 50,000 highway miles, 246 airports, 115,000 oil and natural gas pipeline miles, and over a dozen oil fields that are important to the State's infrastructure portfolio. The SHMP presents the long-term implications of climate change and identifies the most vulnerable populations and sub-groups. The SHMP notes that vulnerability is a result of inequitable distribution of resources and lack of political willpower to address systemic issues, due to institutionalized racism and existing socio-economic inequities.

> Between 1950 and 2017, California has experienced more than 500 state-proclaimed emergencies. Climate related emergencies resulted in 600 deaths and $12 trillion administered for death and injury costs between 2003 and 2017.
>
> *2018 California Hazard Mitigation Plan*

The SHMP presents social vulnerability to climate hazards using a color-coded index which illustrates relative vulnerability across the State. Los Angeles County is highly vulnerable to geotechnical and climate hazards including flood hazards, wildfire hazards, and extreme heat events. Los Angeles County was impacted by 15 federally declared disasters between 2010 and 2017, and more than 60 federally declared disasters since 1950. The report also emphasizes protecting infrastructure assets to minimize physical damage and service interruptions as a means to better protect communities from climate hazards.

2018 Safeguarding California Plan
California Natural Resources Agency

This roadmap aligns California's climate goals with ongoing and needed adaptation actions by State agencies. The plan identifies nine climate change impacts facing the state and links adaptation strategies across different policy areas for integrating into regional and local planning. The climate impacts included in the plan are: increased warming, sea level rise (SLR), more severe and frequent

storms, more severe and frequent heat waves, more severe and frequent drought, decreased snowpack, increased riverine flow, more severe and frequent wildfire, and ocean acidification each year. These impacts will include SLR and erosion leading to diminished beach access, wildfires causing campground and park closures, reduced snowpack shortening the winter recreation season, and drought reducing water levels and freshwater activities. As climate will increasingly affect users, the demand for parks, beaches, and other recreation areas that serve as refuge during extreme heat days will increase. However, extreme heat will make certain recreation areas, particularly those with no shade, undesirable for recreation. Additionally, the plan describes how algae blooms will increase as temperatures rise, rendering freshwater lakes dangerous for recreation. Further, reduced snowpack will negatively affect winter recreation areas with the potential to affect recreation-dependent jobs in these areas.

2018 Planning and Investing for a Climate Resilient California
Governor's Office of Planning and Research

This guidebook outlines the importance of assessing vulnerability to inform planning and investment strategies, for fostering community resilience, and protecting natural and built infrastructure systems. The report identifies potential groups who are most vulnerable to climate change including: low-income people, communities of color, people with disabilities, people who are linguistically isolated, people who are physically or socially isolated, young children or older adults, outdoor workers, and people experiencing homelessness among others. The report also provides guidance for analyzing investment decisions over the lifespan of a project or plan by employing full life-cycle costing, developing performance criteria that reflects climate change impacts, and prioritizing infrastructure projects that provide climate benefits and promote equity. The report does not outline social vulnerability specifically but instead defines infrastructure as a system on which communities greatly rely and depend.

2020 Southern California Climate Adaptation Planning Guide
Southern California Association of Governments (SCAG)

In addition to State guidance documents, SCAG is in the process of developing a Regional Climate Adaptation Framework to support local climate adaptation planning efforts in Southern California, and recently published a Southern California Climate Adaptation Planning Guide. This guide outlines best practices to help local governments with their adaptation planning efforts and comply with SB 379 and SB 1035. The guide presents anticipated climate impacts to the SCAG region which include extreme heat, SLR/coastal flooding and erosion, severe storms and wind, inland flooding, drought, wildfire, air quality and vector-borne disease, landslides, as well as increases in pests or other ecological hazards. While the plan does not analyze infrastructure for vulnerabilities or discuss vulnerable populations, the plan identifies key next steps for jurisdictions looking to complete vulnerability analyses.

1.3 State Legislation

Over the last decade, California has pushed cities and counties to address climate vulnerability through legislation. Bills and executive orders that set the political context for the County's Climate Vulnerability Assessment include:

SB 535 (2012)
Directs at least 25 percent of proceeds from the Greenhouse Gas Reduction Fund to projects that benefit disadvantaged communities with at least 10 percent of funds allocated to projects within those communities.

AB 2139 (2012)
Authorizes the State Coastal Conservancy to address the impacts and potential impacts of climate change on resources within its jurisdiction and to award grants for this purpose to public agencies and organizations, giving priority to projects that maximize public benefits.

EO B-30-15 (2012)
Directs state agencies to consider climate change in their planning and investment decisions, giving priority to actions that both build climate preparedness and reduce GHG emissions, incorporate flexible adaptive approaches, protect the state's most vulnerable populations, and prioritize natural infrastructure.

AB 691 (2013)
Requires local trustees of public trust lands with revenues in excess of $250,000 to submit an assessment of how they propose to address sea-level rise to the State Lands Commission for public access and dissemination.

SB 379 (2015)
Requires all cities and counties to update the safety elements of their general plans with climate adaptation and resiliency strategies, including a vulnerability assessment, a set of goals and policies based on the vulnerability assessment, and a set of implementation strategies.

SB 1000 (2016)
Requires all cities and counties to include an environmental justice element to their general plans that outlines objectives and policies to reduce the health risks in disadvantaged communities in their jurisdiction.

AB 1550 (2016)
Modifies the investment minimums established by SB 535 to require at least 25 percent of Greenhouse Gas Reduction Fund proceeds go to projects both within and benefitting disadvantaged communities and at least 10 percent for low-income communities.

AB 2722 (2016)
Creates the Transformative Climate Communities Program, which awards grants to development and infrastructure projects that achieve major environmental, health, and economic benefits in disadvantaged communities.

SB 1035 (2018)
Requires, after 2022, the safety element to be reviewed and updated upon each revision of the housing element or local hazard mitigation plan to address climate adaptation and resiliency and identify new information regarding flood and fire hazards.

SB 1072 (2019)
Creates Regional Climate Collaborative Program to give disadvantaged communities funding for activities related to climate action, like capacity building, convening stakeholders, and developing plans.

Complying with State Regulations

California SB 379 requires all cities and counties to address climate adaptation and resilience in the Safety Element of a General Plan and/or in the Local Hazard Mitigation Plan. Additionally, SB 1035 requires regular updates to the Safety Element chapter of the General Plan, while addressing climate change adaptation and resilience to flood and fire hazards. The County developed the *2015 Los Angeles County General Plan: Safety Element* and is planning an update to the Safety Element, and recently updated the *2020 Los Angeles County All-Hazard Mitigation Plan (AHMP).* These countywide plans use a hazard-specific framework to describe vulnerabilities. The Safety Element addresses the potential risk of death, injury, and economic damage from natural and man-made hazards, noting the increasing cost of

wildfires and the public health impacts from poor air quality. The AHMP discusses physical vulnerabilities in detail and identifies critical facilities at risk.

1.4 Conclusion

In recent years, communities throughout California have increasingly experienced the worsening impacts of climate change. Preparing for and adapting to these hazards has become a more urgent priority for state, regional, and local planning efforts. The State has laid out a pathway for climate adaptation planning through various guidance, tools, and legislation. In particular, SB 379 ensures that local hazard mitigation plans and Safety Elements start to address climate hazards directly. The foundational step for informing climate adaptation and resilience efforts is the development of a climate vulnerability assessment.

On the regional and local level, jurisdictions are at varying stages of climate vulnerability assessments and adaptation planning, with regional entities such as SCAG developing guidance and tools for the Southern California context. The following sections will go into more depth about the current state of understanding for region-specific climate hazards and vulnerabilities. Both the Physical Vulnerability Review and the Social Vulnerability Review present approaches to selecting and prioritizing preliminary datasets and indicators that will be used for the CVA.

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Part I: Social Vulnerability Review

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1 Social Vulnerability

1.1 Defining Social Vulnerability

> Equity means that all people are justly and fairly included in society and that everyone is able to participate, prosper, and achieve their full potential. It recognizes that everyone enjoys different advantages and faces different challenges, and that everyone should be treated justly and fairly, according to their circumstances.
>
> *2020 California Adaptation Planning Guide*

The definition of social vulnerability can vary by planning area or by jurisdictional scale. These definitions are often centered around one or more factors related to socio-economic status, public health concerns, and environmental justice priorities. The 2017 report *Advancing Climate Justice in California: Guiding Principles and Recommendations for Policy and Funding Decisions*, prepared by the Climate Justice Working Group as part of 2017 *Safeguarding California* update, provides a broad overview of climate justice and vulnerability in the state. The report defines climate vulnerability as "the ways that a person, community, or social system is susceptible to harm or damage as a result of climate change." The report identifies and defines the factors that influence vulnerability as:

- Inequities in access and benefits of education, economic investment, social capital, health protection services, and/or government services;
- Institutionalized bias or exclusion with respect to political and decision-making power;
- Differences in environmental and living conditions; and
- Disparities in individual, family, and community health status.

As a measurement of a person's vulnerability to climate change, social vulnerability is influenced heavily by many factors such as systemic racism and poverty. The use of the term vulnerability is not meant as a statement of a person's weakness or inability to cope but rather a statement of a person's heightened susceptibility to climate hazards and its impacts. Some indicators for social vulnerability like age or underlying health conditions are matter-of-fact while others, particularly race and ethnicity, are included as indicators solely because of years of racist systems and policies that have manifested in higher rates of illness in BIPOC communities, higher rates of poverty, and lower quality infrastructure that makes their neighborhoods more vulnerable to climate change. For example, predominately black neighborhoods often have fewer trees and more pavement than predominately white neighborhoods, exacerbating extreme heat conditions.

As explained in OurCounty, "equity is an end state in which all groups have access to the resources and opportunities necessary to improve the quality of their lives." Through the CVA and future climate work, the County will work to achieve climate justice – taking action to achieve equity in the context of climate hazards. The County aims to protect vulnerable groups so that they don't have to suffer more than other groups. Understanding social vulnerability to climate change in Los Angeles County will help to inform the actions needed to better protect our most vulnerable communities and equip them with the tools to respond to and overcome climate hazards.

1.2 Context for Indigenous and Native Population

Los Angeles County is home to three Native American tribes, all of which are not federally recognized but recognized by the State of California. The County is also home to more Native American / Alaskan

> Traditional ecological knowledge (TEK) is unique to each tribe and underpins many tribes' environmental management and community and economic development approaches… Today, tribes do not have management-level access to their ancestral territories. Due to tribes' reduced ability to tend resources, their traditional materials, foods, medicines and other resources are of low quantity and quality. However, through determined efforts by tribes to maintain these cultural lifeways and stewardship, TEK-based methods are gaining a revitalized position within a larger toolset to combat the causes and effects of climate change by tribal and non-tribal stakeholders alike.
>
> *Summary Report from Tribal and Indigenous Communities within California*

Natives than any other county in the United States at around 141,000 people[1]. The history of Native and indigenous people in the U.S. is littered with discrimination, cultural removal, and forced migration that have led to high rates of poverty and illness on tribal lands and has over time built a sense of distrust in U.S. government institutions. Prior to the European colonization of North America, Native Americans maintained a healthy, sustainable relationship with the land and environment and supported large, prosperous populations. Traditional practices of Native American tribes range and vary from tribe to tribe, but consistently are deeply rooted in the environment and the intrinsic link between human and environmental health. As climate change impacts LA County and the rest of the U.S., Native and indigenous populations are highly vulnerable due to their reliance on the land and environment for livelihood and prosperity.

Native American communities in LA County are particularly vulnerable to climate change because of compounding stresses from historical events and contemporary conditions that pose economic, political/legal, environmental, and health challenges. Native American tribes and communities will face heightened vulnerability because of several reasons, a few of which are listed here[2]:

- For many tribes, local water sources are greatly relied upon and so the changing frequency and severity of drought will significantly impact these communities and leave them without reliable water sources.
- Tribal lands tend to be more rural and so they often have limited access to medical facilities in the case of heat related illness from extreme heat events.
- Wildfires are also a grave concern for rural and isolated tribal lands where decreased air quality is inevitable and there is higher probability for destruction of cultural sites, gathering areas, sacred lands, and agricultural resources.
- Many indigenous communities rely on the land to provide sustenance and traditional gathering activities are at risk. Climate change is resulting in diminished access to traditional foods through prolonged drought, increasing temperatures, declining soil health, invasive species, disease, and tree mortality.
- Asthma rates among adults and children in Native American communities in California are higher than they are among the general population putting them at higher risk to the impacts of extreme heat and wildfires.
- There are historic gaps in critical energy and transportation infrastructure on tribal lands. There are large tribal areas in California that have never had electrical grid, natural gas, internet, or other basic utility services.

[1] Los Angeles City / County Native American Indian Commission

[2] Summary Report from Tribal and Indigenous Communities within California

> Cultural resources are environments, conditions, practices, places, plants, and animals that are of significance to a particular tribe's culture. Climate change is impacting cultural resources across all tribal lands.
>
> *Summary Report from Tribal and Indigenous Communities within California*

Further, due to the nature of these communities and their sovereignty, it is often difficult to collect data and information related to physical infrastructure assets that are important to the communities or social cohesion factors that determine a community's strength in adapting to the changing climate. Indigenous communities often pass down climate information and knowledge through stories that isn't necessarily measurable but observed with tribal expertise. The *Summary Report from Tribal and Indigenous Communities within California*, developed as part of *California's Fourth Climate Change Assessment*, explains that "for many tribes, there is an imbedded, cultural, long-term timescale applied to monitoring climate change: from 'time immemorial' to present. Tribal climate action often contains the distillation of data stretching back thousands of years in the same region. Tribal climate data can include oral and written information passed down from generation to generation and incorporated into cultural norms and land management practices. Today's tribal science looks back to ancient time to identify trends, norms, and adaptive behaviors within symbiotic relationships between humans and their landscapes. Tribal climate assessments incorporate this traditional data where it exists, as inseparable from more recent information." Due to this, there is a challenge to overcome in integrating Native-based information into standard climate vulnerability assessment processes. To truly capture the wisdom and specific needs of these communities, targeted engagement will be needed.

Climate change puts culturally important habitats, places, species, and practices in danger and thus the cultural and mental health, identity, and continuity of Native and indigenous peoples in LA County. In addressing climate justice through climate adaptation work, the County will prioritize Native groups and work to better understand their specific climate vulnerabilities and their ability to adapt and respond. Together, the County and Native and indigenous populations can work together to build resilience and integrate traditional ecological knowledge in the County's climate response.

1.3 Context for Black Population

> The term structural racism refers to a system in which public policies, institutional practices, cultural representations, and other norms work to reinforce and perpetuate racial group inequity. It identifies dimensions of our history and culture that have allowed privileges associated with "whiteness" and disadvantages associated with "color" to endure and adapt over time.
>
> *The Aspen Institute*

A history of discrimination in housing, education, employment, and healthcare in the United States have greatly contributed to the differential impacts of climate change on predominately black communities. Black communities in particular have suffered from racist acts and policies such as slavery, Jim Crow laws, and redlining. The legacy of these racist acts and policies (as well as many others) are often revealed through and exacerbated by climate change. Within this context, black communities have inherited a vulnerability to climate change in the form of marginalization, disinvestment, and failed systems.

