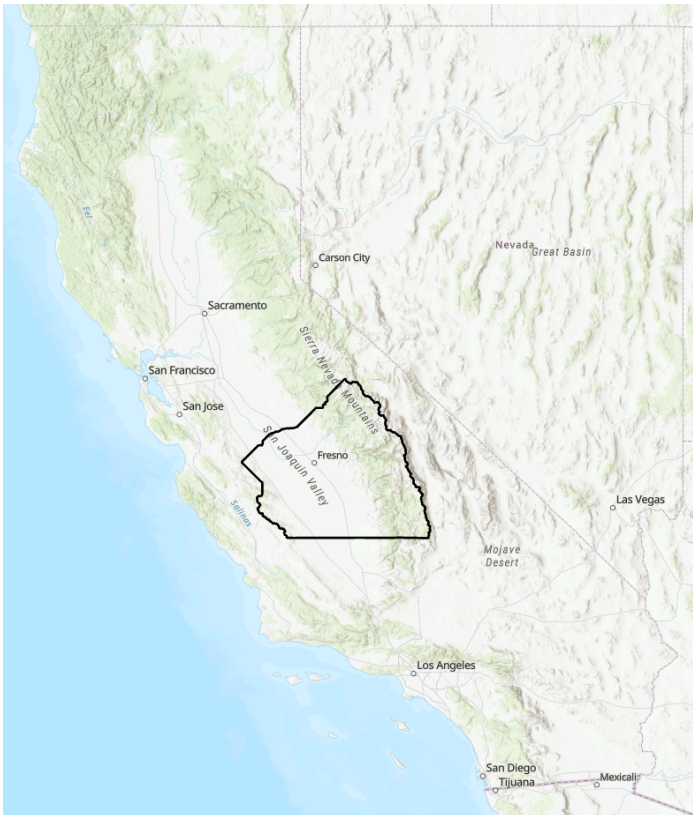
Central San Joaquin Valley Regional Vulnerability Assessment Against Extreme Heat and Flooding

Joshua Kim, Heeseung Sa, Angela Chan, Hugo Sappington, Theo Wyss-Flamm



(1) Executive Summary

- Using various datasets and analyzing them through ArcGIS and Python geopandas tools, we looked into the Central San Joaquin Valley's regional vulnerability against floods and extreme heat.
- Using the 5 major components each with 3 indicators, we identified vulnerabilities and relations between these natural hazards and indicators within our region.
- From our analysis, we saw agricultural, healthcare, and food industries to be potentially affected by these natural hazards as crop yield can decrease, healthcare can become paralyzed, and the hospitality industry can be displaced.
- Based on our analysis, we identified low-income, high ozone, high PM2.5, and high drinking water contaminants percentile to be especially susceptible to these hazards and found 6 communities (zip codes) that matched this criterion.
- The 6 communities were predominantly Hispanic (over 85%) with a small elderly population (~8%) with poverty levels above the 97th percentile.
- For people in this area, poverty disables/discourages them from utilizing cooling resources, and bad surrounding environments worsen their health conditions to make them more vulnerable to extreme heat and floods.

(2) Introduction

The focus of this report is a data-driven analysis of the resilience of the Central San Joaquin Valley amidst flood and heat. The Central San Joaquin Valley, or 'CSJV,' is composed of four counties: Madera, Kings, Fresno, and Tulare. Averaging across all counties, this analysis understands the region could benefit from various programs to promote environmental resilience against extreme heat and flood through policy. Most broadly, our policy recommendations reduce carbon emissions, increase the incomes of the least wealthy, improve access to spaces with safe climatic conditions, and encourage development to avoid flood plains. These policy recommendations emerge from an analysis that yielded a view of a region with immense inequality. Key communities in need of climate justice were intersectionally impoverished and Hispanic, primarily housed in regions whose unhealthiness was compounded by poor air quality, high heat, and rampant flooding. One condition that provokes numerous key challenges that are addressed by our policy recommendations is the uneven development of the region, which has concentrated low-income households into areas of toxic air and flood risk. Inevitably the region will be susceptible and fragile amidst climatic hazards due to one of its core agrarian economies. To perform our analyses, we studied and formatted a diverse breadth of data systems, mediated in ArcGIS and using Python geopanda tools. Further, we clarified our findings and improved their articulation through graphic representations, from maps to charts.

