
Toward a Vibrant, Prosperous and Sustainable Fresno County:

Vulnerability and Adaptation in the Midst of Rapid Change

EXECUTIVE SUMMARY

November 7, 2010

*Prepared for Local Government Commission and
the Fresno County Stakeholder Workshop on September 23, 2010.*



David Jordan, Wikimedia

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**This Executive Summary synthesizes a more comprehensive report for Fresno County.
For more details and references please consult the companion document.**

Introduction

Fresno County's Vision of a Vibrant, Prosperous and Sustainable Future

In early 2006 the eight Councils of Governments in the San Joaquin Valley began developing a common vision for the Valley – the San Joaquin Valley Regional Blueprint. Fresno County – the largest of the eight-county consortium – is participating in this effort through its own, coordinated planning and implementation of land use and transportation decisions. With financial support from the state and federal governments, Fresno thus embarked on a significant investment in its economic vitality and the well-being and quality of life of its residents (see Textbox to the right).

Fresno's Blueprint is intended to help urban areas in the county to better deal with existing and expected future growth-related challenges to public resources, housing, mobility, the health of Fresno's population, its air quality and environment. While its emphasis is on economic and demographic growth and changes, the Blueprint recognizes that the environment will be under growing pressure from development, and it, too, is changing, driven particularly through changes in the global climate.

In 2008, experts at the California State University in Fresno (CSUF) completed a study for the City of Fresno to assess what the specific additional challenges may be arising from climate change, and how the City might address them. The resulting study laid out potential climate-related threats to the city and county and suggested a variety of actions local governments, in collaboration with the private sector, could take to reduce local sources of emissions of heat-trapping gases and related air pollutants. It also offered a small number of actions to deal with the unavoidable impacts of climate variability and change, such as increasing heat extremes. Virtually the entire suite of proposed strategies and actions are consistent with, and in fact, integral to the County's Blueprint principles and strategies.

This summary of an accompanying longer technical report offers the City and County additional insights to build on the intention and momentum of

the regional Blueprint and the CSUF study's recommendations. Our focus is primarily on the regionally differing social, economic and demographic conditions which, along with the pressures of growth, shape how different communities, economic sectors, and the underlying infrastructure and community services vary in their vulnerability to climate-related risks. Regardless of the exact magnitude or causes of future changes in the climate, Fresno can efficiently focus and further enhance its efforts to plan ahead for a vibrant, prosperous, and sustainable future with a fuller understanding of these differential vulnerabilities. The purpose of this report, then, is to provide insights and information to augment existing efforts, to refine current strategies, and help local decision makers meet the challenges of the future and ensure the realization of Fresno's vision.

A vision for Fresno in 2050

"Fresno County is home to unique cities, communities and a diverse population, a healthy, sustainable environment, a vibrant economy built on competitive strengths and world class education and a system of high capacity multi-modal transportation corridors, where cultural and community stewardship is an guiding value, allowing all people to enjoy fundamental rights as members of a free society, and where the community takes ownership of problems and their solutions." (Source: Valley Blueprint)

A previous report and workshop, organized by the National Center for Conservation Science and Policy (NCCSP) focused on potential climate change impacts and adaptation options for the county's natural ecosystems and conservation areas. A functional and healthy natural environment is a critical foundation for Fresno's economy, quality of life, and the health and well-being of its residents. Thus, this summary views the previous report as a critical foundation and complement to the focus here on social systems.

To fully understand what climate change will actually mean for local communities, science-based projections of potential changes in the physical climate (given selected greenhouse gas emissions scenarios) are essential, but not enough. What is

equally necessary to complement these scenarios of future climate (i.e., changes in temperature, rainfall, extreme events such as floods and droughts, and sea-level rise) is a better understanding of the current (and future) condition of the potentially affected natural and social systems.

In this report, we focus primarily, though not exclusively, on these on-the ground vulnerabilities that can be understood by evaluating the existing conditions of social and natural systems. They will help identify adaptation actions that could be considered no- or low regrets options, not because they are necessarily no- or low-cost or easy to implement, but because they can yield benefits to the environment, economy and to people regardless of precisely how climate change will unfold.

We summarize what is known about these potential impacts, but primarily examine available information about

- demographics (race, wealth, education levels, special populations, etc.)
- locally important economic sectors (tourism, agriculture, services, etc.)
- important infrastructure and community services (transportation, emergency management and response, etc.)
- necessary natural resources (water, healthy ecosystems and the goods and services they provide).

This will support the county’s economy and residents to better understand how the region and communities within the County are vulnerable to climate change.

To present such a diversity of background information, this report is organized as follows. First, we will introduce a few concepts that are central to thinking about vulnerability and developing adaptation strategies. Key concepts include: vulnerability, exposure, sensitivity, adaptive capacity, coping, adaptation, and resilience. Second, we will present a summary of modeled climate change projections (biophysical impacts – temperature, rainfall, wildfire, etc.) for the region to remind readers of the potential risks the county may be exposed to. Finally, the core of the report will present information about the population, economic

sectors, water, and infrastructure and supporting services. This information will be related to the concepts introduced earlier to illustrate how certain demographic, socio-economic and other factors make Fresno’s residents and economic activities more or less vulnerable to the impacts of climate change. They will also indicate what capacities the county already has to draw on and could further leverage to begin the process of adaptation.

What is Vulnerability? What is Adaptation?

For the purposes of this report, we employ the terminology used in the State of California’s first Climate Adaptation Strategy (see box of definitions).

A **climate change impact** is an effect of climate change on the structure or function of a system.

Vulnerability – a system’s susceptibility to harm or change as a result of its exposure, sensitivity, and adaptive capacity. *It is a function of the character, magnitude, and rate of climate change and of social and environmental characteristics of the system.*

Exposure is the nature and degree to which a system experiences a stress or hazard.

Sensitivity is the degree to which the system is impacted by a given stressor, change or disturbance.

Adaptive capacity refers to ability to cope with extreme events, to make adaptive changes, or to transform more deeply, including the ability to moderate potential damages and to take advantage of opportunities.

Adaptation is defined as any adjustment in natural or human systems in response to actual or expected climatic events or their effects, which may minimize harm or take advantage of beneficial opportunities.

Resilience is the ability of a system to absorb some amount of change, including shocks from extreme events, bounce back and recover from them, and, if necessary, transform itself in order to continue to be able to function and provide essential services and amenities.

Climate Change Impacts

The Institute of Climate Change, Oceans and Atmosphere (ICOA) at the California State University-Fresno in 2008 produced a report synthesizing the scientific research on climate change science and potential impacts on the region. Since then, several additional studies conducted for the State of California – as part of the state’s periodic impacts assessments – and an independent study conducted by the National Center for Conservation Science and Policy provide additional indications of the potential climate changes that Fresno may expect in the future. Here, we only summarize the key findings of these studies.

Higher Temperature

Across Fresno County, temperatures are projected to increase in the summer by +2-6.0 °F by 2050, and +5.2-11.0 °F by 2100, while winter temperatures are projected to increase by +2-4.1 °F by 2050 and 3.7-7.9 °F by 2100. When dividing the county into upper and lower regions (i.e., the east and west side, respectively), the upper region is projected to increase annual average temperatures by 2.5-4.3 °F by mid-century and then up to nearly 9 °F warmer by the end of the century. In the lower region, where the majority of the population and industry are located, annual average temperatures are projected to increase by 2.3-4.3 °F by mid-century. Average summer temperatures are expected to rise even more (up to 6 °F). By 2100, annual average temperatures are projected to increase by 4.7-8.2 °F and summer averages up to 11 °F (Figure1).