The following excerpt from a PolicyLink report titled *Why Place and Race Matter* succinctly yet powerfully illustrates the important connection between racism (and its manifestation through place) and health.

"It is well documented that people of color, especially with the lowest incomes, have the worst health outcomes of anyone in our society. It is also well documented that neighborhoods of color have the highest pollution levels; the fewest amenities and support structures; the most limited access to fresh foods, park space, and other resources for health; and the most entrenched obstacles to economic and social opportunities… These are the reasons why place and race matter. They must inform our

understanding of the serious health problems confronting our state and nation, and they must shape our solutions."

Building upon this excerpt, the American Public Health Association's *Climate Change, Health, and Equity* guide provides additional examples of climate and health gaps. On the following page are a select few examples.

Black Americans:

- have worse health care access,
- live in neighborhoods that are more likely to have above average air pollution, hazards, and food deserts while having less green space and tree canopy cover,
- are more likely to die from extreme heat,
- have higher rates of poverty than non-Hispanic white families,
- are more likely to suffer from cardiovascular disease, and
- have higher rates of asthma than white Americans.

The cumulative impact of these systemic constructs continues to manifest in lasting health impacts on black people but also economic challenges. In 2019, homeownership rate for black households was 40.6% while white households had a 73.1% homeownership rate.[3] The challenges facing LA County's black population are exacerbated by climate hazards and as such, these populations are included as a priority lens through which to evaluate climate social vulnerability in the County. The CVA will help to understand the level of climate vulnerability and adaptative capacity of black communities in LA County.

1.4 COVID as an Illustration of Inequity

The COVID-19 pandemic is a public health crisis that has disproportionately impacted communities of color and low-income people already burdened by the impacts of climate change, pollution, and other social and environmental inequities. COVID-19 symptoms are wide-ranging, and can cause lung and breathing issues, a major concern for neighborhoods already suffering from bad air quality and high rates of respiratory illnesses. There is a clear link between the COVID-19 pandemic and environmental justice issues, notably the impact of air pollution on health and the role of the built environment to contribute to the severity. A national study by a team at Harvard T.H. Chan School of Public Health titled *Exposure to Air Pollution and COVID-19 Mortality in the United States: A Nationwide Cross-Sectional Study*, suggests COVID-19 impacts are more severe in communities with long-term air pollution exposure, a finding consistent with previous links to air pollution and infectious disease outbreak severity.

In the County, COVID-19 has hit Service Planning Areas[4] (SPAs) 6 and 7 hardest. These SPAs encompass communities such as Artesia, Bell, East Los Angeles, Santa Fe Springs, Whittier, Compton, Crenshaw, Lynwood, Paramount, and Watts, among others. These SPAs also encompass some of the most polluted census tracts according to CalEnviroScreen, with many census tracts in the 85-90% percentile in terms of air pollution. This past fall, numerous fires burned across the state, including the Bobcat Fire, which blanketed the Los Angeles region in a layer of smoke – compounding the risk of respiratory problems among those exposed to the smoke.

[3] Federal Reserve Bank of New York, Liberty Street Economics, *Inequality in U.S. Homeownership Rates by Race and Ethnicity*

[4] A Service Planning Area (SPA) is geographic delineation by the County Department of Public Health to provide targeted programs and services to residents.

Across the US, COVID-19 impacts BIPOC communities disproportionately, and Los Angeles County is no exception. Black people in the County have an age-adjusted mortality rate that is nearly double that of white Angelenos. Further, as of December 2020, Latinx residents have an age-adjusted mortality rate that is triple that of whites. These numbers illustrate stark inequities across the region. It is speculated that for Latinx communities, higher rates of employment in essential/frontline occupations, denser populations, lower testing rates, and a family-centric culture have contributed to this disproportionate rate of mortality.

A Race Counts report titled *How Race, Class, and Place Fuel a Pandemic* states that these inequities in mortality rates are "often due to overlapping vulnerabilities created by generations of disinvestment from public health infrastructure and other structural inequities. Housing segregation and the legacy of redlining means more Californians of color live in denser, multi-generational households where infection can spread more easily; a less-healthy built environment starves low-income people of color of access to safe places to recreate and exercise or to buy healthy food; racialized criminal justice systems disproportionately put Latinx and especially Black residents at high risk of infection in jails and prisons; and the epidemic of houselessness that has overtaken Los Angeles means many people of color have no place to go for shelter from the virus."

The COVID-19 pandemic has illustrated the severity of addressing environmental issues like air quality that can compound and result in unequal impacts and death. Through climate adaptation work and building awareness around environmental justice issues, the County can work to reverse these trends and address foundational inequities in regional infrastructure and services.

2 Evaluating Social Vulnerability to Climate Change

The definition and scope of social vulnerability is broad and capturing its nuanced complexity is not easy. Social vulnerability can be assessed qualitatively, quantitatively, or using a combination of both. Explaining or identifying social vulnerabilities using quantitative data requires one to select indicators based on relevance and availability. Oftentimes, the data is disaggregated geographically and the indicators are combined into an index or score to understand the cumulative effect of multiple factors that lead to increased vulnerability within a given region.

While there are numerous reports that recommend methodology or approach for identifying and combining social vulnerability indicators, there is no standard for selecting social vulnerability indicators. For this Desktop Review, plans, guidance documents, tools, and indexes have been reviewed to identify core indicators that are considered essential to evaluating social vulnerability. This Desktop Review included the review of five reports and seven tools to better understand potential approaches for assessing vulnerability and selecting core indicators.

2.1 Plans and Resources

2012 Social Vulnerability to Climate Change in California
Pacific Institute

This report emphasizes the importance of understanding the role of social vulnerability factors in crafting effective and equitable climate adaptation policies. The authors developed a new index of 19 indicators to measure climate vulnerability. The report classifies social vulnerabilities by hazard and provides key scientific references for each listed indicator. In addition to commonly used indicators (e.g. age, race, gender, health, income, electricity and AC availability, education, and housing status), the report also includes indicators such as isolation (geographic and public agency), institutionalized populations, diabetes, obesity, alcoholism, density, food access, youth fitness, pre-term births, and pregnancy rates that are often underexamined in existing literature. The report identifies education level, income, linguistic isolation, and race-related factors as some of the most significant indicators of vulnerability.

2017 Climate Change and Health Profile Report for Los Angeles County
California Department of Health (CDPH)

In this report, CDPH outlines key demographic factors and health indicators for assessing vulnerability and discusses the health impacts of heat, sea level rise, drought, vector-borne illnesses, and extreme weather, among others. The report profiles eight demographic factors that exacerbate the impacts of climate change including: pre-existing conditions, language and literacy barriers, age, occupation, over-burdened and under-resourced populations, race and income, housing, and neighborhood conditions, and gender.

> In 2005-2010, there was an annual average of 630 heat related emergency room visits in Los Angeles County and resulting in a rate of 6 emergency room visits per 100,000 persons.
>
> *2017 Climate Change and Health Profile Report for Los Angeles County*

The report particularly emphasizes that extreme heat impacts are largely inescapable for both rural and urban communities in the County, regardless of an individual's race, income, and geography (rural/urban). Extreme heat events can create dangerous conditions for the elderly, children, people with limited transportation access, socially isolated individuals, and those with underlying health conditions or who are medically fragile.

2018 Climate Justice Summary Report
Governor of California Office of Planning and Research

The *Climate Justice Summary Report* identified social vulnerability indicators that demonstrate the impact of climate change is worse for specific populations. This report uses socio-economic indicators such as access to healthcare, race, exposure to pollutants, disparities in education, and access to transportation, and demonstrates how existing inequalities will be exacerbated by climate change. The report also discusses disparities between communities as it relates to physical infrastructure that affect adaptive capacity and resiliency. Some of these disparities include physical infrastructure such as green space, transportation options, and built environment interventions (such as air conditioning). The report also notes the interconnectedness between physical infrastructure and vulnerable populations, highlighting that low income or other populations may be less able to cope with damages or changes in supply from physical infrastructure.

2019 Mapping Resilience: A Blueprint for Thriving in the Face of Climate Disasters
Asian Pacific Environmental Network

The *Mapping Resilience* report provides an overview of existing planning initiatives in the State and summarises key indicators, data, tools, and analytical frameworks. The report reviewed more than 40 climate vulnerability frameworks and pulled out four state-wide frameworks that incorporated the largest amount of indicators and had good data accessibility (high quality visualizations). These frameworks include: California Healthy Places Index (HPI), Climate Change and Health Vulnerability Indicators, Social Vulnerability to Climate Change, and Climate Change Vulnerability Screening Index. Other tools highlighted in this review include the Climate Heat Assessment Tool (CHAT), and Surging Seas Risk Zone Map.

The report finds that existing frameworks differ in quality and breadth and recommends that additional research is needed to ensure data gaps are covered and overlooked factors are addressed. The report highlights the need for a comprehensive indicator set and assessment framework. The report also notes that existing frameworks need to offer a more granular reflection on climate data and impacts. Further, most frameworks do not account for future climate risks, environmental justice implications, public health, socioeconomic outcomes, and adaptive capacity needs. To address data limitations and knowledge gaps, the report provides the following guidance for developing a comprehensive framework for vulnerability assessment:

- Climate vulnerability should be assessed and depicted based on regional characteristics and specific climate threats;
- Researchers do not need to develop entirely new climate vulnerability indicator sets as there is sufficient underlying data, established indicators, and published methodologies that can be combined to assess climate vulnerability in California;
- California policy makers need to streamline significant indicators in a centralized repository with an accompanying visualization platform to support decision makers in identifying priority issues, adaptation programs and policies; and
- Public officials should ground truth and complement vulnerability maps with community expertise.

2020 Climate Change and Health Equity: Strategies for Action
Los Angeles County Department of Public Health

This discussion draft highlights community vulnerabilities to climate change through an equity lens and serves as an overarching document for stakeholder outreach. The report documents pre-existing conditions, language barriers, age, occupation, income, housing conditions, race, and under-resourced

populations, who are more likely to be heavily impacted by climate change. Many communities in the County will be disproportionately affected by climate change and face increased health risks.

The report particularly focuses on heat-related illnesses, which are a year-round threat in Los Angeles County. The researchers note communities with fewer green spaces and more impervious surfaces are already at higher risk to extreme heat events, which are increasing in severity and frequency. The report determined climate change will increase food insecurity and adversely impact agricultural and tourism industries (in addition to other land dependent industries).

The report also emphasized the unique risks to outdoor workers and their increased likelihood of contracting Valley Fever, caused by a desert soil fungus. The report notes that African American and Latino workers are more likely to be diagnosed later and die at higher rates from Valley Fever than white workers. The draft report strategizes that to drive public health strategies for climate change, grounded in equity, involves empowering communities and working towards a resilient and sustainable built environment, and health policy.

2020 Assessing the Geographic Variability in Vulnerability to Climate Change and Coastal Hazards in Los Angeles County
National Oceanic and Atmospheric Administration (NOAA)

The NOAA report incorporated stakeholder engagement, development of an index using the Social Vulnerability Index methodology, and assessment of vulnerabilities and risks. The report's goal was to outline areas of vulnerability that may assist jurisdictions within the County as they develop local sustainability and climate action plans. The researchers relied on Census data for their analysis which makes analyzing homelessness, displacement, and gentrification difficult, however they noted that primary data collection could help fill this gap. Key findings from this analysis include heightened wildfire risk in rural and newly suburban areas and the lack of access to green space for more vulnerable populations. The researchers also noted that while their analysis was focused on vulnerability, ideas of resilience and perceived vulnerability could benefit the County's adaptation and mitigation planning.

2.2 Methodology and Tools

The magnitude of social vulnerability is expressed using established indicators that provide the socio-economic, health, and environmental context of a region. These indicators are often combined to create an index, or other scoring mechanism, to describe the jurisdiction's social vulnerability. These indices or scores can be derived from simple additive models, weighted models, and models based on principle components analysis. While no method is perfect, it is important to identify the method that is best at uncovering spatial patterns, flagging overlapping vulnerabilities, and guiding future analysis in Los Angeles County. The tools and indices reviewed here emphasize spatial data that is primarily available at the census tract level.

Statistical Methodologies

Additive Model: In an additive model, the first step is to normalize and/or standardize the values of all social vulnerability indicators. Generally, this can be achieved by taking the percentile rank or per capita value of the indicators so that they are all on the same scale. Next, the indicators are summed up, giving a final score to be used across regions (census tract, city, county). In this methodology, it is assumed that all indicators contribute equally to a region's overall vulnerability, and that all indicators act independently of each other.

Weighted Model: This type of model does not account for potential redundancy among indicators, meaning that indicator selection heavily influences the outcome. For example, if the index has more indicators in the "housing" category than any other, a region's vulnerability score will be determined mostly by its housing quality. A weighted model relies on a similar approach as the additive model except that certain indicators are given more weight –

meaning that they will have greater influence on the outcome. Weighting also allows for tailoring by the researcher, shifting emphasis where needed and in accordance with the plan's goals. While these models can incorporate many indicators, these kinds of indexes do not account for interactions or redundancy between indicators.

Principal Component Analysis (PCA): PCA is a statistical method used for extracting information and identifying relationships in data sets with many variables. PCA controls interactions between indicators by extracting the important variables in a dataset with many variables. This method assumes that each indicator contributes equally to overall vulnerability, but it does account for interaction between them. This can be particularly useful for uncovering inequities and systemic racism.

Reports and plans were reviewed that describe statistical methodologies that serve as the foundation for vulnerability assessment tools. This section provides a brief description of various methodology and tools, along with an example of how each has been used for academic research and/or policymaking. The examples provided in this section are considered the most important for the social vulnerability analysis due to their robustness and prevalence in reviewed literature.

Center for Disease Control's Social Vulnerability Index (CDC SVI)

Additive models, such as the SVI, normalize all indicators and assume each indicator contributes to vulnerability equally.

The SVI methodology uses 15 indicators (from the US Census) to evaluate disaster preparedness (including natural, human, and disease events) at the census tract level. The index contains four themes: socioeconomic status, household composition, disability, race/ethnicity/language, and housing and transportation. This framework is more aligned with disasters and can be applied to events such as chemical spills, hurricanes, and disease outbreaks to identify communities that will need support during emergency operations and in recovery. Because this methodology relies on an additive model, it assumes that each indicator contributes equally to overall vulnerability and that they each act independently of each other.

Social Vulnerability Index (SoVI®)

The SoVI® method is one of the most common approaches used for social vulnerability assessment. SoVI® can account for interactions between indicators and is used in many reports relevant to Los Angeles

SoVI® methodology was developed by a team in the University of South Carolina's Hazards and Vulnerability Research Institute and is broadly used for state and county climate hazard mitigation plans throughout the United States. It is a tool by which policymakers and other stakeholders can empirically examine and compare social vulnerability to stressors at a county level. The index contains 29 different indicators which are simplified into a score using PCA based methods, resulting in a final index score. While many social vulnerability assessments utilize this approach, the set of indicators used are, at times, adapted for different regions or approaches.