(3) Data Collection and Analysis Methodology

To measure factors related to the economic stability and social structure of the CSJV region, we employed the Living Wage Calculator, the FEMA National Risk Index, the EJScreen data set (created under the U.S. Environmental Protection Agency), and the CalEnviroscreen 4.0 Dataset. For all of these data sets, we were impressed with the comprehensiveness of each source and the amount of data available. The CDC Social Vulnerability Index (SVI) data set proved to be one of the most excellent data sources for us, as it was both easy to navigate and it provided both usable raw data, and well-defined indices that moved our analysis forward.

When measuring factors related to the environmental sustainability of the region, we employed the California Department of Water Resources Crop Mapping data set, the FEMA Flood Hazard data set, the I17 California Jurisdictional Dams data set, and the UCLA Heatmaps Excess Emergency Department Visits data set. The I17 CA Jurisdictional Dams source includes all of the California dams under the DWR's jurisdiction. Within the CSJV region, there are a total of 58 dams recorded. The UCLA Heatmaps data set was used to map the quantitative effects of extreme heat per zip code in our area but is limited in use as a proxy due to each zip code having a different population count and thus access to hospitals (or Emergency Response) centers nearby.

Measuring access to resources, we employed the Food Access Research Atlas data set from the USDA Economic Research Service, together with the EJScreen data set and CalEnviroScreen 4.0 data set mentioned above. The Food Access Atlas data set includes the actual counts of people and their share of the total population, regarding proximity to supermarkets, race, and income level, based on each census tract. Although it provided comprehensive information, there was plenty of missing data which made the visual analysis difficult.

While many comprehensive data sources progressed our analysis of climate risks in the region, an additional data set that would enhance our analysis even further would provide insight into the widespread access to air conditioning units, which would help us understand the widespread access to resources required to withstand extreme heat conditions. Additionally, we would have benefitted from a data set that provides an overview of soil property in the region to better understand how flooding and related climate risks will impact the environmental sustainability of the CSJV as a whole.

(4) Vulnerability and Resilience Assessment

(4-1) Economic Stability

This survey of the economic stability of the four counties that make up the CSJV permits some useful generalizations. The Healthy Places Index reveals that almost 50% of the population of the CSJV is impoverished, (FIGURE 1).[1] This analysis will unpack the economic condition of mass impoverishment in terms of three indicators: the local average income necessary to achieve

[1] A rough average of specific numbers: Madera: 42.7%, Kings: 43.1%, Fresno: 45.1%, Tulare: 50.1%, https://map.healthyplacesindex.org/?redirect=false

"basic needs,"[2] three average, annual, industry-specific salaries that fall below the line of basic needs, and the percentage of employed persons in the CSJV within these three industries.

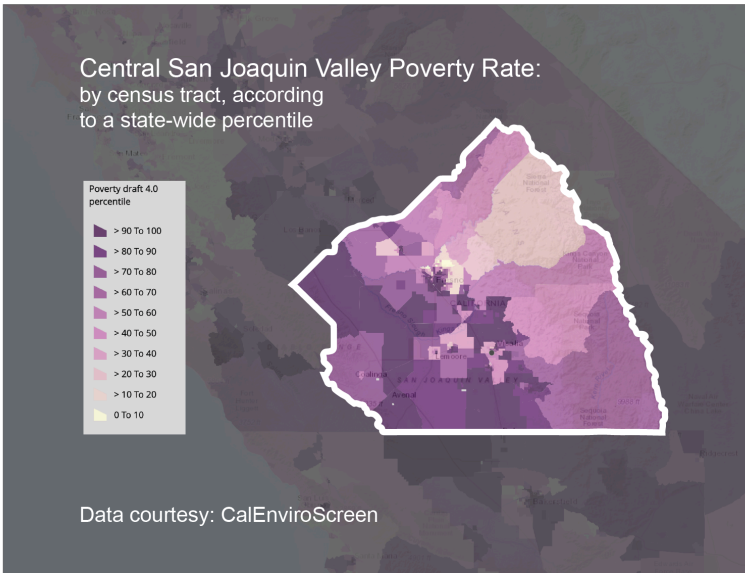


FIGURE 4.1.1, CENTRAL SAN JOAQUIN VALLEY POVERTY RATE

We can identify the social groups who are invested in industries categorized as in most financial stress with the Living Wage Calculator. Averaging the 4 counties that compose the CSJV, an average income of ~$47,000 is required to meet all costs associated with "basic needs."[3] However, average annual salaries for individuals working in Farming/Fishing/Forestry, Food Preparation and Serving, and Healthcare support, all fall below 38,000 USD.[4] The people working or depending on others working in these three industries can be considered our most economically at risk. Census data within CalEnviroScreen further reveals a majority of residents of the region are employed within one of these three sectors, 5.9%, or 53,700 in Accommodation and Food Services (equivalent to Food Preparation and Serving), 2.10%, or 20,897 in Agriculture, Forestry, Fishing and Hunting (equivalent to Farming/Fishing/Forestry) and 25.51%, or 113,119 in Health Care and Social Services (equivalent to Healthcare support).[5] As a collective, this roughly constitutes the 32.51% of households in the CSJV below the poverty line – many of which are essential workers who uphold vital industries.