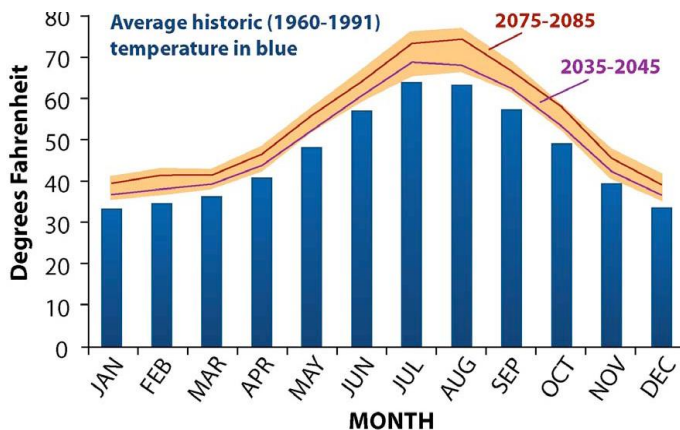


Figure1: Projections of temperature increase in Fresno County (Source: Koopman et al., 2010)

For the urban center of Fresno, where half the county’s population lives and the urban heat island magnifies larger warming trends, extreme heat events are of particular interest. The best available science available projects that the number of days that exceed the local heat threshold of 104 °F will increase by 20-30% by mid-century, i.e., from the current 92 such days to 113-120 extreme heat days. By the end of the century, there could be as many as 126-149 extreme heat days (i.e. 4-5 months per year) in Fresno of over 104 °F unless climate change is curbed through effective global efforts.

Precipitation and Water Supply Changes

Sufficient water supplies are absolutely crucial to the county’s agricultural industry and its residents. They come from sources largely beyond county borders, thus it is critical to examine how the quantity and timing of water availability and supply upon which Fresno depends might be affected by climate change. Much of the agricultural water is supplied by the Kings River, coming down from the southern Sierra Nevada Mountains to the east, and from the aqueducts whose waters originate from snowmelt of the northern Sierra Nevada Mountains. As climate warms, a greater proportion of precipitation will fall as rain rather than as snow, and runoff from meltwater will occur earlier in the spring. Both of these trends are already being documented. Moreover, the best available studies expect a slight overall decline in precipitation in the future, especially in the second half of the century. Consequently, scientists expect a decrease in annual reservoir inflow (from Sierra snowmelt and rain runoff) by 14-23% by mid-century and a total decrease of up to 43% by the end of the century. With runoff from snowmelt occurring earlier in the spring, the period where water availability is more limited, will expand; reduced snowmelt and runoff will also affect hydroelectric power production. The risk of more dry years and droughts will increase as a result of higher temperatures, higher evaporation and, eventually, a decline in precipitation. At the same time, the risk of late winter/spring floods is expected to increase due to more extreme rainfall events, especially when coinciding with earlier snowmelt. The groundwater basins that supply the

majority of water to urban and rural residences, as well as some farming operations, rely on annual recharge from water that also flows down from the Sierra Mountains.

Wildfire and Air Quality

With higher temperatures, especially in summer, and a longer dry period, the risk of wildfires increases. One study projects 300-400% increases by end of century in the area burned annually by wildfires. Smoke from wildfires contributes to worsening air quality, which is already a problem for the valley areas of the county. “Bad air” days are expected to increase in frequency as warmer air increases the formation of ozone, a key component of smog.

Impacts on Power Generation

While sea-level rise will not affect Fresno County directly, it is important to be aware of what happens beyond its borders. Fresno, along with all the other regions in California supplied by Pacific Gas & Electric (PG&E), receives a significant portion of its energy supply from the Diablo Canyon power plant located on the coast. That location is exposed to the impacts of sea-level rise (current best estimates range from 12-17 inches by 2050, and 23-55 inches by 2100), including flooding and coastal erosion. In addition, PG&E relies on in-state hydropower production, the production of which is also projected to decrease in the late summer and early fall months as snow melts earlier in the year.

Outlook

The impacts from climate change – their exact magnitude, severity, and timing – are not set in stone for Fresno County. The projections are based on the expectation of further increases in global greenhouse gas emissions. Such a future would entail more extreme heat days, higher temperature, seasonal changes, and – here in California – water shortages. If Fresno, California, and the global community follow a path toward significantly reduced emissions, the future would hold significantly fewer extreme heat days, and much less reduction in snowfall and thus inflow into reservoirs, than if the world chose a higher-emissions pathway.

Fresno County can minimize the impacts of climate change by significantly reducing its own

emissions and working with the state and broader efforts to reduce the problem. Yet even with significant local and global efforts to reduce emissions, many impacts can no longer be prevented and must be accounted for to achieve the Valley Blueprint vision. In the absence of perfect information about future climate, Fresno can begin examining potential impacts on the county’s residents and communities, assess its vulnerabilities, and explore beneficial and cost-effective adaptation strategies to build its resilience in the face of a rapidly changing world.

Population and Communities

Fresno County is a predominantly rural county with the majority of the population centered in a relatively small area around the City of Fresno. Its population over the past few years has been growing at a moderate rate, and is expected to continue to do so, leading to a projected doubling of the population by 2050. Most of this growth will result from reproduction by the local population and immigration to the area. The profile of the existing population, the amount of growth, and the type of incoming new residents are important to consider with respect to their vulnerability to climate change.

Public Health

Climate change may have a substantial impact on public health as a result of extreme heat events; changes in temperature and rainfall that decrease water supply; worsening air quality; increases in allergens and air pollutants; more wildfires; spread of insects and rodents carrying diseases; and indirect impacts via changes in food security. These increasing threats to public health can increase mortality and morbidity unless actions are taken to protect the population, especially those most vulnerable. California’s statewide Adaptation Strategy highlights that the segments of population that will be most at risk from climate change impacts are the “elderly, infants, individuals suffering from chronic heart or lung disease, persons with mental disabilities, the socially and/or economically disadvantaged, and those who work outdoors.” We summarize these critical social vulnerability concerns below for specific climate change risks (Table 1).

Table 1: Examples of Climate-Related Extreme Events or Environmental Changes Interacting with the Three Components of Vulnerability

Components of Vulnerability	Climate Change Risks	Population Particularly at Risk
Exposure	Floods Heat Wildfire Pests and infectious disease	Floodplain residents Outdoor workers Residents the urban-wildland interface Individuals in crowded and poor living conditions
Sensitivity	Heat, Air pollution Heat	Infants, populations with asthma Elderly
Adaptive Capacity	Heat, Floods, Infectious diseases	Socially excluded and economically marginalized groups

Exposure

Outdoor Workers Exposed to Extreme Heat

People who work outside are directly exposed to outdoor conditions, and exposure to temperature extremes and air pollution are of particular concern for these individuals, regardless of age. Examples of such populations are agricultural field workers and gardeners for residential and commercial establishments, as well as road and building construction workers. They have little incentive or opportunity to seek shade, rest, rehydrate, or avoid exposure altogether (Figure 1). Climate change-related temperature increases will put these workers even more at risk of heat exhaustion, sunstroke, dehydration, and other heat-related illnesses unless effective measures are put in place (i.e., mandated, implemented, and monitored) that allow outdoor workers to seek shade, cool off, and remain adequately hydrated.



Figure 1: Farm and other outdoor workers are particularly exposed to extreme heat. (Photo: Holger Hobbs, Wikimedia Commons)

Floodplain Residents at Risk from Extreme Runoff and Flooding

Climate change is expected to increase the flood risks already present across the county. In the future there may be more extreme downpours and runoff in the winter and spring, which can cause flooding along area creeks and rivers (e.g., the Kings and San Joaquin Rivers), of roads, homes, and agricultural fields. If these events occur over several days and overwhelm the capacity of streambeds and reservoirs, there is risk of dam failure and flooding. People living in low-lying areas, floodplains (along the San Joaquin and Kings Rivers), and downstream of the Big Creek Dam (City of Fresno) and Pineflat Dam are at particular risk.

Sensitivity

Greater Sensitivity to Extreme Heat in Infants’ and the Elderly

Infants and those 65 years and older are physiologically more sensitive to high temperatures and may be less able to protect themselves from extreme conditions. Long-lasting heat waves and, in particular, very warm nights are especially challenging for human health. While the county does not have a particularly large population of persons over 65, the highest concentrations of elderly individuals can be found in or near the City of Fresno, i.e., in the valley, which also gets the hottest temperatures (Figure 2). A high proportion of the elderly population can also be found in the western mountain region, which is cooler but exposed to other risks (see Wildfire below).