One of the drawbacks of SoVI® is that it assumes that each indicator contributes equally to overall vulnerability. However, the tool does account for interactions between different indicators, which can be particularly useful for uncovering inequities and systemic racism. Some Los Angeles County plans that utilize SoVI® methodologies include the *Social Vulnerability to Climate Change in California* report, *Assessing the Geographic Variability in Vulnerability to Climate Change and Coastal Risks in Los Angeles County* report, the South Bay Cities Council of Governments (SBCCOG) *Sub-Regional Adaptation Plan*, and the *Sea Level Rise Vulnerability Study for the City of Los Angeles*.

CalBRACE Climate Change and Health Vulnerability Indicators (CCHVI)

CCHVI provides a list of relevant health indicators, along with data and rationale for their inclusion. Organized into three categories (environmental exposures, population sensitivity, and adaptive capacity), the report identifies key nexus points for measuring vulnerability for different population groups such as ozone levels and children or wildfire incidences and elderly people, or those with disabilities. The tool was created to provide local health departments and stakeholders with the ability to assess and prioritize further public health and resilience efforts.

California Heat Assessment Tool (CHAT)

The State mapping tool, CHAT, specifically focuses on extreme heat and health. It utilizes data from historic events, projections, and vulnerabilities to inform climate and public health action. The tool overlays extreme heat event likelihood with social vulnerability indicators to present overall vulnerability and target neighborhoods for interventions. This tool does not include a social vulnerability index. The 2020 *Heat Vulnerability in Los Angeles County Resource and Methodology Assessment* report notes some limitations with the tool. For example, the tool allows the users to see one vulnerability indicator, thus preventing combination analysis. The tool also does not map land use, housing or infrastructure.

Climate-Smart Cities Tool

This tool created by the Trust for Public Land in conjunction with local experts, *Climate-Smart Cities* was developed with the goal of providing additional data (especially geospatial) on mobility, heat, water, and infrastructure resilience for the City of Los Angeles in conjunction with the 2015 pLAn and 2019 New Green New Deal goal and objectives in mind. The geospatial tool shows areas where green infrastructure projects could provide cooling benefits or implement bike/ped connections to transit and jobs and protect vulnerable populations.

The tool utilizes the following indicators to determine social vulnerability: income levels, people of color, education level, linguistic isolation, people over the age of 65 or under 5, unemployed, low birth weight, and people with asthma. The 2020 *Heat Vulnerability in Los Angeles County* report, noted a limitation in land use, noting that housing development and anticipated growth areas are not considered, in addition to not corresponding to the geographic administrative jurisdiction of Los Angeles County.

Healthy Places Index (HPI)

Weighted models, such as HPI, allows indicators to have increased influence on vulnerability measurements

The HPI is developed by Public Health Alliance of Southern California and builds on its predecessor, the Health Disadvantage Index. The HPI is designed to inform stakeholders and government officials so they can prioritize investments, programs, and actions. HPI indicators are weighted in a way that maximizes association with life expectancy at birth, allowing users to compare the overall health of census tracts against each other, generating a percentile rank to facilitate comparison at the census tract level.

While this model attempts to account for the potential unequal contribution of indicators to social vulnerability through weighting, it does not account for impacts resulting from interactions between indicators. The 2020 *Heat Vulnerability in Los Angeles County Resource and Methodology Assessment* report identifies some limitations with the HPI tool, notably that some criteria included in other reports were excluded in the HPI tool because they did not have sufficient data to support their inclusion (i.e. community power inclusion or exclusion).

Equity Indicators Tool

The County's Department of Regional Planning (DRP) developed the *Equity Indicators Tool* in 2018, with the goal of guiding the General Plan's equity objectives. DRP's *Equity Indicators Tool* showcases socio-

economic, environmental, housing, and demographic indicators in order to identify regions within Los Angeles County that are most disadvantaged. The tool also demonstrates racialized patterns of inequality as it relates to the quality of the built environment and the distribution of vulnerable populations. The tool provides an understanding of how the County views equity in planning. Vulnerabilities are assessed using indicators related to income, housing, race, segregation, parks, land use, employment, languages, and education among others. The tool provides useful input for assessing social vulnerability but does not include a climate change specific framework.

2.3 Adaptive Capacity

Within the climate context, adaptive capacity refers to a system or sub-population's ability to adjust to climate change, to moderate potential damages, or to cope with the consequences. Adaptive capacity is an emerging area of interest for vulnerability assessments and adaptation planning. For the purposes of this Desktop Review, adaptive capacity was reviewed to understand how it is typically defined and its relationship to social vulnerability.

Adaptive capacity, pursuant to the APG, includes the ability to take advantage of opportunities that occur with climate change. Other existing reports and guidance documents acknowledge adaptive capacity but don't always define it. Table 1, below, provides an overview of adaptive capacity definitions from reports and plans related to social vulnerability. Most reports describe adaptive capacity at a high level or present it in combination with social vulnerability.

Table 1: Adaptive capacity definitions

Year	Report Title	Definition of Adaptive Capacity
2020	APG	Derived from the Cal OES California State Hazard Mitigation Plan, defined as the attributes and resources available that can be used to prepare for and act to mitigate climate change impacts or damage or capitalize on potential opportunities.
2019	APEN Mapping Resilience	Using a definition adapted from the CalBRACE project, adaptive capacity refers to the adjustments made to the impacts of climate change, including mitigating potential damage, identifying and capitalizing on potential opportunities, and coping with consequences of the impacts. Indicators that apply across hazards include vehicle and transit access, medical facilities, emergency services, and responders. Specific climate hazards also drive specific adaptive capacity indicators, for extreme heat these can include impervious surfaces, green space and tree canopy and air condition. Flood risk can include flood insurance and impervious surfaces, while air quality includes tree canopy and green space.
Updated 2020	California Building Resilience Against Climate Effects Climate Change and Health Vulnerability Indicators (CalBRACE CCHVIz)	Defined as the range of responses and adjustments to climate change impacts, including mitigating potential damages, taking advantage of opportunities, and coping with consequences. Indicators include households with air conditioning, tree canopy coverage, impervious surfaces, and public transit access.
2019	LA Metro Climate Action Plan	Defined as "an assets ability to withstand the hazard or recover from it."
2018	California 4th Climate Change Assessment	Derived from the IPCC definition, California Fourth Assessment defines adaptive capacity as the "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities."

2013	Racial and Income Disparities in Relation to a Proposed Climate Change Vulnerability Screening Method for California	No specific definition was presented, however the researchers measured adaptive capacity through tree canopy, impervious surfaces, air conditioner use, and public transit access.
2013	Sea Level Rise Vulnerability Study for the City of Los Angeles	Defined as the "ability of an asset to make adjustments in response to a climate impact to maintain its primary functions."

Based on review of existing reports and documents, adaptive capacity discussions are focused on built environment and transportation factors that affect people's adaptive capacity, as well as social cohesion which contributes to individual and community resilience before, during, and after extreme weather events. The subsequent sections capture key findings and data available for analyzing adaptive capacity in Los Angeles County.

Built Environment

Air Conditioning

There is limited data on air conditioning usage across Los Angeles County.

Some reports reviewed refer to air conditioning as an adaptive capacity indicator however, there is criticism that just noting the presence of air conditioning is sufficient. The APEN *Mapping Resiliency* and the 2016 journal article, *Heat Death Associations with the built environment, social vulnerability and their interactions with rising temperature,* report reiterates this, concluding that the presence of air conditioning does not preclude its use or even its usability, highlighting that high electricity costs can prevent low-income users from using air conditioning.

In *Building Thermal Performance, Extreme Heat, and Climate Change*, by researchers Matthew Nahlik, Mikhail Chester Ph.D. M.ASCE, Stephanie Pincetl, Ph.D., and David Eisenman, data was collected on the presence of central air conditioning across Los Angeles County. The study focused only on central air conditioning and did not incorporate room air conditioning units or evaporative coolers. The study highlighted that the presence of air conditioning alone does not equate with usage, citing affordability, and concluded that other retrofits can help slow rising indoor temperatures in extreme heat such as insulation and energy efficient windows. Along similar lines, a case study in Houston, Texas, *Adaptive Capacity to Extreme Heat: Results from a Household Survey in Houston Texas*, by Mary Hayden et al. found that 14.4% of survey respondents reported the high cost of electricity prevented them using air conditioning, despite nearly 85% of respondents reporting they had central air conditioning. In *Household accessibility to heat refuges: Residential air conditioning, public cooled space, and walkability* by researchers Andrew M. Fraser et al., the researchers utilized the County's assessors database and the American Household Survey to gather information on whether a single family dwelling or multi-family dwelling has central air conditioning. At the countywide level, researchers determined that just under 50% of all households have access to central air conditioning.

There are some estimates available about the amount of energy required to power air conditioning, but these estimates do not address affordability. Power consumption data can be obtained from the California Energy Commissions Statewide Residential Appliance Saturation Study, a survey of about 300,000 households that most recently occurred from August 2019 through February 2020. This dataset identifies energy consumption patterns for homes with air conditioning (disaggregate by type), by power provider. The 2020 results are not yet available; however, the 2009 study of over 2,000 individually metered homes, showed just over 40% had central air conditioning.

Cooling Centers and Places of Refuge

Cooling centers and places of refuge can provide community benefits but there is no available data on how cooling centers are used across Los Angeles County, nor is there a quantifiable measurement of their impact.

A 2016 journal article on *Heat Death Associations with the built environment, social vulnerability and their interactions with rising temperature,* by David P. Eisenman, Holly Wilhalme, Chi-Hong Tseng, Mikhail Chester, Paul English, Stephanie Pincetl, Andrew Fraser, Sitaram Vangala, and Satvinder K. Dhaliwal, explored the relationship between mortality, social vulnerability, and infrastructure factors in Maricopa County, Arizona. The researchers examined the benefit of infrastructure factors such as access to air-conditioned space (which includes cooling centers), home air conditioning, and thermal protection residential buildings, for increasing adaptive capacity to heat-induced illnesses and deaths. Finding a decrease in heat-related illnesses in a census tract with increasing accessibility to publicly available cooled spaces such as cooling centers.

80% of County residents have access to a public cooling resource within walking distance, but only 3% of County residents are within walking distance of an official cooling center.

Official lists of cooling centers can be obtained from the California Office of Emergency Services, the County, and other jurisdictions as needed. In *Household accessibility to heat refuges: Residential air conditioning, public cooled space, and walkability* by researchers Andrew M. Fraser et al., the researchers compiled places of refuge for extreme heat, including libraries (which are often used as cooling centers), and commercial enterprises that are open to the public (a sort of unofficial cooling center). Researchers created a matrix that outlines barriers to access (including distance and cost of entry) to quantify their usability. Wait-walk times, as used for the *Household accessibility to heat refuges: Residential air conditioning, public cooled space, and walkability report* are available from the authors.

Transportation

The APEN *Mapping Resiliency* report provides some background on transportation as adaptive capacity. The report raises the need to separate vehicle access from transit access during evacuations. The researchers further note that existing literature often equates car ownership with adaptive capacity and overlooks concerns related to affordability and the operational condition of vehicles. The APEN *Mapping Resilience* report also notes that roads and evacuation routes are examined as part of adaptive capacity in some tools such as the *CRSI, Surging Seas Risk Zone Map*, and the under development *California Department of Transportation's Climate Change Vulnerability Assessment Map*, highlighting that chokepoints and/or poor road quality can create ripple effects across an area in an emergency. Similar findings can be found in the Caltrans *District 7* report which identified road quality as a key concern particularly during extreme heat days and wildfires. However, as noted in the APEN *Mapping Resilience* report the importance of evacuation routes and roads is largely dependent on the hazard being examined.

Transportation data can include information about private vehicle ownership, public transit, and roadway infrastructure. Vehicle ownership data is obtained from the US Census. Public transit data requires coordinating with multiple transportation providers in the Los Angeles region. At large, public transit accessibility is dependent on proximity. Road data can be obtained from multiple sources, the primary source being Caltrans. Caltrans is also developing a tool that depicts climate change vulnerability on roadway infrastructure.

Disinvestment and Adaptive Capacity

The findings from the Desktop Review reiterated that the existing public health disparities are a result of historical processes and disinvestment. Often, communities that experience disproportionate health issues also face more severe impacts from climate change, and have a harder time adapting due to historic disinvestment. A 2019 Prevention Institute report titled *Healing LA Neighborhoods*, outlines some of this history and how housing policies, including redlining, facilitate segregated housing, which in turn led to disproportionate health impacts that remain today. The researchers also explored the impacts of internment policies for Japanese-American citizens, Indigenous people's removal from land, effect on people of color and their housing opportunities and wealth accumulation. Redlining placed undesirable land uses, such as industrial uses, adjacent to low-income and communities of color, while more desirable uses and parks were concentrated in affluent areas.

As indicated in a 2019 study from UC San Francisco and UC Berkeley, *Historic Redlining and Asthma Exacerbations Across Eight Cities of California*, the impacts of redlining continue today. Historically redlined census tracts experience DEP emission rates and Asthma related Emergency Department visit rates nearly double those of A-rated (or "low-risk") census tracts. In addition to high emission levels, historically redlined census tracts were found to have poverty rates over three times greater than A-rated census tracts according to the researchers' study. These findings highlight the continued influence of historic disinvestment on the health and well-being of residents. These findings also provide the narrative around why certain communities have higher rates of Asthma and fewer green spaces, both factors that affect adaptive capacity.

Social Cohesion

There is extremely limited discussion of social factors of adaptive capacity in existing reports and plans.

Social cohesion as an indicator of adaptive capacity is not well defined across reports. Indicators for measuring social cohesion are also not discussed to sufficient detail. The APEN *Mapping Resiliency* report compared multiple vulnerability frameworks, and identified common indicators of adaptive capacity, only one of which "telecommunications access," relates to social cohesion. USC has published social cohesion variables, such as internet access and voter turnout rates, to describe social cohesion in Los Angeles County.

There is limited discussion in reviewed reports and plans that measure social cohesion however, there are a select few resources that are useful for understanding different approaches to defining and evaluating social cohesion. In 2014, the City of Santa Monica completed a Wellbeing Survey as part of their creation for a Wellbeing Index that would measure the City's effectiveness by compiling City data, resident wellbeing surveys, and social media data. The Wellbeing Survey consisted of questions developed from existing wellbeing questionnaires, such as Stress in America 2013, Gallup World Poll, and the European Social Survey. The survey aimed to measure lifelong learning, health, life outlook, and social capital. Additionally, one of the more robust data driven frameworks for social cohesion is USC's Neighborhood for Social Change mapping tool. The tool has a data category for social connectedness in which they include 11 indicators. The indicators are healthcare institutions, high cost lenders, libraries, museums, theatres, religious institutions, park access, language spoken at home, linguistic isolation, voter turnout, and computer and internet access.

Mental Health

Mental health encompasses mental illness and disorders in addition to states of emotional resilience, psychosocial wellbeing, and mental wellness. There is a wealth of existing knowledge on the impacts of disasters on mental health, notably anxiety, depression, and post-traumatic stress disorder (PTSD). However, the nexus of mental health and climate change more broadly is an emerging topic with limited information per a Canadian research article published in 2019, *Factors Influencing the Mental Health Consequences of Climate Change in Canada*. A 2018 article from researchers based in Canada and Australia, *Climate change and Mental Health: Risks, Impacts, and Priority Actions,* projects the impacts of climate change on mental health, identifying strategies for coordinating an effective response to these impacts. The authors note extreme weather events can prompt PTSD, major depressive disorder (MDD), anxiety, depression, trauma, recovery fatigue, and other mental issues. The researchers note however, that existing research is largely connected to extreme weather events or disasters, not to a changing climate. Connecting climate change to mental health is challenging due to a few factors including:

- pathologizing common momentary distress responses to atypical events (and underdiagnosing mental health changes to climate change),
- multitude of potential mental health outcomes,
- causality can be difficult to determine due to the timing of climate change impacts on mental health, and
- intricacies between mental health and social determinants of health.