Scaling out, the FEMA National Risk Index provides solid theoretical numbers for the economic losses incurred within the CSJV if there were to be significant Riverine Flooding. The CSJV is categorized as high risk, averaging Risk Index scores across its four constituent

---

[2] Basic needs / Typical expenses is calculated according to location and family size, a sum including values for categories: food, child care, medical, housing, transportation, civic, internal & mobile, other and annual taxes. https://livingwage.mit.edu/counties/06107

[3]

[4] For Madera: 49,430, / >38,000, Kings: 46,431 / >38,000, Fresno: 46,548 / >38,000, Tulare: 45,502 / >38,000. Furthermore, in each instance, >38,000 translates more specifically to within the range of 35,000 to 37,900: https://livingwage.mit.edu/counties/06031

[5] https://properties.zoomprospector.com/california/community/Central-San-Joaquin-Valley-CA-/r1703/business

counties, it ranks in the 97.6275 percentile. In the event of Riverine Flooding to the degree of intensity that is estimated, the industry-indiscriminate sum of economic loss across the CSJV is equal to $76,052,892.[6] On the other hand, if there were to be a Heat Wave, the CSJV is categorized as at high risk, averaging Risk Index scores across its four constituent counties, it ranks in the 99.1325 percentile. The predicted industry-indiscriminate sum of economic loss across the CSJV is equal to $68,568,630.[7] The massive economic losses predicted for the event of a climatic disaster would not only crash the economy but would severely threaten the health and livelihood of individuals working in these sectors.

(4-2) Social Structure

To consider the impact of extreme heat and flooding on the population of CSJV, the following indicators were measured to determine how different population groups would be impacted: household size, household income, and ethnicity distribution (both generally and for the elderly population).

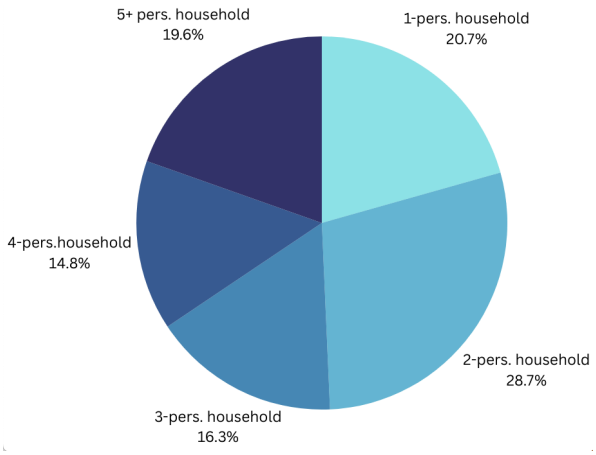


FIGURE 4.2.1 AVERAGE HOUSEHOLD SIZE

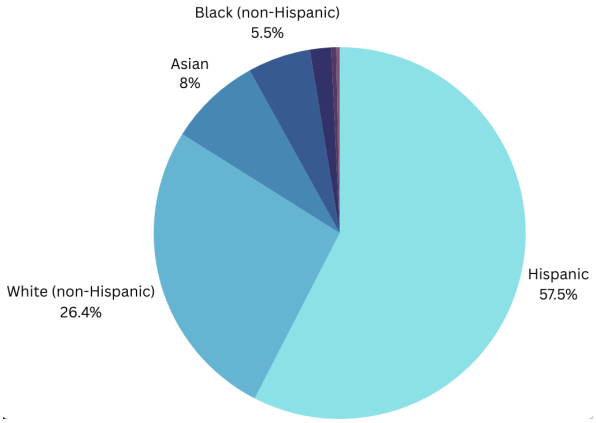


FIGURE 4.2.2 ETHNICITY DISTRIBUTION

According to the GoBiz Community and Place-based Data Tool, the highest percentage of household size in the CSJV is a 2-person household, at 28.65% of the region's housing population. Single-resident households make up 20.65% of the population, followed by 5+-person households at 19.6% (Figure 4.2.1). These three household sizes are the most common in the region, and thus most impacted by climate hazards in the area. When household income levels are segmented, it is clear that there is a dramatic distribution across income groups. While 33.69% of the households have an average income of over $100k, there is an even distribution