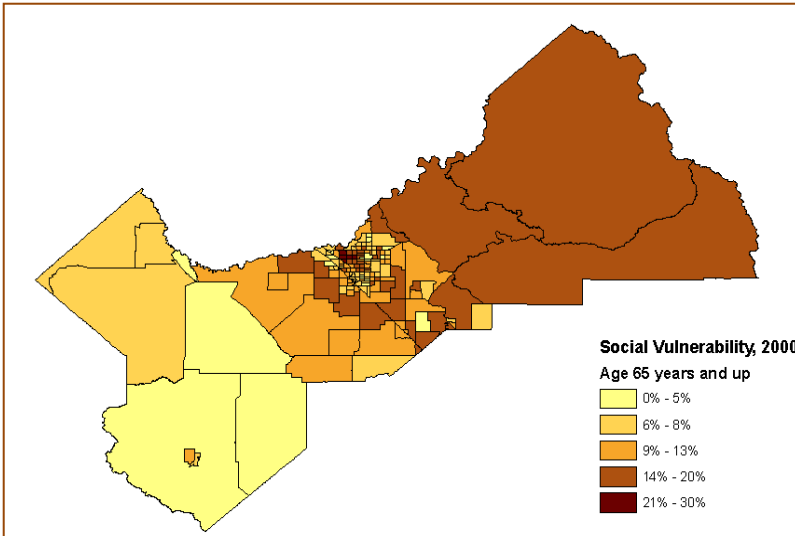


Figure 2: Percentage of the population 65 years and older (Source: Census 2000)

Higher Sensitivity of the Elderly and Children to Air Pollution

The San Joaquin Valley is among the regions with the worst air quality in the country. Ground-level ozone, particulate matter, and diesel soot are the main air pollutants, stemming largely from agricultural operations, related industrial processes, combustion of wood and fossil fuels, construction and demolition activities, road dust, and transportation-related emissions (major routes such as Interstate Hwy. 5 and Hwy. 99 cross through the county). Again, children, the elderly, and those with preexisting pulmonary conditions are most sensitive to air quality related health risks. The proportion of young children is highest in the western, low-elevation, valley portion of the county where agriculture is the dominant land use and where the concentration of agriculture-related and other pollutants (ozone, particulate matter) is highest. Other areas with high concentration of children include the City of Fresno, some surrounding suburbs, and areas in the south-central part of the county (Figure 3). Higher temperatures will significantly increase the formation of ozone, an important air pollutant. Drier conditions can increase dust. And wildfires are projected to at least triple in total area burned due to the combination of hotter and drier conditions.

This will especially affect the mountainous region along the western portion of the country, and contribute to worsening air pollution there.

Adaptive Capacity

Some populations are more vulnerable to climate change impacts because they are less able to cope with extreme events or make necessary changes. Common characteristics of society that indicate lower adaptive capacity and therefore greater vulnerability to climate change impacts include poverty and low income, age, lower educational attainment, race, linguistic isolation, university students, institutionalized populations, and females as head of households. These traits are common among large portions of Fresno’s population, but are unevenly distributed across the county.

Lower Income Correlates with Lower Disaster Readiness and Response

Lower income often correlates with lower access to the necessary resources to prepare for or evacuate in the case of a disaster, or to invest in actions required to adapt to climate change (e.g., insulating one’s house, elevating it above a certain flood elevation, moving away from high-risk fire zones).

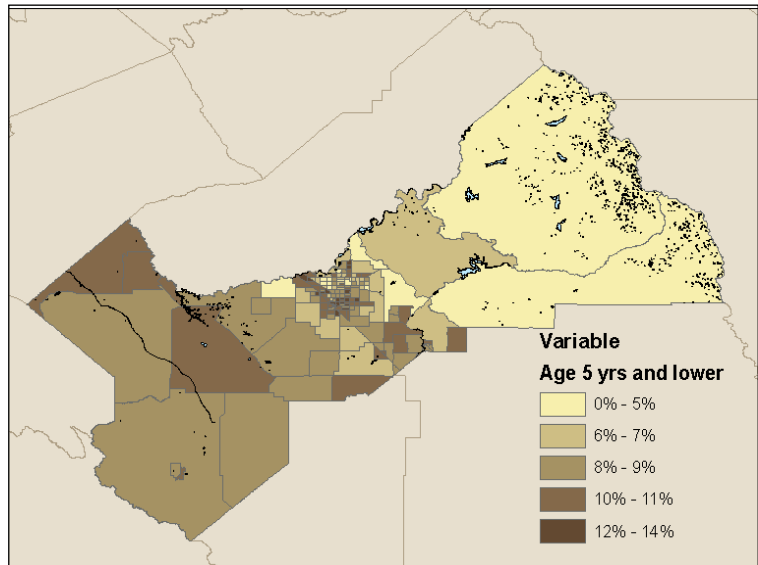


Figure 3: Children under 5 years old as percentage of total population (Source: Census 2000)

Countywide median per capita income in 2000 was estimated to be \$15,495. The central and eastern portions of the county have the highest per capita income, while the northwest and small pockets in the south-central region have the lowest average per capita income (Figure 4). In 2008, the Census estimated that 22.1% of the county's population was living below the federal poverty level, a figure considerably higher than the state average, which in turn is higher than the US average. There is little or no data available for the poorest populations of the county, including those that have makeshift homes (cooking over fire, using a hose for showering etc.). To the extent some of them are undocumented immigrants and workers, such data can be difficult to obtain.

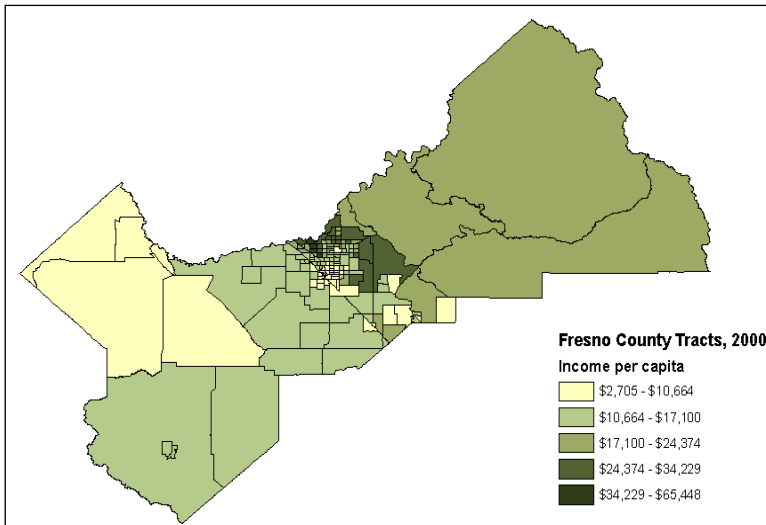


Figure 4: Per capita income by Census tract (Source: Census 2000)

What emerges from looking at the spatial distribution of income related information is that the highest concentration of low income and poverty can be found in the western region of the county. Part of the reason for high poverty in the county is the high proportion of low-wage workers, especially in this region. For example, many in agriculture depend on seasonal, low-wage jobs and collect unemployment during the off-season. Extreme poverty and generally low levels of wealth undermine the ability of families and communities to take proactive steps, and when disasters strike, they are largely dependent on support from outside (state and federal sources). Low income thus is one of the most important

indicators of limited adaptive capacity, and can be addressed through special needs-related programs or by creating opportunities for low-income populations to make a better living (e.g., through education and training programs, providing a living wage, diversifying the economy). These strategies are consistent with the Blueprint Vision of a prosperous Fresno County, based on world-class education, vibrant, attractive communities, and a more diversified economy.

Less Education Can Undermine Adaptive Capacity

Lower educational attainment often correlates with lower adaptive capacity to deal with extreme events. Possible connections between education and the ability to deal with disasters and change include

lower wage- and salary-earning capacity, and thus lower income; a lower capacity to obtain and understand emergency preparedness and response information, lack of access to health care, and various types of insurance (e.g., fire, flood, and health insurance), some degree of disenfranchisement from society etc. People with less education thus require a different level of attention and assistance from public agencies than those with greater resources of their own. Distribution of the percentage of people over 25 years old who have not graduated from high school is highest in tracts in the western

portion of the county, as well as some parts of the urban central region and in the southeast around Orange Cove.