Existing research focuses on the outcomes of the disaster or event rather than the pre-disaster stage where heightened anxieties, "feelings of impending doom," and fatalism can be prompted with an anticipated disaster or extreme event. In 2017, the American Psychological Association put forth a research brief *Mental Health and our Changing Climate: Impacts, Implications, and Guidance*, identifies acute and chronic stresses people may experience because of climate change, such as "ecoanxiety," which some news outlets refer to as "climate grief." The APA recommends strategies to support individuals and improve communities, particularly through expanding mental health infrastructure, improve community design by facilitating social cohesion in public space, training disaster response workers, providing clear information, reducing disparities, and identifying particularly vulnerable populations.

2.4 Key Findings and Data Gaps

Summary of Social Vulnerability Indicators

One primary objective of this Desktop Review was to identify indicators and vulnerability indexes that can be measured at the census tract scale, for integrating multiple data sources and for ease of aggregation at jurisdictional and county levels. A summary matrix of the indicators assessed in the resources reviewed is provided on the next page (Table 2). During the process of reviewing local resources, several key findings arose:

- Common indicators were used throughout multiple resources reviewed. Common indicators included: poverty, income levels, populations over 65, children, people of color, linguistic isolation, race, no high school diploma, and unemployment.
- Housing is a common social vulnerability category however, the specific housing indicator used varied across resources. Examples of different housing indicators included: percent renters, housing quality, and overcrowding.

- Some indicators that were rarely used in reviewed materials may be important to the County's CVA. These less common indicators include: households with air conditioning, energy/cost burdens, homeownership, homeless populations, and mobile homes.
- Some of the social vulnerability indicators listed were included in either sensitivity or adaptive capacity sections of reviewed resources. As an example, access to personal vehicle was considered a measure of sensitivity in several reports and tools but was also included under adaptive capacity in the APEN report.
- Additional indicators identified in these resources include: crime rate, crowding, diabetes, female participation in labor force, female/women, foreign born, homeless count, housing value, low birth weight, median age, mobile home, obesity, parents per household, pre-term births, persons receiving social security benefits, social isolation, unoccupied housing, and youth fitness.

Table 2: Summary of indicators assessed in resources reviewed

		Income/ Wealth		Age and Gender		Housing and Mobility			Race/Ethnicity and Language			Education	Occupation		Health and Safety			
		Poverty	Income	Over 65	Children	Renters	Housing Burden	Group Quarters	People of Color	Linguistic Isolation	Race	No High School Diploma	Unemployment	Outdoor Workers	Disability	Health Insurance	Preexisting Conditions (Asthma/Cardiovascular)	Food Access
Plans and Resources	Social Vulnerability to Climate Change in CA																	
	APEN Mapping Resilience																	
	Climate Change + Health Equity																	
Methodologies and Tools	CDC's SVI																	
	SoVI®																	
	CalBRACE's CCHVIz																	
	CHAT																	
	Climate-Smart Cities Equity Priorities																	
	HPI																	
	LA DRP – Equity Indicators Tool																	

Indicators and Adaptive Capacity

Social vulnerability encompasses a wide array of both sensitivity and adaptive capacity measures. Both sensitivity and adaptive capacity influence the degree and manner in which an individual, sub-population, or region might experience a climate hazard. In certain cases, the distinction between sensitivity and adaptive capacity is obvious and uncontroversial. An example of this might be older adults or persons with pre-existing health conditions where there is a common understanding of their sensitivity to climate hazards. However, for a handful of indicators, the difference is a bit blurred. Access to a personal vehicle, air conditioning, tree canopy cover, and health insurance are all indicators that have been represented as either measures of adaptive capacity or sensitivity in prevalent resources. These categorical labels shouldn't influence the outcomes of subsequent analyses but are important to note as an observation made during the Desktop Review.

Table 3: Indicators classified as social vulnerability or adaptive capacity indicators

	Plans/Resources		Tools/Indexes			
	Social Vulnerability to Climate Change in California *	**APEN Mapping Resilience**	**CalBRACE's CCHVIz**	**HPI**	**SoVI® ***	**CDC's SVI ***
Air Conditioning	Sensitivity	Adaptive Capacity	Adaptive Capacity	Adaptive Capacity	N/A	N/A
Access to Personal Vehicle	Sensitivity	Adaptive Capacity	Sensitivity	"Transportation"	Sensitivity	Sensitivity
Tree Canopy Cover	Sensitivity	Adaptive Capacity	Adaptive Capacity	Adaptive Capacity	N/A	N/A
Health Insurance	Not in main index	Sensitivity	Sensitivity	"Healthcare Access"	Sensitivity	N/A

**Resource does not discuss adaptive capacity*

Generally, in reviewing resources to better understand adaptive capacity in the region, the following points summarize the key findings:

- There is limited data on air conditioning usage in the County. Reviewed documents concluded that an indicator of housing with air conditioning systems is not sufficient as it does not include the usage of the equipment. Oftentimes running air conditioning systems can be costly and greatly increase energy bills and as a result some households may not use the equipment.
- Data is available on the location and quantity of cooling centers in LA County but there is limited available data or information on how they are used and how effective these centers are at managing impacts of extreme heat.
- There are two indicators related to transportation that are often used for adaptive capacity including access to a vehicle and access to transit. Similar to other adaptive capacity indicators, data on car ownership or access to a vehicle ignores the condition or usability of the vehicle which may limit the effectiveness of the indicator.
- Social cohesion is rarely defined or discussed in the resources reviewed. Two resources, the City of Santa Monica's Wellbeing Survey and USC's Neighborhood for Social Change mapping tool, provide some insights into social factors and related indicators.

Assessing Non-Spatial Data

The majority of reports reviewed and presented in Part III use spatial data for determining social vulnerability. While a bulk of indicators and other measurements can be presented spatially, there is the possibility that using quantitative spatial methods alone can overshadow vulnerabilities for certain population groups. For example, people experiencing homelessness, a sub-population explored in detail later in this report, are very vulnerable to climate change. Determining how this population group is affected at the census tract level is very difficult to measure and represent spatially.

To address vulnerability data that cannot be represented spatially, the County CVA will utilize non-spatial methods to conduct more detailed and nuanced investigations of climate vulnerabilities to supplement geospatial analysis. Non-spatial analysis can use either quantitative or qualitative inputs and may include (but isn't limited to) regression analysis, descriptive analysis, and narrative analysis. Information and data gathered from stakeholder feedback and focus groups will also be assessed and presented in a non-spatial manner. These findings will be supplemented by existing outreach efforts such as the Santa Monica Wellbeing Index and USC's LABarometer surveys. The LABarometer is a recurring survey of nearly 2,000 LA County residents. The survey covers topics such as mobility, health, and sustainability, and because it is conducted regularly it can offer temporal context and reveal attitude shifts. Tapping into these information-rich resources provides additional insight on factors of vulnerability that transcend geographical boundaries.

Qualitative data can help us understand the nuances in people's lives and experiences, and non-spatial quantitative analysis can help us understand how social conditions or policies may affect vulnerability to climate hazards regardless of geographic location.

3 Limited Spatial Data

Of the resources reviewed for this report, there was a noticeable emphasis on spatial data, particularly at the census tract level. Given this finding, it is important to reiterate that some aspects of vulnerability are not influenced by geographic factors. For example, gender is evenly distributed across geographic boundaries, but women still experience disproportionate climate change impacts due to existing gender inequalities. Also, some populations are either not understood well enough at a spatial scale to include, or the data are very limited. In turn, census tract level assessments often do not include these populations. Outdoor workers, undocumented people, and people experiencing homelessness are highlighted in reviewed reports as vulnerable to climate hazards, but with limited or no spatial analyses on social vulnerability to climate change. For this reason, this section provides some research and key findings based on these groups, as well as data gaps for assessing the vulnerabilities of these populations.

3.1 Outdoor Workers

The term outdoor worker generally refers to individuals involved in farming, fishing, forestry, construction, transportation, gardening, warehouses, and utilities occupations where a majority of their working hours are spent outdoors. In the materials reviewed, there is no consistent definition of outdoor worker. In the context of this report, the impacts discussed below apply to any workers who spend much of the day outdoors and are involved in physically demanding tasks. Outdoor workers are more exposed to climate hazards and they often suffer from compounding socio-economic vulnerabilities and lack the means to adapt to climate change. Though existing plans and reports reviewed call out outdoor workers in the Los Angeles region they do not address the economic impacts that outdoor workers may face in a changing climate. Economic impacts include decreased crop outputs due to extreme heat and drought, declining worker outputs due to extreme heat, and the potential for increased health costs associated with increased climate hazard exposure.

Key Findings

Outdoor workers are particularity vulnerable to climate hazards, especially extreme heat and wildfire smoke.

Numerous reports and tools include outdoor workers in their social vulnerability analysis, or mention outdoor worker vulnerability, noting exposure to extreme heat as a key concern.

Outdoor workers are much more likely to have prolonged exposure during extreme heat events and they tend to have physically demanding jobs. For these reasons, they are more likely to experience heat-related illness like rhabdomyolysis, heat exhaustion, fainting, and heat rash. Without protective filtration systems, outdoor workers are exposed to poor air quality, particularly during wildfire events. This increases the likelihood of experiencing respiratory illness. Furthermore, outdoor workers who are linguistically isolated or have limited access to personal vehicles may experience compounding vulnerabilities and barriers during unhealthy weather events and evacuations. Various regional reports like the Caltrans *District 7 report*, 2019 *LA Metro Climate Action and Adaptation Plan*, and the Long Beach *Climate Vulnerability Assessment,* note that outdoor workers (particularly construction workers) are vulnerable to extreme heat. A 2018

Outdoor workers are highly vulnerable to extreme heat in the LA region. For most workers, the decision to not work, or inability to work, in extreme heat or another climate hazard, can result in lost wages. Most outdoor workers are compensated by the hour (i.e. for the duration spent on each task). This compensation structure incentivizes outdoor workers to work without necessary breaks which makes them even more susceptible to heat-related illnesses. Extreme heat can also lead to productivity losses, which in turn can impact the economic livelihood of outdoor workers.

report from UCLA researchers, *Mortality and Morbidity during Extreme Heat Events and Prevalence of Outdoor Work: An Analysis of Community Level Data from Los Angeles, County, California*, identified outdoor workers in industries such as agriculture and construction. The report showed a relationship between community-level patterns of work and broad public health indicators of heat-related health outcomes, concluding that outdoor workers increase a neighborhoods social vulnerability.

> Outdoor worker health will be negatively impacted by drought and subsequently Valley Fever.

The 2020 *Climate Change and Health Equity: Strategies for Action* is an overarching document for stakeholder outreach. This draft, prepared by the Los Angeles County Department of Public Health, highlights community vulnerabilities to climate change through an equity lens. The report determined climate change will increase food insecurity and adversely impact agricultural and tourism industries and workers (in addition to other land-dependent industries). The report also emphasized the unique risks to outdoor workers, notably the increased likelihood of contracting Valley Fever, caused by a desert soil fungus.

Drought conditions can also increase the chances of outdoor workers contracting Valley Fever. The *Climate Change and Health Equity Issue Brief* notes changes in vector ecology, which may increase instances of Valley Fever, further exacerbating this problem. Drought also impacts job availability and productivity in the agricultural sector, leaving workers with volatile schedules and reduced incomes. This can further lead to food insecurity, displacement, and other economic stressors.

Data Gaps

> When incorporating outdoor workers into social vulnerability analyses, workers in the construction and agricultural sectors are often included, however jurisdictional context can determine which sectors are included.

Existing reports and plans identify worker status as a key component of community vulnerability, but the same occupation types or sectors are not used across reports. Most reports define outdoor worker largely depending on the context. For example, SBCCOG identified outdoor workers as those who work in the construction sector, any agricultural workers who live in that region are not included in their analysis. While the report *Mortality and Morbidity during Extreme Heat Events and Prevalence of Outdoor Work: An Analysis of Community Level Data from Los Angeles, County, California* aggregated both construction and agriculture workers.

The data sources used in these reports are often unclear or lack granularity. For example, the American Time-Use Survey from the Bureau of Labor Statistics collects occupation level data, but it is not disaggregated to the county or census tract level. The US Census aggregates occupational data at the place of residence rather than at the workplace and does not encapsulate informal workers. As the US Census data is compiled by occupation, it does not capture specific information related to whether someone's job is completed outside or not. This makes it very challenging to identify where vulnerable jobs are concentrated and restricts the spatial analysis to construction and agriculture industries.

Frontline Workers

In the context of the COVID-19 pandemic, frontline workers are defined as those whose work both is essential and puts them outside of their home and in contact with people. This includes industries like healthcare, protective services, grocery and general merchandise, production and food processing, cleaning and maintenance, agriculture, and public transit.

The COVID-19 outbreak has illustrated that frontline workers are uniquely susceptible to infectious diseases due to heightened exposure. Compared to the general population, frontline workers tend to have lower pay, rely on public transit more, and have more minorities and women then other occupation

groups. Additionally, many frontline workers are employed as independent contractors which reduces job security and benefits.

Capturing vulnerabilities to all outdoor and exposed workers is difficult and not possible using a single data source, vulnerabilities to some frontline workers can be examined using census data. Workers in the following occupation categories will be included: agriculture, forestry, fishing and hunting, transportation and warehousing, waste management and remediation services, educational services, health care and social services, and accommodation and food services. There is considerable overlap between outdoor and frontline workers, but the added value comes from the ability to highlight sub-populations that are both exposed to the environment and essential.

3.2 Undocumented People

The *Climate Change and Health Equity issue brief* from the California Department of Health identified people with undocumented status as one of the most vulnerable groups to climate change. Similarly, the OurCounty plan identifies undocumented immigrants and migrant workers for the disproportionate impacts they face related to climate change. The 2020 journal article, *The (in)visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and indigenous immigrants*, by researchers Michael Méndez, Genevieve Flores-Haro, and Lucas Zucker notes the importance in understanding the vulnerability of undocumented Latino/a and Indigenous immigrants from Latin America. The researchers note that these groups are impacted more severely, and differently, than their documented counterparts, necessitating special considerations in disaster and climate change planning. The researchers found inadequacies in the California's wildfire mapping process, notably the lack of reliable renderings of vulnerable populations in high risk zones, which hinders the development of strategies aimed at reducing disparities in disaster impacts.

Key Findings

People who are undocumented face disproportionate impacts from climate change due to an increased likelihood of working in outdoor occupations, limited ability to assert worker rights, and linguistic isolation which can make accessing information difficult.