[6] Utilizing a self-generated report, we can visualize how each of 4 constituent counties might be effected by relevant climate and other hazards. https://hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06039,C06019,C06107,C06031#SectionExpectedAnnualLoss

[7] Utilizing a self-generated report, we can visualize how each of 4 constituent counties might be effected by relevant climate and other hazards. https://hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06039,C06019,C06107,C06031#SectionExpectedAnnualLoss

across each $10k income range from <$10k to $60k. This range indicates a wide span of median household incomes across the region, pointing back to the vulnerability of these lower-income households, of various scales, against climate hazards.

The large majority of ethnic distribution in CSJV is of Hispanic origin, at 57.52% of the total population. The next most-represented ethnicity is of White (non-Hispanic) origin, at 26.35%, followed by Asian (non-Hispanic) origin, at 8.01% (Figure 4.2.2). According to the FEMA National Risk Index, the four counties collectively rank "Very High" in terms of Social Vulnerability and rank "Very Low" in terms of Community Resilience.[8] The detrimental effects of these FEMA scores directly impact the demographic groups that are represented in the region, of which the majority are Hispanic, White, and Asian.

Indicators	Fresno	Kings	Tulare	Madera
% Population 65+	45	58	47	35
% Population 85+	39	52	41	46
% 65+ Live Alone	41	52	43	44
% 65+ <Poverty	**8**	16	**7**	11

TABLE 4.2.1: COUNTY RANKINGS ON KEY DEMOGRAPHIC INDICATORS[9]

When considering the impact of extreme heat in the CSJV region, it is important to recognize that elderly people are at higher risk of having consequential health issues and/or barriers to accessing sufficient cooling resources. As evident in Table 4.2.1, Tulare and Fresno counties respectively rank 7th and 8th, out of the 58 counties in California, as having the highest percentage of elderly living below the poverty line.[10]

(4-3) Public Health

To analyze public health performance in CSJV, air pollution, the percentage of population uninsured, and home overcrowding were studied as indicators for the overall public health status and resilience of the region. These indicators are considered significant by the CDC because they "address determinants of health that promote quality of life, healthy behaviors, and healthy development across all life stages."[11] Furthermore, these indicators' co-location with heat and flooding hazards was considered to understand how they intersect with the looming climate crisis. This data was gathered from FEMA's National Risk Index, the EPA's EJ screen, and the

[8] https://hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06019,C06039,C06031,C06107
[9] California Association of Adult Day Services (2002). https://chhs.fresnostate.edu/cvhpi/documents/aging-report.pdf
[10] https://chhs.fresnostate.edu/cvhpi/documents/aging-report.pdf
[11] https://www.cdc.gov/nchs/healthy_people/hp2020/hp2020_indicators.htm

CDC's Social Vulnerability Index, all reputable government agencies with sophisticated data tools that use raw data from a variety of sources to generate indices from the pooled data.

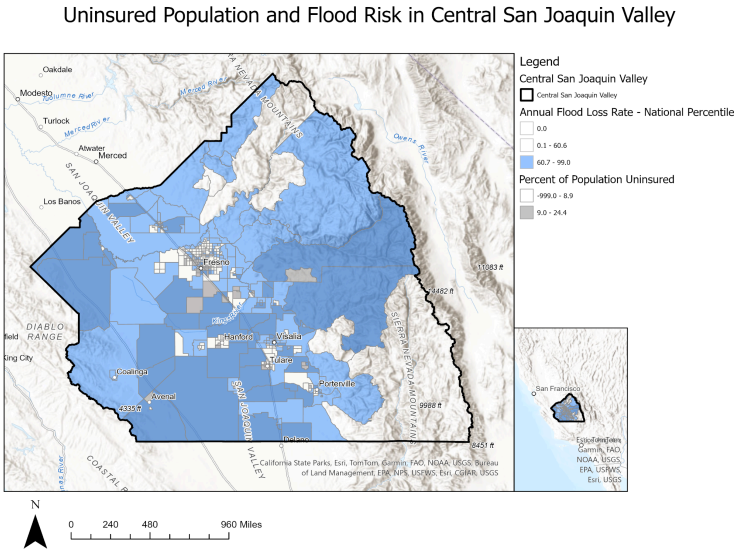


FIGURE 4.3.1 REGIONAL FLOOD RISK AND UNINSURED RATES

Uninsured status is pervasive in CSJV. Statewide uninsured rates are around 9%, but as can be seen in the figure below, much of CSJV's census tracts have much higher rates. This leaves residents vulnerable to sickness or injury and can exacerbate difficulties derived from already unsteady social standing. When flood risk is overlaid with uninsured rates, it can be seen that climate vulnerability frequently converges with this negative public health indicator.