Race and Environmental Injustice in Adaptive Capacity

Minority populations tend to have lower capacity for responding to disasters and adapting to climate change than non-Hispanic whites. The most likely reason for the correlation between race and lower adaptive capacity is the disproportionate amount of poverty and often lower incomes among African Americans and Hispanics compared to white segments of the population. In minority populations where English is not the first language spoken, linguistic proficiency can also play a role. Other factors, such as being tightly embedded in social

networks, may compensate to some extent. According to the census, high Latino/Hispanic populations reside throughout the entire western and valley portion of the county and southeast of the urban center to Orange Cove (Figure 6).

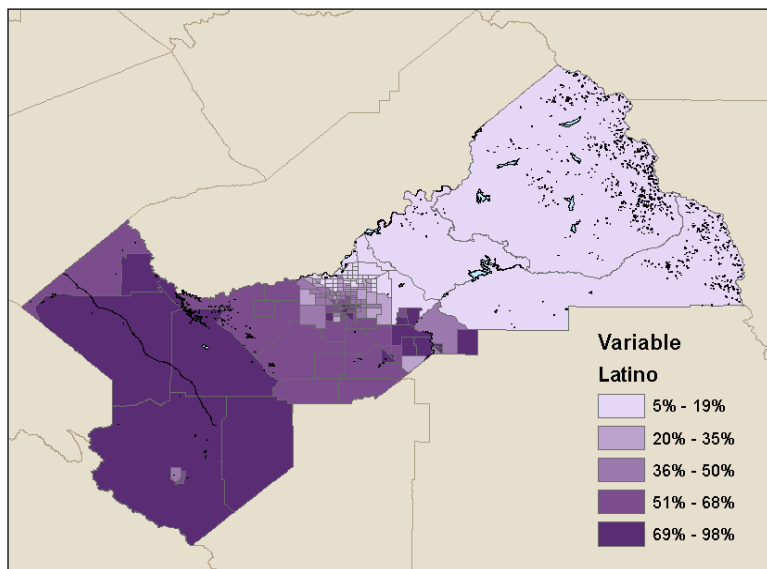


Figure 5: The geography of Hispanic/Latino populations in Fresno County by percentage of the total population. (Source: Census 2000)

Limited Mobility, Fixed Incomes and the Adaptive Capacity of the Elderly

Age can play a role not just in sensitivity but also in adaptive capacity. For example, the elderly are considered to be more vulnerable in emergency situations because of possible mobility challenges. Some may also depend on limited fixed income which restricts their ability to take proactive measures. Higher concentrations of people 65 years and older exist along the eastern portion of the county. In Sentinel, Shaver Lake, Prather, and other eastern towns near and in the Sierra Nevadas, the 2000 U.S. Census shows that more than 15% of the people living in this area fell into this age bracket. This region’s communities may be of particular concern during climate- and weather-related disasters (e.g., wildfires) because it is relatively remote, emergency response times are long (see below) and individuals themselves may be less mobile without outside assistance.

Renters with Limited Control over Housing

Housing also tends to be a factor in adaptive capacity. Home ownership versus renting with regard to adaptive capacity, indicates income status but also how much control individuals have over their housing, e.g., to make structural adjustments to their home for flood protection or insulation from heat, or whether they are able to modify vegetation surrounding the house (a form of protection from wildfire). There were an estimated 45% renters countywide, albeit with considerable variation.

Of Special Concern: Students and Institutionalized Populations

In studies of disaster vulnerability, university students have been found to be of particular concern, and sometimes special disadvantage. Students – especially those based far from home (especially foreign students) – tend to live apart from their families and to be disconnected from their resident community. Students also may not own vehicles and may have a lower response rate to public warnings about emergencies. While Fresno County’s college student population is not very large, it is significant enough to warrant special attention. As of fall 2009, 21,500 students were enrolled at CSU-Fresno. The majority of students (56% in 2007) are from Fresno County, 26% from other parts of the Central Valley, 15% from outside of the Central Valley in California, and the remaining 3% from outside California (elsewhere in the U.S. or international origins). The influence of isolation from family on student’s low adaptive capacity is magnified by another factor: students tend to be renters when they live away from their families and thus have lower control over their housing situation.

Pleasant Valley State Prison, just north of Kettleman City, has about 5,200 inmates. The prison is located adjacent to a high risk flood zone, and may be exposed to flooding during future high runoff or rainfall events. The emergency response capability of the prison should be reviewed in light of changing flooding risks under climate change.

Community Organizations and Social Capital: Enhancing Adaptive Capacity

Social groups can be important resources for communities in cases of emergency. They provide resources and support and can help increase public awareness about what households and communities can do to cope with and adapt to the impacts of climate change. Trustful social relations are among the most important immaterial resources during times of stress and change. Social groups can develop strategies for helping individuals and families to become familiar with the risks, take actions to reduce their exposure, assist targeted populations during emergencies (e.g., a social buddy system during heat waves), and support each other in the aftermath of disasters to rebuild and bounce back more quickly.

Fresno County is rich in social organizations, including clubs, interest-based associations, and religious communities. Some 55.5% of the population identifies as religious and over half the religious population is Catholic. The county has 40 rapidly growing Catholic congregations with a total of 232,565 adherents. The second most dominant religious affiliation is Evangelical Protestant with 94,156 adherents. Churches often serve as safe areas for evacuees in times of disasters, such as wildfires and flooding events. They provide emergency services, food, shelter, information, and social, emotional, and spiritual support. Some may be particularly well positioned to reach into otherwise linguistically or culturally isolated segments of the population (e.g., especially Catholic churches with high Hispanic/Latino membership may be able to help get information about disaster preparedness and coping strategies to Spanish-speaking community members).

In addition to churches, the county has many other organizations with the mission to help communities, advocate for certain populations, and provide support networks for the most vulnerable. These include, but are not limited to, Fresno Metro Ministry, Fresno Center for New Americans, Coalition for Clean Air, UC Coop Extension Young

Nutrition Education Program, Center for Economic Research and Education of Central California (research program, CSU-Fresno), California Rural Legal Assistance, and many more. These groups could play active and necessary roles as adaptation planning and the implementation of the Valley Blueprint move ahead.

Summary: Uneven Social Vulnerability

To synthesize the factors affecting vulnerability, 32 census variables commonly associated with low adaptive capacity and high sensitivity to climate-related impacts. The result is an integrated picture of social vulnerability across Fresno County (Figure 7).

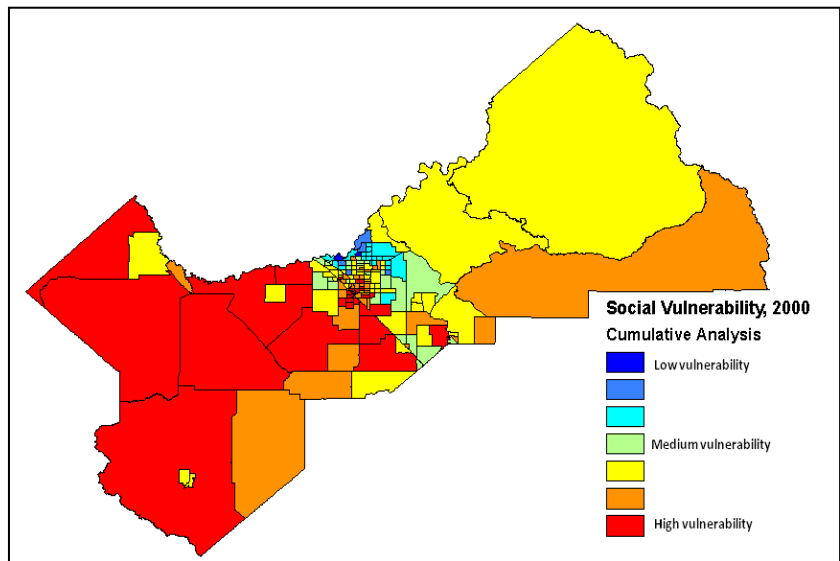


Figure 7: Social vulnerability map integrating 32 census variables associated with low adaptive capacity and high sensitivity to climate-related impacts. Areas determined as most vulnerable include nearly the entire western portion in the county, much of the urban area in the central region, and a large Census tract along the southeastern edge of the county (into the Sierra Nevada Mountains).