The *Los Angeles Region Report* details the disproportionate impacts to undocumented immigrants/workers as people who "face poverty, linguistic isolation, political disenfranchisement, and fears of being apprehended by immigrant officials when accessing government services, which present significant barriers to seeking resources to adapt to extreme weather and other climate impacts." *APEN Mapping Resiliency* notes disproportionate impacts to undocumented workers. The report notes the overlap between agricultural workers and people who are undocumented - of the agriculture workers in the State 60% are undocumented.

People who are undocumented face unique barriers to accessing resources, limiting their adaptive capacity.

Undocumented people may be fearful of seeking assistance due to their immigration status, and they are excluded from receiving federal disaster aid. The 2013 *Sea Level Rise Vulnerability Study for the City of Los Angeles* described the 2010 floods in San Pedro and Wilmington, where inundation necessitated the creation of temporary shelters. The areas impacted by the floods were mostly Hispanic/Latinx, many were undocumented, and some did not speak English. A Red Cross shelter, set up to shelter flood victims was closed prematurely after a low turnout, however after the disaster it was learned that many neighborhood residents turned to a local non-profit that was not set-up to assist victims but was known and relied upon in the community.

This scenario paints the picture of why communications, particularly related to emergencies and disasters, should be tailored to the surrounding community.

Data Gaps

There is extremely limited data on undocumented immigrants. The Public Policy Institute of California in a 2011 report estimated 916,000 undocumented immigrants in Los Angeles County in 2008, representing 9.3% of the County's total population. A 2007 paper by The Urban Institute, titled *The Characteristic of Unauthorized Immigrants in California, Los Angeles County, and the United States*, estimated the number of people who are undocumented in the County to be around 1 million. The US Census collects data on where respondents were born ("Foreign Born") this category can include people who are documented or undocumented immigrants, making it difficult to assess hazard impacts experienced by this group.

3.3 People Experiencing Homelessness

According to OPR, an individual experiencing homelessness, is one who sleeps in shelters, outdoors, or in areas not intended for habitation. The *Los Angeles Region* report notes individuals experiencing homelessness as more vulnerable to hazards and experience barriers to assistance. People experiencing homelessness – especially those who sleep outdoors – have increased exposure to climate hazards. Additionally, a National Institute of Health study, *Health of the Homeless and Climate Change* by researchers Brodin, Ramin, and Tomislav Svoboda, indicates that many underlying social vulnerabilities may limit an individual experiencing homelessness's ability to adapt (adaptive capacity), including increased rates of cardiovascular and pulmonary disease, social isolation, poor living conditions, limited access to health care, and lower incomes than the general population. Climate hazards of concern include extreme heat, flood events, wildfire, increased air pollution, and vector-borne diseases, such as West Nile Virus.

Key Findings

The *AHMP* outlines the number of people experiencing homelessness in unincorporated Los Angeles County and the City of Los Angeles who will be impacted by some climate hazards. However, this information is not available in other climate related reports across the county, nor does the AHMP include how these people will be impacted.

The Los Angeles County *AHMP* includes people experiencing homelessness as a vulnerable population. The *AHMP* mapped individuals experiencing homelessness and hazard areas using the 2019 Point-in-Time (PIT) count data from the Los Angeles Homeless Services Authority for both unincorporated Los Angeles County and the City of Los Angeles. The PIT count data is collected by volunteers and staff annually by walking designated census tracts in the County and visually tallying people experiencing homelessness. The report also pulled specific information on the impacts of hazards on this population spatially. The information does not provide context on whether the same people are vulnerable to multiple hazards or information about areas outside of the City of Los Angeles and unincorporated Los Angeles County.

Table 4: People experiencing homelessness who will be impacted by hazards as determined by the AHMP

Hazard	Jurisdiction	# of Homeless	% of Homeless
3 ft. SLR	City of Los Angeles	51	0.15%
	Unincorporated LA County	0	0%
6 ft. SLR	City of Los Angeles	126	0.38%
	Unincorporated LA County	2	0.04%
Dam Failure	City of Los Angeles	1193	3.62%

	Unincorporated LA County	13	0.22%
Flood Impact (0.2%)	City of Los Angeles	1601	4.86%
	Unincorporated LA County	170	2.88%
Flood Impact (1%)	City of Los Angeles	87	0.26%
	Unincorporated LA County	0	0%
Landslide (Class IX and X)	City of Los Angeles	234	0.71%
	Unincorporated LA County	325	5.55%
Wildfire (Very High LRA FHSZ)	City of Los Angeles	1291	3.92%
	Unincorporated LA County	88	1.49%
Wildfire (High SRA FHSZ)	City of Los Angeles	0	0%
	Unincorporated LA County	58	0.99%
Wildfire (Very High SRA FHSZ)	City of Los Angeles	0	0%
	Unincorporated LA County	465	7.91%

Individuals experiencing homelessness are particularly vulnerable during fast-onset events or disasters and extreme heat. Reports examined identify that this population needs special assistance before, during, and after a disaster or extreme event.

The 2018 *Venice Sea Level Rise Vulnerability Assessment* discusses the vulnerability of people experiencing homelessness in coastal areas. The report notes that individuals experiencing homelessness are particularly vulnerable to fast-onset hazards (such as tidal gate failures), emphasizing the need to prioritize emergency communications and response. Along similar lines, the 2013 *Sea Level Rise Vulnerability Study for the City of Los Angeles*, prepared by the USC California Sea Grant Program for the City of Los Angeles, performed a social vulnerability assessment and listed people experiencing homelessness as a particularly vulnerable population who may need special assistance in emergencies. The USC Sea Grant researchers noted the vulnerability of the homeless population to flood events, however, acknowledge there is limited data on this population group. The report also notes the importance of community-based programs and organizations in working with people experiencing homelessness in preparation for, during, and after disasters.

The SBCCOG *Sub-Regional Adaptation Plan* includes a vulnerability assessment and a set of climate adaptation strategies for the South Bay region. SBCCOG incorporated homeless counts into their vulnerability indicators as part of their sensitivity analysis using LAHSA information (percent of population). When calculating their Heat Vulnerability Index, a dominant indicator used for assessing health was homelessness (in addition to no trees and disease rates). SBCCOG suggests developing a check-up system during extreme heat events to check on these specific populations.

Data Gaps

Collecting data on hard-to-count populations like those experiencing homelessness is difficult. It is however crucial to understand where individuals are located to determine potential exposure to climate hazards and direct services. Different organizations and plans monitor homelessness at varying geographic scales, which makes it a challenge to assess the number of people experiencing homelessness in the County. For example, the LAHSA Continuum of Care, excludes the cities of Pasadena, Glendale, and Long Beach from the total count. The AHMP did not include estimates for the number of people experiencing homelessness outside of unincorporated Los Angeles County and the City of Los Angeles. In the 2020 NOAA NCCOS report *Assessing the Geographic Variability in Vulnerability to Climate Change and Coastal Hazards in Los Angeles County, California*, the researchers relied on census data for their analysis, which makes analyzing homelessness, displacement, and

gentrification difficult. The NOAA researchers noted this data gap could be overcome using primary data collection methods, such as the PIT count.

While aggregating census level data (or vulnerability index) for people experiencing homelessness, there is the risk of losing qualitative information like the lack of housing, health status, and severity of their exposure to climate hazards. For example, the PIT count data is collected by volunteers and staff annually by walking designated census tracts in the County and visually tallying people experiencing homelessness, but it is not sufficient for assessing risks to people experiencing homelessness.

4 Informing the Assessment

4.1 Social Vulnerability Indicators by Climate Hazard

When evaluating social vulnerability, it is important to note that the relevancy of indicators will depend on the climate hazard being assessed. For example, asthma and cardiovascular disease are commonly used as social vulnerability indicators but are only relevant for extreme heat, wildfire, and drought due to their impact on a bodies' increased susceptibility to extreme temperatures and particulate matter. For this reason, the LA County CVA will provide additional evaluation of social vulnerability based on the primary climate hazards and their relevant indicators. Sets of indicators (both adaptive capacity and sensitivity) that are most relevant for each particular hazard will be based on desktop review findings and hazard-specific mapping analysis.

4.2 A PCA-based Approach

A PCA-based approach was selected as the recommended approach to evaluating social vulnerability. This approach was determined to be the best fitting for several reasons that include its flexibility and ability to account for the interactions between different indicators, which can be particularly useful for uncovering inequities and systemic racism as it relates to climate hazards and impacts.

The SoVI® method is currently used by 20+ County level hazard mitigation plans, 17+ state level hazard mitigation plans, and several other city and regional plans across the United States.

Based on this Desktop Review, the most cited and used methodology for social vulnerability and heat vulnerability assessments is SoVI®. Additionally, this approach has been utilized at state, regional, county, and city scales, allowing for contextually sensitive analysis. In her master's thesis, titled *Comparative Analysis of Social Vulnerability Indices: CDC's SVI and SoVI®,* Hanna A. Tarling notes that SoVI® provides more flexibility in index creation and provides more nuanced results compared to the CDC's SVI. For these reasons, a PCA-based approach is our recommendation.

4.3 Social Vulnerability Indicators

Plans and reports were reviewed to gather a set of key indicators for use in a CVA's social vulnerability analysis. From a methodological point of view, there were numerous challenges in analyzing how vulnerability was measured as most of the quantitative analysis is not explicitly presented in reports and are largely context specific. Some reports emphasize social determinants of health while others focus solely on the impacts of hazards. The intertwining of physical factors with their social implications presented in these reports reminds readers that both social and physical vulnerabilities must be understood in order to plan for effective adaptation.

A refined list of 60 unique indicators was developed through the Desktop Review. These indicators were grouped into categories based on commonalities in existing frameworks that are noted in this review. Most frameworks included indicators in each of the following broader demographic categories: income/wealth, age, housing, mobility, health, race/ethnicity, education, community, and occupation. Indicators that were common across these resources and available at the census tract level were considered core (see Table 5). Partly for this reason, many of the core indicators originate from the Census Bureau's American Community Survey (ACS) data. In addition to analyzing core indicators geospatially, non-spatial analysis and non-spatial data will be used in the CVA (as is described in *Section 2.4 – Assessing Non-Spatial Data* of this Desktop Review).

School-aged children as an additional indicator was added to the list of core indicators based on discussion with the County and other stakeholders. School-aged children was noted as a separate indicator from age-related indicators because children are susceptible to additional extreme heat impacts while at school, where air conditioning is not a legal mandate.

Table 5: Core indicators

Core Sensitivity Indicators
Age: children, older adults, older adults living alone
Community + language: foreign-born, female, female householder, library access, voter turnout rate, limited English proficiency
Occupation: outdoor workers, unemployment
Education: no high school diploma
Health: disability, asthma, cardiovascular disease, no health insurance
Housing: living in group quarters, mobile homes, cost-burdened, renters
Income + wealth: median income, poverty
Race / Ethnicity: Black, Asian, Hispanic/Latinx, Native/Indigenous
Access to information: no internet subscription
Transportation: households without vehicle access, transit access

These core indicators were then considered in relation to climate hazards and the potential impact or influence of each sensitivity for each climate event. This process ensured that the selected indicators are substantiated by an evidence-based rationale. The process for identifying and vetting core indicators is summarized in Figure 1.

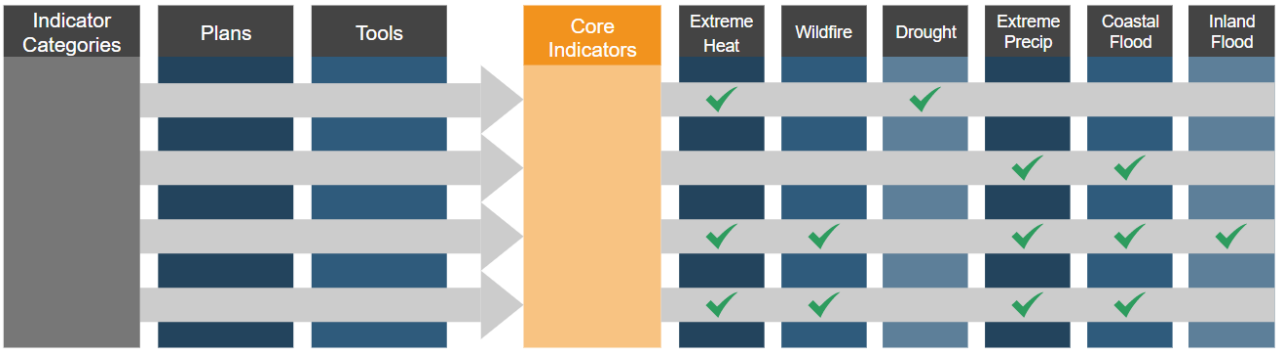

Figure 1: Generalized schematic depicting the visualization process completed for the indicators to determine their applicability to climate hazards

In addition to the core indicators, there were some indicators that did not neatly fit into the any of the categories identified but were still worthy of discussion and analysis. Many of these indicators fall into health or housing categories and include variables such as overcrowding, energy costs/burden, low birth weight, and alcohol consumption or alcohol outlet density. Some limitations arise due to data availability or data granularity issues, as the information is not available at the census level or is an imperfect fit for geospatial indexing. While much of the analysis is reliant on spatial data, a few particularly vulnerable groups that cannot be easily mapped and are not usually included in the formal planning process are left out, such as undocumented immigrants and people experiencing homelessness.

4.4 Supplementary Indicators of Community-Scale Adaptive Capacity

Adaptive capacity interventions/measures can have multiple dimensions, which may be categorized as either social or physical, and therefore the indicators used for measuring adaptive capacity do not fit neatly into a single box. For example, vehicle access is typically measured at the household level and considered a social aspect of adaptive capacity, however this ignores an individual's ability to afford to operate the car (a social indicator) and the road quality (a physical indicator). Though related to vehicle ownership, the transit access indicator is physical because it is dependent on the household's proximity to public transit, which again does not incorporate whether transit it used.

The following indicators have been identified for evaluating adaptive capacity at the community level across the County. This list is preliminary and does not represent a comprehensive list of indicators that are readily available for analysis. For some of the indicators provided below, there is not sufficient data available. For instance, property insurance, air conditioning, emergency response and 211 calls, sense of community, and others are some of the indicators where data is lacking. Based on data availability and interest from the County and stakeholders, this list will be further refined during the CVA development process.

- Cooling centers and heat refuge
- Outdoor community spaces
- Park access
- Impervious surfaces
- Roof albedo/reflectivity
- Tree canopy
- Access to property insurance
- Air conditioning
- Water capture
- Battery storage
- Community-based organization density
- Sense of community

Appendix: Additional Resources

Other reports, plans, and related documents were reviewed for the Desktop Review, which are outlined below by geographic scale analyzed. While not referenced in the above analysis, they provide added detail and context about social vulnerability in the County.

5.1 US and California Resources

Climate Change, Health, and Equity: A Guide for Local Health Departments, developed by the American Public Health Association, Public Health Institute, and Center for Climate Change and Health in 2018, identified social vulnerabilities for various climate change impacts. The report notes that root causes of climate change and health inequities are the same, noting the role that class and race have in their perpetuation. Though the report was written at the national scale for widespread inclusion across the country, it integrates the need for cross-departmental collaboration within counties/cities to address the climate crisis. The report recommends local health departments include social and health inequities in vulnerability assessments, find and acknowledge data gaps, highlight inequalities in publications, and use community-based participatory research methods.

In 2018, OPR published *Defining Vulnerable Communities in the Context of Climate Adaptation,* a report that outlined the process for defining vulnerable communities. The report presents vulnerability indicators in four categories: existing inequities (institutionalized racism or exclusion), physical states or conditions that increase vulnerability, poor environmental conditions (including access to services or living conditions), lack of investment and opportunities. These categories and the analysis completed by jurisdictions works to define what a vulnerable community is, defining these communities as likely to "experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts." This vulnerability is caused by physical and social (or economic) factors including race, class, national origin, and income.

CalEnviroScreen, developed by the Office of Environmental Health Hazard Assessment (OEHHA), is a tool that incorporates and examines the cross-section of pollution, public health, and social vulnerability to classify disadvantaged communities pursuant to SB 535. The tool evaluates pollution burdens on communities, and ranks them across the State, identifying areas for environmental justice grants and targeting areas for environmental intervention. The ranking criteria is then used to prioritize State funding for environmental and climate projects.

ECOSTRESS, a NASA JPL program, is a data gathering program used for informing urban heat island effect. The spatial tool developed using satellite imagery to measure differences in surface temperatures in Los Angeles County during a high heat period in 2018 to produce a fine-scale model that describes the location of high heat areas in Los Angeles County. This data can be used to inform location-specific adaptation and resilience interventions for extreme heat; however, the tool does not include social vulnerability data.

The *Coastal Resiliency Mapping* tool provides data and visuals for sea level rise across existing, medium and high scenarios and from 2010 to 2100. The tool focuses on storm flooding, coastal erosion, cliff erosion, and rising tide, and examines the relationship between coastal habitats and disadvantaged communities by overlaying the effects of nature based adaptations to mitigate the impacts of sea level rise to measure the impact on jobs and access.

The *Community Health Vulnerability Index (CHVI)*, developed by the US EPA identifies areas at higher health risks due to wildfire smoke. The index combines known susceptibilities of people to air pollution such as asthma, some chronic disease, age, and socio-economic status. The known data is then layered

with air quality forecast data to determine where vulnerable communities are located and prioritize strategies to protect public health.

Risky Business: From Boom to Bust? Climate Risk in the Golden State is an economic risk assessment of climate change on California's economy from the Rhodium Group. While a statewide report, the researchers divided the state up into various regions to analyze economic impacts. The County fell into the South Coast region. The report noted extreme heat (including secondary impacts) and sea level rise as impacts to the region. Researchers noted the impacts of coastal erosion potentially harming the tourism industry, and increased energy costs from rising temperatures for a region marked by its manufacturing economy. Finally, the researchers noted that heat-related mortality will increase as a result of extreme heat, explaining that it is likely for the region to experience an additional 20 heat related deaths per 100,000 residents by the end of the century.

The 2020 *Resilience before Disaster Report* by the APEN Institute and SEIU California highlights opportunities to support communities recover from disasters (and the COVID pandemic), while also addressing systemic issues relating to racial inequity, economic instability, and environmental injustices. The report notes that traditional State programs for disaster planning are not well-equipped to support vulnerable populations (particularly working-class communities of color) facing unique challenges such as social and linguistic isolation, lack of vehicle access, insecure housing, and dependence on medical equipment. These communities often lack the investment needed to withstand and recover from disasters. Furthermore, shortage in home care service and public sector health personnel, who are critical for emergency preparedness and response, is a major issue across the State. To address these issues, the report advocates for two models—resilience hubs and fostering in-home resilience—to deliver resilience services and resources at the community level. These models recommend using state resources to fund resilience hubs and establishing resilience hub networks for providing public health and social services; investing in home care workforce and empowering them to support vulnerable residents during emergencies; rebuilding the public sector workforce; and improving emergency response coordination to protect vulnerable populations, especially medically vulnerable populations.

5.2 Southern California and Los Angeles County Resources

The 2020 *Heat Vulnerability in Los Angeles County Resource and Methodology Assessment*, prepared by the Center for Resilient Cities and Landscapes at Columbia University, for Los Angeles County, is a narrative report that outlines existing methodologies for analyzing extreme heat impacts in the County. The report compiles various methodologies, global practices, and tools that are have been discussed in depth within this Desktop Review. The authors used existing literature to identify knowledge gaps related to exposure and sensitivity indicators, highlighting opportunities to combine indicators in the County's sustainability plan, OurCounty. For example, the target to reduce heat-stress related emergency department visits could include mapping the bottom 25th percentile on the Healthy Places Index, extracting projected "Heat Health Events" from the CHAT tool, and overlaying known land uses associated with underlying conditions that drive heat-related illnesses, which can identify at-risk populations. The report reviewed numerous tools presented below within an extreme heat context.

The 2013 *Sea-Level Rise and Impacts and Flooding Risk in the Context of Social Vulnerability* created a social vulnerability index using the following factors: income, poverty, education, females as head of household, race, linguistic isolation, age, housing type and age, and physical and mental illnesses and disabilities. This index is modelled in three geographic areas (Pacific Palisades, Venice/Playa del Rey, and San Pedro/Wilmington Harbor), using both the SoVI® methodology and the Climate Change Community Screening Tool (CCCST) developed by DPH independently of each other. The tools resulted in slightly different results when identifying at-risk areas within the City of Los Angeles, SoVI® showed a lower vulnerability score along coastal areas in comparison to inland areas, while CCCST produced a higher vulnerability score along the coast than SoVI®. Nevertheless, the SoVI® model showed an elevated social vulnerability score in San Pedro, Wilmington, and a census block in Venice.

Neighborhood Data for Social Change, developed by the University of Southern California in 2018, shows environmental, food, health, housing, public safety, social connectedness, and transportation data at a neighborhood level to highlight trends and opportunities for change. The mapping platform uses demographic, educational, economic, environmental, health and social, food policy, transportation, and housing data to assist decision makers with contextualizing neighborhood information across the County. While not climate-focused, the platform provides neighborhood and census level data that can help us understand and define indicators for adaptive capacity (such as transportation data to determine transit dependency) and social vulnerability.

The *Multiple Air Toxics Exposure V Study* (MATES V), by the South Coast Air Quality Management District (SCAQMD) characterizes air pollution risk by monitoring air quality at ten fixed sites throughout the South Coast Air Basin to monitor air toxicity. While the MATES V study is ongoing, the MATES IV study published in 2015 notes the importance of such work for environmental justice initiatives due to the widely unquantified effects of pollutants.

A 2019 UCLA Master's capstone report for the City of Los Angeles Mayor's Office of Sustainability, *Adapting to a Hotter Climate: Identifying Communities that are Most Vulnerable to Climate Change in the City of Los Angeles* by Mariana Zimmerman identified areas where extreme heat will more greatly impact communities in both hazard exposure, and their sensitivity to those increments. The report used localized climate change data to contextualize the impacts of extreme heat, sea-level rise, wildfire, drought, and precipitation on vulnerable communities to examine the intersection of exposure and sensitivity to extreme heat. The report recommended that a targeted, and phased, program be implemented for extreme heat interventions starting with the most vulnerable populations.

Housing Inequality in Los Angeles, a 2019 UCLA research brief, presents the impacts of housing inequality in the Los Angeles region and points to indicators when measuring vulnerability such as rent status and rent burden, and for homeowners, the presence of subprime mortgages. It points out critical historical discriminatory mechanisms that have led to inequity in housing stability and homelessness, two factors present in many social vulnerability analyses.

Prepared by Climate Resolve, *Ready for Tomorrow? A Snapshot of Climate Preparedness Planning in Southern California* is a narrative outline of the status of climate preparedness planning in Southern California Edison's service territory. The report brings together numerous documents to identify gaps in existing planning initiatives. The report outlines the state of affairs in the region and identified reports for review when generating information pertaining to methods and data for the CVA. Three key issues are identified in the report: lack of knowledge of municipal-level climate planning amongst state stakeholders, lack of consistent criteria for assessing climate planning efforts, and lack of capacity and resources, especially in disadvantaged communities, to support climate planning.

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Desktop Review
Part II: Physical Vulnerability Review

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1 Physical Vulnerability

Physical infrastructure refers to a broad array of capital assets and institutions that provide essential services, support economic activity, and facilitate a productive society. Examples include energy systems, roads, highways, bridges, ports, water supply and treatment infrastructure, wastewater systems, and telecommunication networks, among others.

Physical vulnerability refers to the susceptibility of facilities and assets to physical damage, due to climate hazards, that may affect the lifespan or operations of an infrastructure systems. Vulnerability is a function of both exposure and sensitivity to a climate hazard. Determining the physical infrastructure that is most vulnerable to climate hazards can inform adaptation and resiliency planning, as well as identify vulnerable infrastructure pinpoints and population groups (users) who may experience service disruptions in the event of disaster. This document outlines and synthesizes existing knowledge about physical vulnerabilities to climate hazards in Los Angeles County.

This document describes critical infrastructure and facilities, that are identified using state guides, including the State Hazard Mitigation Plan and California's Fourth Assessment, and are refined using regional and sub-regional reports. This document groups findings by hazard type, referencing County documents and others specific to Southern California. Discussed first are reports that summarize risks and vulnerabilities to multiple climate hazards, followed by reports that describe physical vulnerabilities to individual climate hazards. The evaluated climate hazards include coastal flooding (including sea level rise), inland flooding, extreme heat, and wildfire.

Prevalent Climate Hazards

Los Angeles County experiences multiple climate hazards including drought, extreme heat, wildfires, and flooding (coastal and inland flooding). The County's exposure to these hazards is detailed in Part I: Climate Hazard Assessment. In the context of physical vulnerability, the major hazard impacts anticipated in the region are listed below:

- **Sea level rise (SLR)** will impact the ports of Long Beach and Los Angeles, in addition to coastal areas such as Malibu and Venice. Impacts are anticipated to beaches (and tourism), publicly owned facilities, infrastructure along the coastline including housing, highways (e.g. pacific coast highway), and bridges.
- **Inland flooding** due to dam failures can impact structures and facilities in floodplains (10, 50, 100, and 500 year). Several public facilities are located within the floodplains including County Animal Care and Control, Fire Department, Health Services, Libraries, Education, Parks and Recreation, Public Works, and Sherriff's Department buildings.
- Southern California is prone to extremely dry conditions which may lead to prolonged periods of **drought**. Multi-year droughts reduce replenishment of local groundwater, surface water, and may impact imported water supplies to the County.
- **Extreme heat** can stress the power supply in the County due to increased consumer cooling demand, which places an additional burden on energy generating plants, substations, and transmission lines.
- **Wildfire** threat depends on several factors including temperature, soil moisture, terrain, wind, and the presence of organic matter (e.g. trees, shrubs) which serve as potential fuel. As a result of climate change, the severity of wildfires, and duration of wildfire season in the County can increase due to warmer temperatures, drier fuels, low humidity conditions, and Santa Ana winds. Vulnerabilities and concerns pertaining to wildfire's interaction with physical infrastructure include

damage to access roads and buildings in the Wildland-Urban Interface (WUI) and Fire Hazard Severity Zones, and disruptions to energy supply due to Public Safety Power Shutoff events.

Geotechnical hazards that can be impacted by climate change include mud and debris flows, active deep-seated landslides, and hillside erosion. These hillside hazards are prevalent in unincorporated areas that have a hilly or mountainous terrain and can damage physical infrastructure assets such as roads, rail routes, and energy transmission and distribution assets, among others. While seismic hazards are outside the scope of this Desktop Review, they nevertheless pose a threat to the County. There are at least 50 active or potentially active fault segments in the County, four of which are blind thrust faults.

1.1 Defining Critical Infrastructure and Facilities

State and regional plans generally include energy, water, wastewater, transportation, telecommunication, public health, and safety systems as critical infrastructure.

In the context of climate change, State and regional plans evaluate criticality based on climate change impacts on infrastructure systems and facilities (or assets) and downstream impacts on communities and the broader economy. Climate hazards may affect the service lifetime and functionality of these infrastructure systems, which can disrupt essential services impacting daily life, public health, and safety.

The definition of critical infrastructure and facilities, and the scope of evaluation varies depending on the jurisdiction the report is written for (local, state, federal) and the specific infrastructure system that is being discussed (see Table 1).

Table 1: Critical infrastructure and facilities definitions

Year	Report Title	Definition
2009	2009 California Climate Adaptation Strategy	Critical infrastructure includes roads, power lines, and waste/wastewater pipelines, but it is not clearly defined.
2013	Sea Level Rise Vulnerability Study for the City of Los Angeles	Critical infrastructure includes hospitals, power plants, wastewater treatment plants, and schools, but it is not clearly defined.
2013	Sea-Level Rise Impacts and Flooding Risks in the Context of Social Vulnerability: An Assessment for the City of Los Angeles	Reports include infrastructure that provides critical or essential services, which if disrupted would impact daily life, safety, or health. Critical infrastructure is not explicitly defined but includes transportation routes/ports/airports, underground utilities, emergency response, electricity outages, communication, and water.
2016	Comprehensive Floodplain Management Plan	Critical infrastructure is identified using FEMA's CRS definition: "A structure or other improvement that, because of its function, size, service area, or uniqueness, has the potential to cause serious bodily harm, extensive property damage, or disruption of vital socio-economic activities if it is destroyed or damaged, or if its functionality is impaired. Critical facilities include health and safety facilities, utilities, government facilities, and hazardous materials facilities." The steering committee, which informed the plan, specified the following for Los Angeles County (in conjunction with the AHMP): facilities critical to government response, facilities if damaged could have serious secondary impacts, and facilities critical to utility operations.

2016	Regional AdaptLA: Coastal Impacts Planning for the Los Angeles Region	Critical facilities are not explicitly defined; however, the report measures the impact to transportation, buildings and structures, public facilities, sewers, storm drains, and beaches.
2018	Indicators of Climate Change in California	Critical facilities are not explicitly defined; however, infrastructure noted as "critical" includes airports, homes, natural gas lines, power plants, and wastewater plants.
2018	California State Hazard Mitigation Plan	Critical infrastructure is defined as "essential to the State's ability to provide assistance to its people for their everyday lives" or assist with disaster response. The following is noted as critical infrastructure: drinking water systems, hazardous waste facilities, transportation routes, utilities, government facilities, schools, and hospitals. The report listed California as recognizing the following sectors as critical infrastructure sectors: chemical/hazardous materials, commercial facilities, communications, critical manufacturing, dams, defense industrial base, emergency services, energy, financial services, food/agriculture, government facilities, healthcare and public health, information technology, nuclear reactors/materials/waste, transportation systems, and water/wastewater systems.
2018	Safeguarding California Plan: 2018 Update	Includes systems and facilities that can harm utilities or disrupt lifeline systems, such as energy, dams, and agriculture systems.
2018	Fourth Climate Change Assessment: Statewide Summary	The report refers to *Risk Assessment and Management for Interconnected Systems*, another report, which defines critical infrastructure as "assets and systems essential for the provision of vital societal services and include large engineered supplies for water, electricity, telecommunications, transportation and financial services."
2018	LA River Master Plan Update (Full report not available at time of writing)	Critical infrastructure is listed as: transit facilities, bridges and tunnels, communication, electric power, oil, dam, potable/reclamation water systems, and disaster routes.
2018	Planning and Investing for a Climate Resilient California	"California's critical infrastructure includes but is not limited to: public and privately owned roads, bridges, ports, airports, and railways; water, wastewater, drainage, and sewer systems; schools; jails; hospitals and health care facilities; government facilities and commercial buildings; power plants; terrestrial, satellite, and wireless transmission systems; telecommunications and data information systems."
2018	Climate Change Vulnerability Assessment Results: Long Beach Climate Action and Adaptation Plan	Critical assets are defined as facilities that "are important in providing core services and functions of City departments." Thus data was collected on City-owned and publicly-owned buildings, parks, beaches, wetlands, marinas, roads, bike paths, bridges, energy substations/transmission lines, energy generation facilities, natural gas mains, wastewater pump stations, sewer main/forced-main potable water facilities, potable water mains, vulnerable populations (for public health)."
2020	County of Los Angeles All-Hazard Mitigation Plan (AHMP)	The AHMP identifies critical facilities as providing essential services or functions to a community, with emphasis on services during and after a disaster. Examples include fire/police stations, hospitals, schools, wastewater/water facilities, and utilities. Additionally, the AHMP identifies staging areas as critical, including community centers or libraries and large public gathering areas.