Based on this analysis, the most vulnerable populations are located predominantly in the western region, with some in the southeast also indicating medium vulnerability. The population in the western portion of the county is characterized by low educational attainment, high proportion of Hispanic/Latino people, high poverty and low income, high agricultural employment (low wages,

outdoor workers), high number of people per household, high proportion of people that speak English less than well, and a high proportion of the population with young children. This region is largely rural, with many communities residing in unincorporated parts of the county and therefore without access to many of the services commonly available in cities (such as central sewage systems or excellent health care facilities). These areas are also prone to street flooding or are downstream of inundation in cases of dam failure, the risk of which may increase with climate change due to the likely increase of higher runoff earlier in the year. The higher vulnerability on the southeastern side of the county reflects the relatively high proportion of low-income and elderly populations, which tend to be less mobile in cases of emergencies, dependent on fixed incomes, and more sensitive to extreme events. While this southeastern area is largely covering the foothills and mountains and therefore does not get the same heat extremes that the valley endures, this area is especially at risk of fire threats due to its steep slopes and forested terrain.

Economic Activities and Sectors

Fresno County's economy is dominated – in terms of employment – by service industries (retail, transport, distribution, food services, medical services, education, etc.) and agriculture with its related industries, such as food processing and packaging. Trades and government comprise other major employers in the county. In recent years, Fresno County has been hit especially hard by the economic downturn, with an unemployment rate (16%) that is substantially higher than the state's average (12%). Because of its particular sensitivity to changes in climate and its dominant importance to the economy of the county, we focus primarily on agriculture, with only cursory treatment of other sectors.

Agriculture

Fresno is the #1 agricultural county not just in California, but in the entire United States, with a total value of production in 2008 of over \$5.6 billion, an increase of more than 6% over the previous year. According to the 2007 U.S. Census, the county had nearly half of the county land area (48%) in farms.

Clearly, farming and agriculture-related businesses are dominant components of the local economy and are responsible for no less than one out of every three jobs. Fresno's agriculture includes a majority of conventional and a growing number of organic farms. While the list of major crops in the county is long, the ten highest ranked crops by dollar amount in 2009 were grapes, tomatoes, poultry, almonds, cattle, milk, nectarines, oranges, peaches and garlic.

Climate change poses a serious threat to agriculture for Fresno County. Temperature increases observed elsewhere have been partially masked in the Valley in the past few decades by cooling from irrigation. But the aerial extent of irrigation is expected to stabilize, and therefore will be unable to mask further increases. Thus, temperature increases and other climatic changes pose serious threats to the leading economic sector of the county, including:

- **higher temperatures**, including extreme temperatures, can negatively affect crop growth during various stages of their development, cattle and poultry health and reproduction, and can be dangerous to agricultural works;
- **reduced water availability** as a result of (a) the projected decrease in snowpack as more precipitation falls as rain than as snow and (b) higher temperatures leading to higher evaporation from reservoirs and soils resulting in reduced reservoir storage and generally drier conditions; any decrease in total precipitation as projected by the latest climate change projections for the state would only exacerbate these declines in water supplies;ⁱ
- **more intense downpours** can lead to fruit, vegetable and flower damage, more soil erosion;
- **increased water demand** by plants and animals (for drinking, cooling) as temperatures rise;
- **reduced number of chill hours** (with relevant temperature thresholds varying by fruit crop);
- less-well understood **effects on pollination**;
- **lower productivity of rangelands** for cattle; and
- **increased risk of pest infestations and spread of invasive plant species.**

One of the potential benefits of a warmer climate is that cold extremes and late winter and spring frosts – which can pose serious threats to

sensitive crops – will become less frequent (**Error! Reference source not found.8**). Many crops also respond positively to elevated carbon dioxide under lower levels of warming, but this beneficial effect on growth and yields is limited quickly by higher levels of warming and water or nutrient shortages.



Figure 8: Frost-sensitive crops such as cherries and oranges may benefit from the decreasing risk of late winter and spring frosts. (Photo: USDA)

Farmers' ability to deal with these climatic changes depends on a number of factors. Their particular vulnerability is a function of their exposure to these climatic changes, their sensitivity to those changes, and their adaptive capacity. Key factors include:

- location (e.g., valley or hills, exposure, soil types)
- types and diversity of crops grown and/or livestock raised
- current farming practices (e.g., soil and water conservation practices, organic/conventional farming) and willingness and ability to change these practices
- access to water resources, wells, and water rights
- access to native pollinators (particularly, native rather than European bees)
- financial resources to invest in technologies such as irrigation, cooling and farm equipment required for growing new/different crops
- dependence on income solely from farming vs. several income sources
- access to flood and drought insurance
- participation in farming cooperatives
- access to, and use of, climate-related information for advance planning
- access to labor markets, and
- market-, policy-related, or legal constraints.

In general, smaller farmers with fewer financial, technological, and water resources, and farmers with fewer or less flexible response options, limited crop diversity, fewer risk sharing opportunities, and greater dependence on farm income tend to be more vulnerable to climate change. In 2007, 59% of farmers in Fresno County owned 50 acres or less, thus could be considered relatively small farms. Just over 20% made up the larger farms with 180 acres or more.

The county's agricultural sector exhibits existing sensitivity to two main types of climate-related extreme disturbances: changes in temperature and potentially reduced water availability (Table 2, next page). For example, temperature changes will lead to higher temperatures and longer, more frequent extreme heat in the summer, but also lead to reduced chill hours in the winter. While spring frosts will become less frequent over time, they will still occur and potentially cause serious economic damage, especially if frosts are preceded by unseasonably warm temperatures that caused early blooming. For example, in 2006 Fresno County growers were impacted by cold and wet spring weather with an estimated \$21 million in losses. Increases in temperature during the winter and spring can lead to increases in pests and disease for crops since the warmer winters allow insects and pathogens to survive and reproduce more frequently.

In summary, Fresno County as the leading agricultural County in the state and country is most vulnerable in its leading economic sector: agriculture. Much of the crops and commodities produced are already heat-tolerant ones, thus further warming may exceed heat-tolerance for some crops and livestock. Given the dominance of the agricultural sector in terms of production value and employment, negative impacts on this industry will reverberate throughout the county and affect farmers, their employees (many of which are among the most vulnerable social groups), related industries, and consequently local government budgets. Thinking about adaptation in agriculture thus is not a luxury or task to be postponed to some future time, but is at the very heart of the county's economic vitality, and thus central to the implementation of the Valley Blueprint vision.

Table 2: Leading Crops in Fresno County: Vulnerabilities and Adaptation Needs



Photo: USDA

In 2007, grapes were the top crop the county in terms of the number of acres (215,170) and dollar value (over \$667 million) produced. Fresno ranks as the top producer of grapes in the state and the country. While grape varieties grown in the valley are adapted to high temperatures, unseasonably high temperatures at certain times in the year can undermine the quantity that can be produced.



Photo: Michael Favor, Wikimedia Commons

With a value of over \$500 million, almonds are the fourth highest value crop in Fresno County. Almonds require 100-500 chill hours between 14°F and 59°F to properly set buds; pistachios need 600-1,500 hours. The higher these numbers, the greater the chance that the warming climate may restrict productive harvests. Almonds are also particularly sensitive to nighttime warming in February (probably because low temperatures during the bloom season enhance pollination success). Perennial crops like almonds and nut trees are a major investment and varieties cannot be changed from one year to another. Adaptation will require selection of varieties requiring fewer chill hours, different placement and farming practices (e.g., irrigation method as almond trees require significant amounts of water).

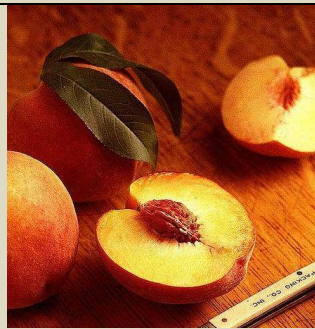


Photo: USDA

Fruit and vegetable crops will benefit from a longer growing season, but may be variously affected by increases in temperatures, especially extremely high temperatures, the general drying trend and related water shortages, as well as higher flood risks near rivers and streams. More heat-resistant varieties may be available, but vegetable crops grown in the Central Valley are already among the more heat-resistant. Other crops require long-enough periods of dormancy. Most varieties of peaches, for example, require between 400-800 chill hours, making those with higher requirements less viable in the long run. In addition, certain temperature ranges during particular months are critical for adequate development and ripening.