1.2 Physical Vulnerabilities by Hazard

Through the Desktop Review, insights were collected as to how different infrastructure systems and asset types were most vulnerable to different hazards. The following documents, listed in Table 2 and described in the following sections, include key findings related to either multiple hazards, or individual hazards.

Table 2: Reports and climate hazards

Planning Area	Year	Title	Coastal Flooding (Sea Level Rise)	Inland Flooding (Extreme Precipitation)	Drought	Extreme Heat	Wildfire
Los Angeles Region	2020	Southern California Climate Adaptation Planning Guide	x	x	x	x	x
Los Angeles Region	2018	Fourth Climate Assessment: LA Region Report	x	x	x	x	x
Los Angeles Region	2017	Southern California Climate Adaptation Project: Vulnerability Assessment Model and Method		x	x	x	x
Los Angeles Region	2017	Los Angeles Basin Study		x	x		x
Los Angeles Region	2016	Regional Adapt LA: Coastal Impacts Planning for the Los Angeles Region	x				
SCE Service Area	2020	2020-2022 Utility Wildfire Mitigation Plan					x
Los Angeles County	2020	Assessing the Geographic Variability in Vulnerability to Climate Change and Coastal Hazards in Los Angeles County	x	x	x	x	x
Los Angeles County	2020	Los Angeles County All-Hazard Mitigation Plan	x	x	x		x
Los Angeles County	2020	2020 Los Angeles County Comprehensive Floodplain Management Plan	x	x			
Los Angeles County	2019	Metro Climate Action and Adaptation Plan	x	x		x	x
Los Angeles County	2019	Caltrans Climate Change Vulnerability Assessments	x	x		x	x
Los Angeles County	2018	Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat				x	
Los Angeles County	2016	Los Angeles County Public Beach Sea-Level Rise Vulnerability Assessment	x				
City of Los Angeles	2018	Venice Sea Level Rise Vulnerability Assessment	x				
City of Long Beach	2018	Climate Vulnerability Assessment: Long Beach	x	x	x	x	
City of Los Angeles	2018	Port of Los Angeles Sea Level Rise Adaptation Study	x				
City of Los Angeles	2018	Adaption Blindspot	x	x	x	x	x
City of Long Beach	2016	Port of Long Beach Climate Adaptation and Coastal Resiliency Plan	x				
City of Los Angeles	2013	Sea Level Rise Vulnerability Study for the City of Los Angeles	x				

1.2.1 Multiple Hazards

2018 Fourth Climate Assessment: LA Region Report
Office of Planning and Research, California Energy Commission, and California Natural Resources Agency

The LA Region Report notes physical vulnerabilities to multiple climate hazards in Los Angeles, Ventura, and Orange Counties, and adjacent urbanized portions of San Bernardino and Riverside Counties. The report particularly focuses on climate hazard threats to energy, water, and transportation infrastructure systems in the region. The report highlights the region's existing reliance on out-of-state energy generation, that can have negative implications on communities, should those systems be impacted, particularly during extreme heat events.

> Under the more severe RCP 8.5 scenario extreme heat days at LAX will increase from 15 days per year to between 50 and 90 days per year. Aircraft may be grounded due to extreme heat or subjected to weight restrictions because of changes to allowable plane weight for take-off and landing. How extreme heat will specifically impact LAX and other airport operations needs additional research.

The report also discusses vulnerabilities to wastewater, stormwater, and potable water systems. Southern California can face water shortage issues due to excessive dependence on imported water combined with the likelihood of increased drought in the American Southwest. Higher sea levels are expected to impact groundwater supply, urban drainage (stormwater outlets), and wastewater treatment plants along the coast. The Venice Storm Water Pumping Plant and Terminal Island Reclamation Plant are noted as highly sensitive to SLR.

Vulnerabilities in the transportation sector focused on transportation networks, operations, and people (transit users, pedestrians, and cyclists). Commercial airports and ports, freight rail terminals, and major transit stations are considered essential to the Southern California transportation system. Of these facilities, ports of Long Beach and Los Angeles are considered most vulnerable to SLR. The report also describes vulnerabilities to highways, streets, rail routes, bikeways, and shipping lanes, noting wildfires and SLR as the major hazards. The report indicates that nearly 56 miles of Los Angeles County roadways are exposed to a 100-year coastal flood. The report further emphasised the need for improvements in street design, transit frequency, and access to cooling facilities, to reduce transit user's exposure to extreme heat.

2017 Southern California Climate Adaptation Project: Vulnerability Assessment Model and Method
United States Forest Service (USFS)

This report details the vulnerability assessment methodology used for the Southern California Climate Adaptation Project. Twelve focal habitats including Alluvial Scrub, Chaparral, Conifer, Desert, Grassland, Sage Scrub, and Rivers and Streams habitats in Los Angeles County were reviewed in the vulnerability assessment. A team of ecology experts assigned one of five rankings (high, moderate-high, moderate, low-moderate or low) for each component of vulnerability (sensitivity, adaptive capacity, and exposure) to subject habitats. The researchers found Alluvial Scrub habitats, which are in the County, to be one of the most vulnerable of the 12 habitats analyzed.

2019 Caltrans Climate Change Vulnerability Assessments
California Department of Transportation

The District 7 report by Caltrans describes the impacts of climate change on transportation infrastructure in Los Angeles and Ventura counties. In Los Angeles County, there are 1,173 state highway miles managed by Caltrans, including 550 high-occupancy vehicle (HOV) lane-miles. The report

> During the Thomas Fire alone, 30 miles of US Highway 101 were closed and 275 traffic collisions occurred on Los Angeles area highways.

outlines how a changing climate is affecting the State Highway System. Over time, the mileage exposed to impacts from sea level rise, extreme heat, wildfire and other hazards will increase, resulting in declined performance and usability. Under the more severe RCP 8.5 Scenario, 311.6 centerline miles will be impacted from projected extreme heat and wildfires, while 6.9 miles will be exposed to inundation and other impacts from SLR by 2050. Bridges and culverts are also considered vulnerable to inland flooding events, however additional research is needed to further understand these impacts.

2019 Metro Climate Action and Adaptation Plan
LA Metro's Environmental Compliance and Sustainability Department

The report outlines the actions Metro is currently taking to combat climate change through reducing GHG emissions and making its system more resilient across the greater LA region. The Plan outlines vulnerabilities and impacts to public-facing, non-public-facing, and other infrastructure involved in LA Metro operations. The report presented used an index-based system to score hazard risks to Metro's infrastructure. Some key findings include:

- Subway lines are the most vulnerable LA Metro asset. They are particularly vulnerable to extreme heat and impacts from electrical grid outages, wildfires, and riverine flooding.
- Bus Rapid Transit (BRT) is vulnerable to both extreme heat impacts and riverine flooding.
- Terminals and rail stations are most vulnerable to extreme heat and the impacts from increased electrical grid outages.
- Almost 200 LA Metro assets are at "high or extreme risk" to landslides or mudslides, the second largest threat to the LA Metro system behind extreme heat.

2020 Los Angeles County All-Hazard Mitigation Plan
Chief Executive Office and Office of Emergency Management

The Los Angeles County All-Hazard Mitigation Plan (AHMP) is a comprehensive overview of hazards in unincorporated Los Angeles County and it's 88 cities, in accordance with the Disaster Mitigation Act of 2000. While more aligned with emergency management planning and hazard mitigation, the *AHMP* outlines the impacts of climate change (including SLR) on the County, with more detailed profiles of wildfire and flood impacts. The *AHMP* also notes the impacts of wildfires, stating while hillside areas are most vulnerable to burn, the greatest impact to people lies in the wildland-urban interface areas, and though strict regulations exist to mitigate fire risk they do not apply to homes constructed before 1991.

The plan finds that in a 1% annual risk flood scenario there is only one critical facility at risk, which belongs to the Department of Public Works. The *AHMP* projects that under a 0.2% annual chance of flooding scenario, there are 129 County critical facilities impacted. The County Fire Department has 46 critical facilities at risk representing just under 14% of their total facilities. The Department of Public Works has 41 critical facilities at risk or just under 18% of the Department's facilities.

SLR will impact low-lying coastal communities in the County. Between 2050 to 2060, a three-foot SLR scenario, coupled with the mean high tide, will inundate 2.25 square miles of the County, of which 0.03 square miles are in unincorporated areas. In the six-foot SLR scenario, 6.13 square miles of Los Angeles County will be inundated, of which 0.15 square miles are in unincorporated areas. Under a three-foot SLR scenario five critical facilities are impacted (three Public Works facilities, one Sheriff's Department facility, and one Fire Department facility) and under a six-foot SLR scenario, 11 facilities are impacted (five Fire Department facilities and six Public Works facilities).

2020 Assessing the Geographic Variability in Vulnerability to Climate Change and Coastal Hazards in Los Angeles County
National Oceanic and Atmospheric Administration (NOAA)

This report applies NOAA's National Centers for Coastal Ocean Science (NCCOS) Integrated Vulnerability Assessment Framework to analyze structural, natural resource, and social (discussed in Part III: Social Vulnerability) vulnerability in Los Angeles County. The report discuses multiple climate and coastal risks including coastal, stormwater, and combined flooding, in addition to erosion, drought, heat, and wildfire. Structural vulnerability components were determined after consulting with stakeholders and a literature analysis and are defined as follows: parcel age, critical infrastructure, disaster routes, historic places, and improvement value. Natural resource vulnerability was determined by creating an additive index using greenness, tree canopy cover, habitat fragmentation, wetland areas, species richness, and significant ecological areas. In short, the assessment identified numerous key findings including:

- Extreme heat will impact inland areas, particularly surrounding Palmdale more than coastal areas of the county.
- Wildfire risk will increase in rural and wildland-urban interface areas.
- While some coastal areas are vulnerable to erosion, affected structures tend to have lower structural vulnerability.
- There are many areas of high social vulnerability and high combined flooding risk throughout the County. There are cultural and historic resources at risk for flooding.
- Many disaster routes are at risk of flooding and erosion, including the PCH.
- Natural resources are vulnerable across the County, overlapping largely with the same areas at risk for extreme heat impacts.

2018 Adaption Blindspot
Susanne C. Moser and Juliette Finzi Hart

This technical report from the Fourth Climate Assessment identifies a conceptual framework for assessing the nexus of communications and energy, including cascading impacts to people and emergency management. Physical vulnerabilities identified in this report include transmission and distribution lines, highway and rail systems, and other transportation and communication infrastructure. The study includes the first unified map of the interconnected lifeline systems for metropolitan LA, describing the interconnectedness between energy and telecommunications infrastructure. The report notes coastal erosion and flooding may impact energy infrastructure, transportation infrastructure such as bus, rail, airports, ports, and roads, and water reservoirs. Drought can impact steam power generation, hydropower generation, and airports (planes need water to recharge). Wildfire can impact energy infrastructure, transportation infrastructure, and water resources such as snowpack and reservoir stock. The researchers also identified the potential for wind to impact bridges and airports. Precipitation and flooding will impact hydropower generation, transportation infrastructure, and impact water resources and storage.

The researchers identified that extreme heat and other climate hazards can disrupt basic service delivery of critical infrastructure, either through a direct impact or via the failure of another infrastructure system, highlighting the interconnectedness of service delivery in the Los Angeles area. For example, researchers modelled a power failure scenario, showing that after three days, water reserves would decline, stressing residents. However, the researchers were able to show that the transportation network would still function and be able to carry additional supplies and emergency personnel.

1.2.2 Coastal Flooding

2013 Sea Level Rise Vulnerability Study for the City of Los Angeles
University of Southern California (USC)

The report highlights findings of three vulnerability assessments that provide a preliminary examination of the physical, social, and economic impacts of sea level rise on the City's coastal assets, resources, and communities. This assessment identified city roads, water systems, and cultural assets as the most vulnerable physical assets. The reports determined that Venice and surrounding neighborhoods of the Port of Los Angeles have a higher proportion of older housing units, which may be more sensitive to flooding due to less restrictive building codes and limited flood-proofing measures.

2016 Regional Adapt LA: Coastal Impacts Planning for the Los Angeles Region
USC Sea Grant Program

This report discusses the impacts of SLR, coastal erosion, storm flooding, and beach deterioration to coastal areas. In a SLR scenario of 5.5 feet, 143 miles of roadway/bikeway would be impacted by 2100 and, if coupled with a 100-year flood event, 327 miles could be impacted. Models show similar shoreline change projections: beach retreat will stretch across County beaches in a high sea-level rise scenario. As a result, low-lying areas of Los Angeles County will see significant increase in flood hazard exposure, which in turn increases vulnerabilities for adjacent transportation infrastructure, underground infrastructure, public facilities, ecosystem assets, and wildlife habitats. In a long-term erosion scenario, 1,136 out of 1,591 buildings that are subject to increased exposure are in Malibu alone. However, in a 100-year flood storm event, Long Beach has the most buildings exposed. By 2050 in a 5.5-foot SLR scenario, over half of all buildings projected to be impacted will be in Long Beach (7,617 buildings out of 14,705). Though this report focuses on buildings and structures, it does not focus on residential structures and concerns related to housing infrastructure in coastal areas.

2016 Los Angeles County Public Beach Sea-Level Rise Vulnerability Assessment
LA County Beaches and Harbors

The Los Angeles County Department of Beaches and Harbors maintains 19 facilities, and support infrastructure (parking lots, restrooms, concessions, maintenance yards, utilities, lifeguard stations) for a total of 121 physical assets. This report reviews public beach facilities in Los Angeles County to assess their vulnerability to SLR and saltwater intrusion. Vulnerabilities to beaches and adjacent physical assets is defined based on ground elevation, proximity to shoreline, exposure to beach erosion, wave runup, and inundation exposure. The report also analyzes the impacts to accessible beach for public use, noting the elimination of some beaches entirely by 2100.

2016 Climate Adaptation and Coastal Resiliency Plan
Port of Long Beach

SLR will impact the Port of Long Beach, which handles cargo valued at $180 billion every year, and the Port of Los Angeles which handled $236 billion in containerized cargo in 2015.