Photo: Unleo, Wikimedia Commons

At over \$500 million per year, poultry is the third highest valued agricultural commodity in the county. Chickens and turkey are especially sensitive to rising summer temperatures. The heat waves in 2006 and 2007 caused thousands of dairy cattle and poultry to die. Adaptive measures will need to be taken to prevent such massive die-offs and economic losses to farmers as climate change increases the risk of more frequent and more intense heat waves. Such measures might include providing cooling through shade, ventilation, or air conditioning (with increases in CO₂ emissions) or selecting even better heat-adapted varieties of turkeys and chickens. For farmers, this means higher production costs, and for consumer higher food prices.



Photo: "Tractorboy60", Wikimedia Commons

Annual cattle sales are valued at over \$301 million in 2009, making it the fifth highest value agricultural commodity in Fresno County. Climate change poses direct threats to this industry through heat extremes and higher demands on water resources, but also indirectly through changes to the quantity and quality (and thus price) of forage. Increased temperatures put cattle are at risk of mortality and reduce reproduction. To avoid these risks, farmers can keep cattle cool by hosing them off, providing shade, fans, or air conditioning (resulting in higher CO₂ emissions), although these adaptation options typically are labor intensive and/or require substantial economic resources. High temperatures also reduce milk production. In 2006, agencies provided disaster relief to the tune of \$16 million for lost milk production to Central Valley counties.

Service Industry

The service industry is next to agriculture the most important employer in Fresno County. The service industry employs approximately 26 percent of the nonagricultural wage and salary employment in Fresno County. It comprises work in retail, accommodation, food and cleaning services, administration, health care, education, and so on. While these jobs may not be directly dependent on or sensitive to changes in climate, the existence of a viable economy in the service sector depends on the level of diversification and development of the economy as a whole. In Fresno, there presently is a very high reliance on agriculture and related industries, and only limited diversity of other industries. Consequently, when agriculture suffers, so does the rest of the county economy. Moreover, many, though not all, of the jobs in the service industry are in the low-income category, leaving those dependent on them in an economically vulnerable position.

A limited number of service jobs are in the recreation and tourism sector. The county offers a variety of outdoor recreation opportunities (lakes for fishing, boating, swimming and water skiing; hiking trails, golfing, biking, hunting; skiing and snowmobiling in the mountains; and other outdoor sports activities). Many of these activities are dependent on environmental conditions (such as sufficient snow, comfortable outdoor temperatures, water temperatures required by recreational fishers, absence of health risks such as fire, air pollution, and insects), and thus will be affected by climate change in direct and indirect ways. As many of these activities take place on Federal land (1/3 of the county area is Federal), close collaboration on adaptation between local and Federal land managers will be critical.

Fresno also serves as a major gateway for Yosemite, Sequoia, and Kings Canyon National Parks (Figure 9). Yosemite received nearly 4 million visitors in 2009, and those coming from Southern California typically arrive through Fresno (Highway 168) to enter the park. Services to support these visitors are thus a part of Fresno's service sector economy. To the extent, climate change alters the desirability of these tourism destinations for outside visitors and as



Figure 9: Climate change impacting environmental conditions for recreation and the desirability of tourism destinations, as well as higher energy prices, may affect the service jobs in recreation and tourism in the county. (Photo: “Ngresonance”, Wikimedia Commons)

transportation costs increase, Fresno may experience some indirect impacts in this sector as well.

Supporting Infrastructure & Services

In support of people's daily life, well-being, safety, travel and participation in Fresno County's economic activities, cities and the County provide a variety of infrastructure and community services. Many of them are susceptible to being affected by climate change, both directly and indirectly. First and foremost is the provision of the most essential resource for both urban and rural areas: water. Water quality and supply issues are already high on the public agenda (as evident, e.g., in the 2010 Tulare Basin Conservation Plan Water Supply Strategies Report), and climate change will assure that they remain there. In addition, we will discuss wastewater management, transportation, emergency preparedness and response systems, and energy. The Valley Blueprint recognizes the all-important conservation and management of ecosystems for the goods and services underlying much of Fresno County's economy and quality of life. We refer the reader to the natural systems adaptation workshop and resulting report.

Water

Water management in California involves a complex mix of state and federal agencies, local, tribal and special district institutions, and private companies. Each has specific responsibilities around the three principle areas of water management: supply, quality (including wastewater) and flood control. One of the principal challenges Fresno will face in dealing with water management issues in the future is to foster effective collaboration, communication, and coordination among all these entities, given the absolute importance of water for the county economy and its people.

Water Supply

Water supply shortages are a serious problem for the county and under the modeled climate change impacts these shortages are projected to get worse. Between now and 2050, Fresno County expects a doubling of its population (i.e., more urban and residential water users) and continued productivity and growth in agriculture (the primary water user). Thus, even if climate change were not an issue, Fresno would face considerable challenges in meeting its water needs. Many communities rely on diminishing supplies of groundwater, while others rely on surface water stored in reservoirs that comes from the rivers fed by runoff from the Sierra Nevada Mountains. The City of Fresno, for example, relies largely on groundwater and its water basin level has already “dropped from less than 30 feet below the surface in 1930, to more than 128 feet below the surface in 2009” (Figure 60). As the water table sinks lower due to overdraft (taking out more water than is being naturally recharged), more electricity and deeper wells are required to pump up the water. Recognizing the costs of

overpumping groundwater, the City has implemented a water recharge program by purchasing water from Millerton Lake and allowing it to percolate back into the ground to help recharge the depleted groundwater basin. Until 2004, the city relied entirely on groundwater, but now has a facility providing up to 15% of the potable water (during peak summer season) from surface water originating from snowmelt from the Sierra Nevada running off into the Kings and San Joaquin Rivers.

Historical and recent experiences make clear that water supply shortages are already a serious problem for many regions in Fresno County. Most recently, in 2009, near the end of the multi-year drought, environmental needs for a federally listed endangered species, the Delta Smelt, led to extreme water restrictions in the Valley. Under the projected climate changes the county will experience a longer dry summer season, and generally drying conditions, especially from the middle of the century onward. In addition, climate change is projected to lead to a reduction in snowpack and earlier snowmelt. The region may also see fewer but more intense rainfall events. Currently, there is insufficient infrastructure to harness any surplus of water during wet years. Moreover, higher temperatures will increase evaporation from open water surfaces and soils, thus increasing the demand for water supplies (for irrigation) while groundwater, mountain snowmelt, and streamflow are expected to decline, especially when demand is highest. Furthermore, evaporation from irrigated soils can lead to damaging and costly problems with salinization (Figure 71).



Figure 6: Excessive use of groundwater over time has led to groundwater basin depletion and substantial subsidence of land. This 1977 photo shows how many feet the land subsided as a result of groundwater withdrawal in the San Joaquin Valley from 1925 to 1977. (Photo: USGS, 1977)

Clearly, the county is aware of the water shortage problems, especially in light of the growing demands from its growing population. In addition to recognizing current water shortage problems, it would be consistent with and necessary for successful implementation of the Valley Blueprint, if Fresno County communities would consider managing water in light of dwindling supplies (especially the decline of Sierra Nevada snowpack) and the increasing energy demand for pumping groundwater up from ever-greater depths. Because the county's water system and economy depend so tightly on limited water supplies and require substantial energy to function, Fresno is highly exposed to the impacts of climate change and to those of the state's greenhouse gas reduction policies (Figure 82).



Figure 71: In hot climates such as the inland Mediterranean climate experienced in the Central Valley, irrigation of agricultural crops is commonplace. Salinization of irrigated soils – as a result of water evaporating while salts remain in the soil – can be an undesirable and costly side effect. (Photo: USDA)

Flood Control

A complex system of flood control facilities operated by local, state, and federal agencies is involved in the strategic management of reservoir storage and releases and the use of canals to reroute stormwater around urban areas in case of imminent risk of flooding. If winter and spring runoff pulses increase in the future, while water storage for the long dry summer months becomes even more pressing, reservoir and flood managers will be increasingly hard-pressed to balance the costs, benefits, risks,

and trade-offs between too little water when it's needed, and too much water, when it's not.

Regionally, flooding risk varies across the county. The western part of the county, which is mostly used for agriculture and grazing and generally sparsely populated, drains many streams off the eastern slope of the Coast Range toward the Fresno Slough on the valley floor. In the central part of the county – the most urbanized and populated region – the major flood issues are associated with the San Joaquin and the Kings Rivers and their tributaries. Several smaller reservoirs and flood detention basins as well as three major dams have been built to control flows on these rivers, including Friant and Mendota Dams (San Joaquin) and Pine Flat Dam (Kings). Numerous roads are subject to street flooding during heavy rains. The County is well aware of its flood risks, yet again, may need to augment its planning efforts by monitoring changing flood risks over time, as well as consider the additional risks of bigger floods in some years as it permits more building and development in flood-prone areas over the coming years. While fewer people live on the eastern side of the county, this region contains watersheds that contribute significantly to flooding potential on the valley floor.

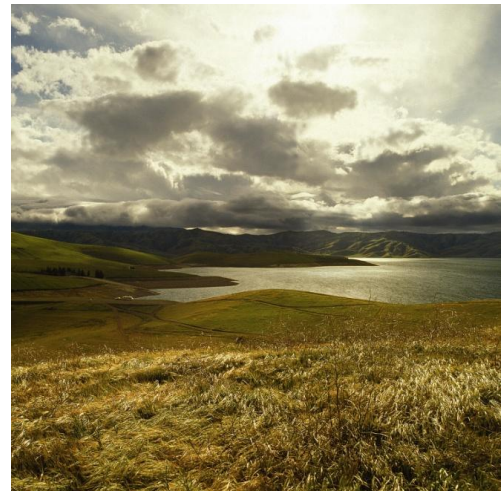


Figure 82: San Luis Reservoir is one of the important water sources for supporting irrigation in the western portion of Fresno County. A mix of surface and groundwater resources will be essential to meet Fresno's water needs. Higher temperatures will extend the summer dry period, evaporate more water from surface sources such as reservoirs, and increase the demand for water. (Photo: CA DWR)

Emergency Preparedness and Services

Well functioning emergency plans, preparedness, response services and careful recovery planning are critical for regional and community resilience. **Error! Reference source not found.**3 lists a number of significant disasters that Fresno County has experienced in recent decades. Most of them are weather-related, though the list underestimates the actual occurrence of weather-related damages as droughts and extreme heat events are not included. Climate change is expected to decrease late-spring freezes and increase the number of climate- and weather-related extreme events, such as wildfires,

droughts, flooding and heat waves, thus increasing the demand for emergency services. Over time, this implies a need for increasing budgets and contingency planning so as to be able to respond effectively.

Drought

The recent multi-year drought (2007-2009) illustrates the enormous importance and potentially severe economic and social impacts that such “slow-onset” disasters can have (see the discussion of additional impacts in the section on agriculture above). Past droughts in Fresno have led to water

shortages for agriculture, urban areas, increased wildfire risk, restricted outdoor use of water for residences, and even a food crisis for those unemployed.

The Fresno County Office of Emergency Services provides links to educational materials on how to respond to heat and cold waves, storms, flooding, wildfires, and other hazards. The County does not currently explore the implications of climate change, and an important opportunity exists here to update existing plans, and strategically consider and plan for the financial and social implications of more frequent weather-related disasters.

Table 3: Significant Disasters in Fresno County since 1972

Hazard Type	Disaster #	Year	State Declaration	Federal Declaration	Location	Damage*
Freeze and Severe Weather Conditions	--	1972	4/17/72	--	Fresno County (and 16 other counties)	\$111,517,260
Drought	--	1976	2/9/76	--	Fresno County (and 30 other counties)	\$2,664,000,000
Rains Causing Agricultural Losses	--	1982	10/26/82	--	Fresno County (and 10 other counties)	\$345,195,974
Winter Storms	DR-882	1982/1983	3/15/83	2/9/83	Fresno County (and 43 other counties)	\$523,617,032
Coalinga Earthquake	DR-882	1983	5/02/83	5/3/83	Fresno County	No deaths 47 injuries \$31,076,300
Storms	DR-758	1986	2/26/86	2/18/86	Fresno County (and 38 other counties)	13 deaths 67 injuries \$407,538,904
Wildland Fires	--	1987	9/03/87	--	Fresno County (and 23 other counties)	3 deaths 76 injuries \$18,000,000
Freeze	DR-894	1990	1/11/91	2/11/91	Fresno County (and 32 other counties)	\$856,329,675
Late Winter Storms	DR-979	1992	1/21/93	1/15/93	Fresno County (and 23 other counties)	20 deaths 10 injuries \$600,000,000
Severe Winter Storms	DR-1044	1995	1/17/95	1/13/95	Fresno County (and 44 other counties)	11 deaths \$741,400,000
Late Winter Storms	DR-1046	1995	--	1/10/95	Fresno County (and all other counties except Del Norte)	17 deaths \$1,100,000,000
January 1997 Floods	DR-1155	1997	1/5/97	1/4/97	Fresno County (and 46 other counties)	8 deaths \$1,800,000,000
Severe Winter Storms and Flooding	DR-1203	1998	--	2/9/98	Fresno County (and 39 other counties)	17 deaths \$550,000,000
Freeze	DR-1267	1998-1999	--	2/7/99	Fresno County (and 7 other counties)	--
Severe Freeze	DR-1689	2007	--	3/14/07	Fresno County (and 11 other counties)	\$1,400,000,000

Source: California Governor's Office of Emergency Services, www.oes.ca.gov/
*Damage amount and deaths and injuries reflect totals for all impacted counties

Levee and Dam Failure

Climate change is projected to intensify the hydrological cycle and thus lead to an increase in intense downpours in California, even if the overall amount of precipitation changes little or decreases somewhat toward the end of the century. Three types of flooding can occur in Fresno County: localized (street flooding from large amounts of surface runoff), riverine flooding (see Flood Control section above), and dam failure. Several road areas in the county flood regularly and require regular flood signage in the roadways.

The 2008 Fresno County Local Hazard Mitigation Plan (LHMP) notes that Fresno County's vulnerability to dam failure is high with a "highly likely" probability of a dam failing in the future. Even without more refined climate projections for rainfall for the county, statewide studies anticipate more extreme/severe rainfall from storms, as well as higher runoff from the mountains in the winter and spring; therefore flood managers should expect an increased risk of dam breaks. According to the 2008 LHMP, all 23 dams in or upstream from the county "present a significant safety risk to downstream populations if one or more were to fail", but four in particular pose the greatest threat: Big Dry, Fancher Creek, Friant (which would result in inundation of significant portions of the City of Fresno), and Pine Flat. A catastrophic failure of any of these dams would likely result in loss of life and property.

Ensuring that dams and levees are maintained to meet safety standards as rainfall patterns and runoff change in the future, requires coordination among a significant number of public agencies and private land owners. As of 2007, there were 37 levees on private land across the county that were deaccredited, typically because the owner did not intend to seek certification/accreditation. Especially along the Kings River, many levees did not meet the requirements to gain certification.

Wildfire

Wildfires are a hazard of major concern in Fresno County, particularly in the mountainous regions in the eastern county, and some higher-elevation areas in the western Coast Range (Figure 103). Wildfire risks across the county will not only increase because of climatic changes (higher temperatures, general drying trend), but also where and when development increases at the wildland-urban interface. Second-home development in the foothills of the Sierra Nevada and the Coast Range are of particular concern in this regard.