This plan outlines the direct and indirect effects of climate change (notably sea level rise) on port operations. The report found that while their piers are largely resistant to impacts from short term flooding there are some assets on the piers such as electrical components, shore-to-ship power, communications, and lighting that may be at risk of damage. The report noted that under various sea level rise scenarios there will be impacts to cargo loading/off-loading due to pier inundation (or railway inundation).

2018 Port of Los Angeles Sea Level Rise Adaptation Study
Port of Los Angeles

The Port of Los Angeles commissioned a study to outline the potential impacts of SLR on Port assets. The study analyzed asset vulnerability by measuring their exposure, sensitivity, and adaptive capacity to sea level rise impacts. This study noted that container terminals have low vulnerability to sea level rise, but other assets such as pump stations, transportation networks, and commercial assets could be impacted under various SLR and storm surge scenarios. Pump stations, life safety facilities, and utilities could be temporarily flooded in a 37-inch SLR scenario with storm tides. Like Long Beach, the Port of Los Angeles identified various aspects of their transportation network to be vulnerable to sea level rise such as the Volpak, WBCT, and TraPac rail ways. Though largely unaffected by smaller increases in SLR, the various aspects of the Port will impacted by more severe SLR, such as their 66-inch scenario, necessitating additional research and planning to mitigate against impacts.

2018 Climate Vulnerability Assessment: Long Beach
City of Long Beach Development Services

> SLR is anticipated to impact beaches (and tourism), publicly owned facilities, and infrastructure (including housing, highways, and bridges) in Los Angeles County. However, we do not have consistent information about the impacts to the housing stock across all coastal areas.

The report outlined the climate vulnerability of structures and facilities, including City-owned buildings/facilities, privately-owned buildings, and their associated mechanical/electrical/plumbing systems. Under 5.5-feet SLR projection, 26 publicly-owned buildings will be exposed to inundation during King Tides[1] (seven parks/recreation/marine buildings, six marine safety buildings, four fire stations, three police facilities, three schools, one health resource center, one library, one solid waste facility). In this scenario, over 17 million square feet of privately-owned buildings will be exposed during a King Tide, of which nearly 12 million square feet are residential. The 500-year flood plain contains two hospitals, 11 fire stations, a police station, and 96 schools. Vulnerability to energy assets included exposure of the NRG Generating Station and eight miles of transmission lines to annual King Tides with 11 inches of SLR. With 55 stormwater pumps and over 400 storm drain outfalls in Long Beach, impacts from SLR (coupled with King Tides) can cause severe stormwater system failures. The report also explored impacts to the transportation system, wastewater system, and potable water assets.

2018 Venice Sea Level Rise Vulnerability Assessment
City of Los Angeles Department of City Planning

This report noted that North Venice and the Ballona lagoon areas are highly vulnerable to SLR. The report also noted the heightened vulnerability to SLR at the Lifeguard Headquarters, parking lots, Coeur d'Alene Elementary School, Westminster Avenue Elementary, Westside Global Awareness Magnet school, LAPD Venice Substation, and the LA Fire Station 63.

[1] King Tides refer to higher than average tides that usually occur during a new or full Moon.

1.2.3 Inland Flooding

2017 Los Angeles Basin Study
Los Angeles County Flood Control District and US Bureau of Reclamation

> Los Angeles County imports 59% of its water from outside the region which necessitates our emphasis on including vulnerabilities to the water system from the Colorado-River and Bay-Delta regions.
>
> *OurCounty Sustainability Plan*

This study examines the region's water supply and demand, and the impacts from projected population growth and changing climate in the watersheds of the Los Angeles region. The *Los Angeles Basin Study* outlines key vulnerabilities in the region include: uncertainty and variability of future water supplies, including imported sources from the Colorado River and Bay-Delta; changing local water supply planning strategies from short-term to long-term approaches to meet future demands; and increasingly complex regulatory challenges.

2020 Los Angeles County Comprehensive Floodplain Management Plan
Los Angeles County Department of Public Works

> Between 1969 and 2016, the County experienced 13 flood-related events that required federal disaster declarations. In the 2016-2017 winter rain season, an all-time rainfall record was set at the Long Beach Airport of 3.87 inches in a single storm.

This plan identifies potential increases in the likelihood of spillway events and other dam failures. The Los Angeles County Drainage Area Project has 100 miles of main stem channel, 370 miles of tributary channels, more than 200 debris basins, 15 flood control/water conservation dams, and five flood control dams. Within the 100-year floodplain, there is over $3.94 billion in buildings and contents at risk of flood exposure, and 75 identified critical facilities. In the 500-year floodplain there is $16.78 billion in buildings and contents exposure, equaling 8.6% of the total replacement value of the planning area, of which there are 192 critical facilities. The report notes the majority of structures in the floodplains are residential.

2018 Draft LA River Master Plan Update

Los Angeles County Department of Public Works

The 2018 draft *LA River Master Plan Update* noted that flooding is a risk for the entire LA River from inundation to rushing water and debris. The lower portion of LA River will be impacted by sea level rise (SLR) and tsunamis. The industrial nature of some portions of the LA River area pose risks when analyzing downstream impacts from the LA River as physical infrastructure and the surrounding energy/water infrastructure. There are 610 hazardous sites within a mile of the LA River, including 8 powerplants, 12 superfund sites, 16 brownfield sites, two water reclamation plants, 358 toxic release sites and 292 large quantity hazardous waste sites. Crossing fault lines at Miles 4 and Mile 28, the area around the LA River is generally vulnerable to earthquake damage.

1.2.4 Extreme Heat

2018 Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat
University of California LA and Arizona State University

This technical report examines future electricity demand, grid response, and subsequent vulnerability due to increased heat events in the Southern California Edison territory. The effects of population growth, building densification, air conditioning penetration and efficiency, and rising air temperatures are modelled to assess electricity demand. The peak hour electricity demand is projected to increase in residential and commercial sectors by 0.2 to 6.5 GWh (2 to 51%) by 2060. The report noted system vulnerabilities stemming from the increased demand and decreased system capacity during extreme heat events, including decreased capacity of transmission lines and substation load capacity (affecting 99% of County substations). The report identified vulnerable areas noting that by 2060 inland areas will experience the greatest vulnerability to power failures.

> Extreme heat can stress the energy system in the County through generating increased consumer cooling demand, which places an additional burden on energy generating plants, substations, and transmission lines.

1.2.5 Wildfire

2020-2022 Utility Wildfire Mitigation Plan
Southern California Edison (SCE)

This plan analyses the ignition probability and wildfire exposure, and presents "risk-spend efficiency" analyses for each mitigation measure to ensure the proper use of ratepayers' funds. The report notes that object contact with power equipment and equipment failure (such as transformer failure) are some major drivers of wildfire ignition (see Table 4).

> Vulnerabilities and concerns pertaining to wildfire's interaction with physical infrastructure include damage to access roads and buildings in the Wildland-Urban Interface and Fire Hazard Severity Zones, and disruptions to energy supply due to Public Safety Power Shutoff events.

This plan identifies various steps to reduce wildfire risks associated with electrical equipment in SCE's service area. These include infrastructure hardening, vegetation management, detailed inspections and remediations, and situational awareness for wildfire monitoring. The plan also emphasizes Public Safety Power Shutoff (PSPS) as a measure to proactively de-energize portions of the grid to prevent wildfires. SCE partners with various 2-1-1 service providers and independent living centers to support electricity-dependent customers during PSPS events.

2020 Vulnerability of California Roadways to Post-Wildfire Debris Flow
Mikhail Chester and Rui Lu

This journal article emphasizes the importance of understanding post-fire debris flows on transportation infrastructure. The researchers conducted a vulnerability assessment for roadways in the entire state of California, concluding that under a 10-year storm, 60 road miles are vulnerable to post-wildfire debris flow across the state, increasing to 444 road miles in a 100-year storm. Under the more severe CanESM2RCP 8.5 scenario (one of California's ten priority GCMs), a 10-year storm would render 254 road miles vulnerable and in a 100-year storm, 1,104 road miles. The researchers then recommend a phased approach to addressing this vulnerability, noting the immense scale of the road network in California, but encouraged extending transportation services and committing "to reassessing conditions, technologies, designs, and operations for a future defined by uncertainty."

2 Key Findings and Data Gaps

This document builds on existing state guidance as well as regional and sub-regional plans to summarize existing and future physical vulnerabilities that are relevant to Los Angeles County. These climate vulnerabilities stem from physical damage to infrastructure systems, facilities, and assets, leading to service interruptions that can be detrimental to regional productivity, community wellbeing, and the economy. Some notable findings from these reports are summarized below:

- Few reports have a comprehensive approach to vulnerability. Most reports either focus on one infrastructure system (i.e. energy or transportation) or on one hazard (i.e. SLR or wildfires). As such there is limited discussion on cascading impacts between systems.
- Vulnerability to coastal flooding, and sea level rise in particular, is well documented in the region. On the other hand, there has been less holistic and focused evaluation of physical vulnerability to infrastructure, across multiple assets, in the County due to extreme heat, drought, and wildfires.
- In Los Angeles County, the electricity grid is exposed to extreme heat, wildfires, and drought. Increases in electricity demand during extreme heat events can burden energy generating plants, substations, and transmission lines, increasing the risk of power failures.During high wind, red flag conditions, Public Safety Power Shutoff events (enacted to reduce the potential for wildfire ignition) cause disruptions to energy supply in some areas. Increases in drought can affect hydropower electricity outputs. Ensuring grid reliability is therefore critical for supporting communities and maintaining essential services such as water, telecommunication, transportation, and other infrastructure systems.
- The County is currently reliant on imported water supplies from the Colorado River and Bay-Delta areas. Future water supplies, both imported and local, may be impacted by changes in precipitation that could lead to multi-year droughts. Furthermore, local water systems are exposed to inland and coastal flooding, which can impact ground and surface water supplies and quality, stormwater systems, and underground infrastructure (potable and non-potable) largely due to dam failures and saltwater intrusion.
- The transportation sector is vulnerable to multiple climate hazards. Extreme heat can damage road and highway infrastructure, rail infrastructure pavements, and discourage transit ridership. Power failures due to extreme heat can disrupt Metro's assets and transit services. Wildfires and flooding events can impact evacuation routes resulting in disastrous ripple effects during emergency operations. Coastal highways, bikeways, and port facilities are exposed to SLR and coastal erosion, in particular.
- The following infrastructure categories were less likely to be emphasized for physical vulnerabilities to climate hazards, including: housing infrastructure, waste, and communications. Housing, as infrastructure, was not addressed in any reviewed reports except the NCCOS report, which covered housing in flood prone areas or areas prone to public safety power shutoffs, in particular.

In general, the connection between physical vulnerabilities and impacts on community health and wellbeing, is rather limited in the reports reviewed. With the exception of *Adaptation Blindspot*, few reports examine the interdependence between different infrastructure systems and services and the value of these systems to local communities. In subsequent phases of the County CVA, the impacts of physical vulnerabilities on infrastructure systems and the effect on communities will be explored. Where relevant, the codependencies between systems and risks to communities residing in close proximity to infrastructure assets that are highly vulnerable to climate hazards will also be evaluated. Considering the downstream impacts of infrastructure failures or disruptions, particularly on socially vulnerable

populations, is important for prioritizing investment decisions to ameliorate disproportionate downstream impacts.

3 Informing the Assessment

3.1 Infrastructure Prioritization

This section summarizes the approach to prioritizing infrastructure types by criticality for the Physical Vulnerability Assessment of the Los Angeles County CVA. The approach aims to identify infrastructure types for geospatial evaluation where overlays of climate hazard map layers and infrastructure geospatial data will be applied. These exposure maps will provide the foundation for corresponding analyses of sensitivity and vulnerability of physical infrastructure. The Physical Vulnerability Assessment methodology involves developing geospatial overlays of climate hazards with critical infrastructure systems to identify exposed assets. This mapping exercise will be constrained by the amount of data that is meaningfully interpreted in the resulting maps and used in adaptation planning and decision-making.

To prioritize infrastructure types as critical, an initial screen of datasets collected through the Desktop Review was conducted, screening for those that contained data on assets that are most sensitive to climate hazards. This initial screening was conducted based on our past experiences doing similar analyses. With the refined list, it was then determined whether each dataset could be meaningfully evaluated spatially for exposure. As an example, sidewalks are commonly relied on infrastructure for commuting and accessing critical assets but are difficult to assess spatially because of lack of consistent data and information on the location and condition of sidewalks. It was also determined that some datasets were better suited for areas of the Vulnerability Assessment other than the Physical Vulnerability Assessment. For example, datasets on residential building thermal performance were considered under the Social Vulnerability Assessment as they can help to illustrate sensitivities and potential vulnerabilities of occupants rather than the buildings themselves.

After applying initial screens, a refined list was developed that included potential physical infrastructure types that are most sensitive to climate and can be illustrated through spatial analysis. With this refined list, the asset types were evaluated against the following criteria using expert judgment and findings from the Desktop Review. These criteria include:

- Does the infrastructure type have an important role in emergency response?
- Does the infrastructure type have an important economic role for a large community?
- Does the infrastructure type have an important role for socially vulnerable populations?
- Is the infrastructure type important because of a lack of redundancy?

Meetings with County departments were held to ensure agreement with the proposed list of infrastructure types and to capture any additional insights that will enable preparation of datasets for the CVA analysis. Using this feedback from County departments, the list of infrastructure types was finalized to be included in exposure maps, summary statistics, and sensitivity and vulnerability matrices in the Physical Vulnerability Assessment.

3.2 Initial List of Critical Infrastructure and Facilities

Most regional plans discussed in the document focused largely on vulnerabilities in power, water and wastewater, and transportation systems. Reports by more localized jurisdictions like the County and city departments were reviewed to understand vulnerabilities in other sectors. Many local reports emphasize vulnerabilities to specific assets such as ports, hospitals, disaster/evacuation routes, beaches, government facilities, and emergency response, among others. The initial list of infrastructure facilities and assets was developed through a combination of the Desktop Review and input from the County and stakeholders, as described in *Section 3.1 Infrastructure Prioritization*. The list presented below (Table 3) is a preliminary list of infrastructure types and facilities within the County that will be analyzed in the County CVA.

Table 3: Initial list of critical infrastructure categories and types

Infrastructure Category	Initial List of Infrastructure Types
Communications	Cell towers
Community Facilities	Child and family services, home-based daycares, daycare, schools , universities, cooling/refuge centers, community centers, parks and open space, regional centers, prisons/jails
Economic Centers	Job rich areas
Energy	*Electricity*: Substations, electricity transmission, power plants *Oil and Gas*: petroleum terminals, oil refineries, oil pipelines, oil wells *Natural Gas*: transmission and distribution lines
Housing	Low-income housing stock, nursing homes/elderly care/residential care facilities, homeless shelters and long-term housing facilities
Medical Facilities and Emergency Response Infrastructure	Hospitals, LACDMH providers, medical clinics, fire departments, sheriff and police stations, government emergency centers
Transportation	Highways (functional classification and condition), bus lines, Metro lines, Metrolink, bridges, tunnels, disaster/evacuation routes, LA/LB ports, airports
Waste	Hazardous waste disposal, landfills/solid waste facilities
Water System	Active private/permitted wells, water treatment/reclamation, active public water systems (SDWIS), storm drain system, reservoirs, debris basins/spreading grounds

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