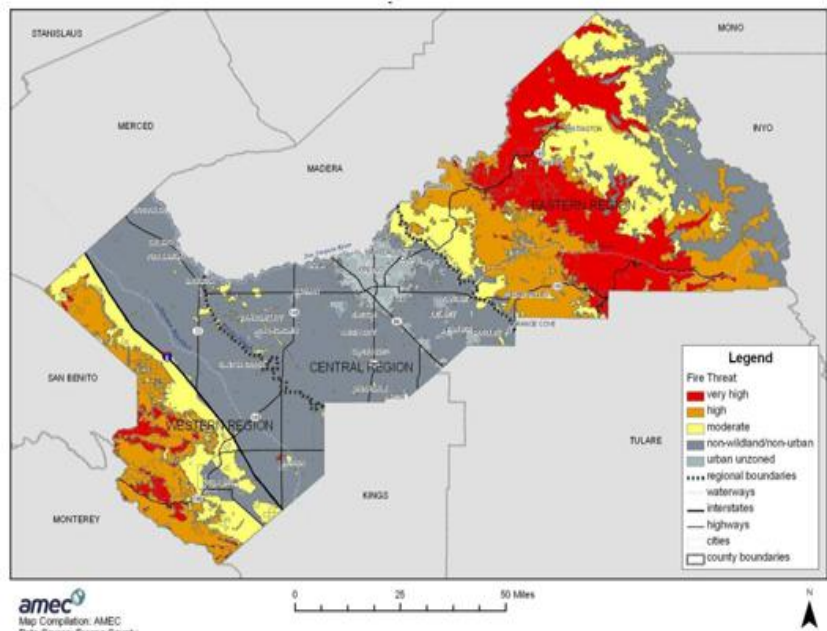


Figure 93: Map of fire hazard zones in Fresno County (Source: Fresno County Multi-Hazard Mitigation Plan 2008, Figure 4.40)

The risk of fires is greatest between June and October when humidity is lowest, vegetation is dry, and temperatures are hot. Not only do wildfires require a large amount of financial and human resources to fight, they also put people, important infrastructure and residential development, as well as species, ecosystems and the goods and services they supply (e.g., slow water infiltration, protection against soil erosion and landslides, water supply, timber, rangeland, aesthetic and recreational value of forest landscapes) at risk.

Of particular concern in water-scarce Fresno County – especially during already dry years – are the enormous water resources required to fight fires (see also Water Supply and Drought sections above)(Figure 104).



Figure 104: Fire fighting consumes large financial, human, and water resources. During already dry periods, when fire risk is highest, potentially difficult tradeoffs have to be made between water for human and agricultural uses versus fighting fires. (Photo: US Navy)

Landslides

Landslides often follow heavy rains, especially in areas previously affected by wildfires and in mountainous terrain where soil is exposed to heavy rains. Given that both wildfires and the severity of heavy rain events may increase with climate change, landslide risks may also increase. Currently the highest risks for landslides are in the western part of the county, in the coastal range, where runoff from the region’s many streams can be high, but fortunately population density and urban development is relatively low there. Again, careful monitoring of changing climatic patterns, cautious soil management, and care in development of high-risk landslide areas (e.g., housing, roads and other infrastructure) are relevant adaptive measures.

Transportation Infrastructure

The main transportation infrastructure of the county – its roads, airport, and railway – is in various ways susceptible to the impacts from climate change. Transportation routes in the county are exposed to several climate related risks, including:

- heat extremes,
- flooding,
- increased wildfire, and
- associated problems with soil erosion, sedimentation, and landslides).

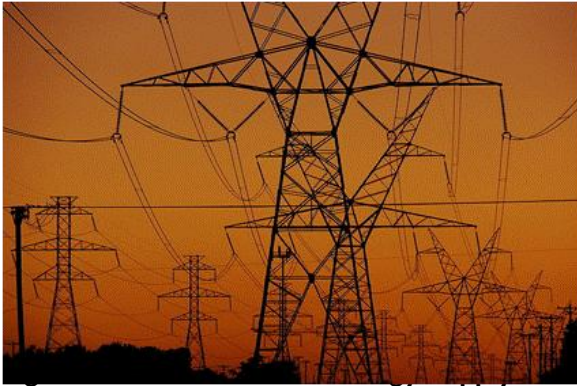
The main transportation routes in the Valley are at greatest risk, given their location downstream of reservoirs or adjacent to the county’s rivers. Increased severity of heat extremes can damage existing roadways and railways (e.g., by increases in so-called "blowups" – sudden cracking and tilting of pavement slabs). In the past, wildfires have led to closures of important evacuation routes (e.g., Highway 168 in the Big Creek Wildland fire in 1994) and climate change is projected to result in more fires in the region (with resulting higher costs for emergency repairs). Good maintenance of road infrastructure is thus integral to, and essential for, the county’s ability to provide emergency services to its residents and is at the heart of maintaining the infrastructure that supports a vibrant economy. Failure to monitor, maintain, and adapt transportation infrastructure will undermine the ability to respond effectively to emergencies.

Energy

Energy-related infrastructure is another important lifeline for the county. Given Fresno County’s inland Mediterranean climate, with its very hot summers and cold winters, residents rely heavily on energy to maintain comfortable indoor temperatures. Moreover, agriculture and related industries are major consumers of electricity used. Together, farmers and food processors consume a total of 6% of the state’s electricity. Currently, the county’s energy comes from natural gas, coal, nuclear, hydro and other renewable sources. There are several ways in which climate change will impact both the production of energy and the demand for energy. In short: Demands on energy supply will increase while energy supply sources will be stressed by climate change (5).

Both the county’s Valley Blueprint and the City of Fresno’s “Green Strategy” lay a foundation for building a more sustainable region and city, including using energy and other resources more efficiently.

Foundations like the Valley Blueprint and the Fresno Green Strategy illustrate how harmonized strategies can meet the mutually enhancing objectives of greater energy security, fewer greenhouse gas emissions, and better protection against the negative impacts of climate change.



Fresno County will increase while energy supply sources will be stressed by climate change. The resulting economic impacts may hit low-income populations hardest. (Photo: D. R. Tribble, Wikimedia Commons)

Conclusions

Climate change will impact Fresno in a variety of ways, some potentially severe, with direct impacts on its people, its all-important agricultural sector (and related economic activities), its supporting infrastructure and services, as well as the natural environment on which much of the county's economy, rural character, and quality of life depends. The impacts will differ based on current and future vulnerabilities to weather- and climate-related changes. A clear picture of social and economic vulnerabilities emerges here, one characterized above all by the large dependence of the county's economy and population on the highly climate-sensitive agricultural sector. Thus, the most critical vulnerabilities include:

- Significant social vulnerabilities, particularly among the poor, the elderly, infants, socially and culturally isolated individuals, and outdoor workers, who already do and – absent concerted interventions – will experience the greatest exposure, the highest sensitivity and the lowest adaptive capacity in the face of climate change.
- The singularly most vulnerable portion of Fresno County's population is the low-income,

Latino/Hispanic population, especially those also employed in the most vulnerable economic sector: agriculture. This population is predominantly located in the western and central part of the county. Diminished public health and limited access to health care and other social services can aggravate the situation.

- The county's leading economic sector – agriculture and associated industries – is most vulnerable to climate change due to its dependence on sufficient water resources, particular temperature regimes, and the absence of extreme events (e.g., droughts or floods). Small farmers and those with less diverse crop and livestock systems and limited resources to invest in adaptive technologies will be most vulnerable to the impacts of climate change.
- Crucial supporting infrastructure and services will experience greater demands as climate change-related risks grow, including for already scarce water supplies, emergency preparedness, response and recovery services, transportation, energy and infrastructure. Water cuts across all of these: As runoff of snowmelt comes earlier in the year, potentially coinciding with winter rains, flood risk increases. At the same time, water storage for the long dry summer becomes more pressing. Water managers will be increasingly hard-pressed to balance the costs, benefits, and risks between too little water when it is most needed, and too much water, when it is not.

Clearly, the county faces growing challenges that can be surmounted, but only with timely and adequate planning and preparation. While difficult choices will need to be made, city and county governments can integrate many precautionary adaptive measures into their ongoing efforts to implement already existing plans, such as the Valley Blueprint, Fresno Green, and others. Many of these measures can be implemented on regular maintenance, upgrading, planning, and budgeting cycles. They will bring benefits to the county's residents, its quality of life and natural environment, its fiscal situation and its economy overall. Thus, developing adaptation plans and implementing agreed-upon measures is directly in support of Fresno County achieving its vision of a vibrant, prosperous and sustainable future.

Acknowledgments

The preparation of this report was supported through a grant from the Kresge Foundation to the Local Government Commission. This report benefited from review comments by Holly King, Dr. Marni Koopman, Kate Meis, Rocky Rodgers, and others received at the Stakeholder Workshop in Fresno on September 23, 2010. Responsibility for the final content of this report remains solely with the authors.