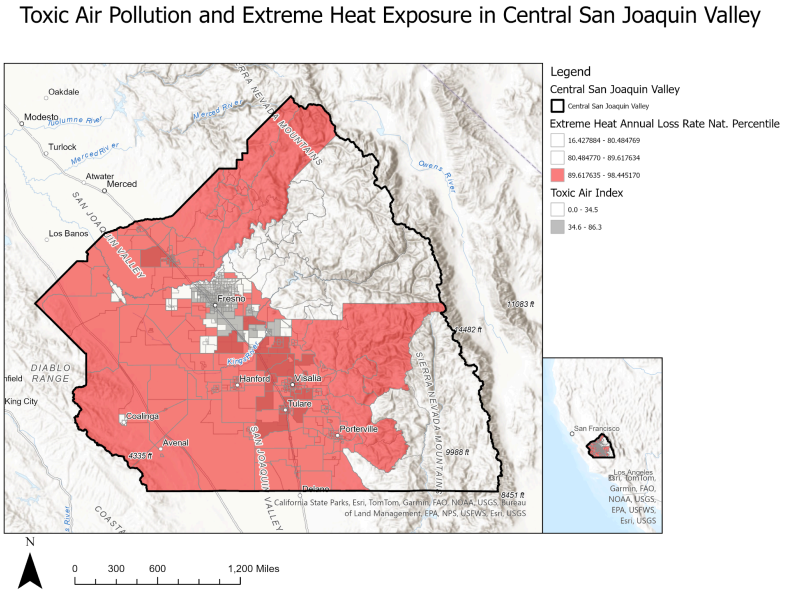


FIGURE 4.3.2 REGIONAL AIR POLLUTION AND HEAT EXPOSURE

EJScreen's Toxic Air Index can be seen overlaid with extreme heat risk data which shows the intersection of these two problematic environmental and manufactured indicators. With many census tracts falling into the upper tier of both of these indices, CSJV can be considered extremely vulnerable to extreme heat and respiratory issues.

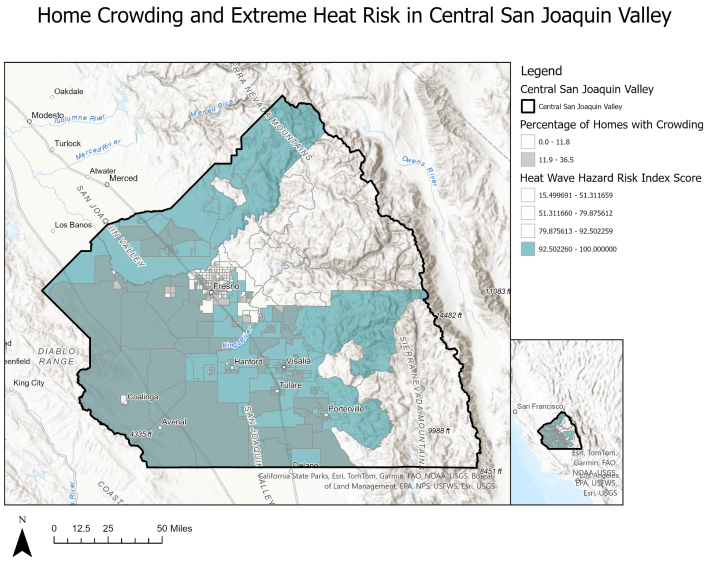


FIGURE 4.3.3 REGIONAL CROWDING AND HEAT RISK

Home crowding rates indicate the comfort and health of living conditions in the population. Depending on climate factors, among others, home crowding health can be greatly exacerbated by extreme heat hazards that are extremely common in CSJV.

These three indicators reflect poorly on the state of climate justice in CSJV because those that are most impacted by flooding and extreme heat are also those greatly affected by negative public health indicators.

(4-4) Environmental Sustainability

We utilized three indicators to look at environmental sustainability against floods: landslide vulnerability, dam locations, and crop mapping datasets. These datasets were obtained from the California Department of Water Resources (DWR) and were used together with FEMA's flood hazard dataset to assess vulnerabilities and relations in the CSJV region to flooding.

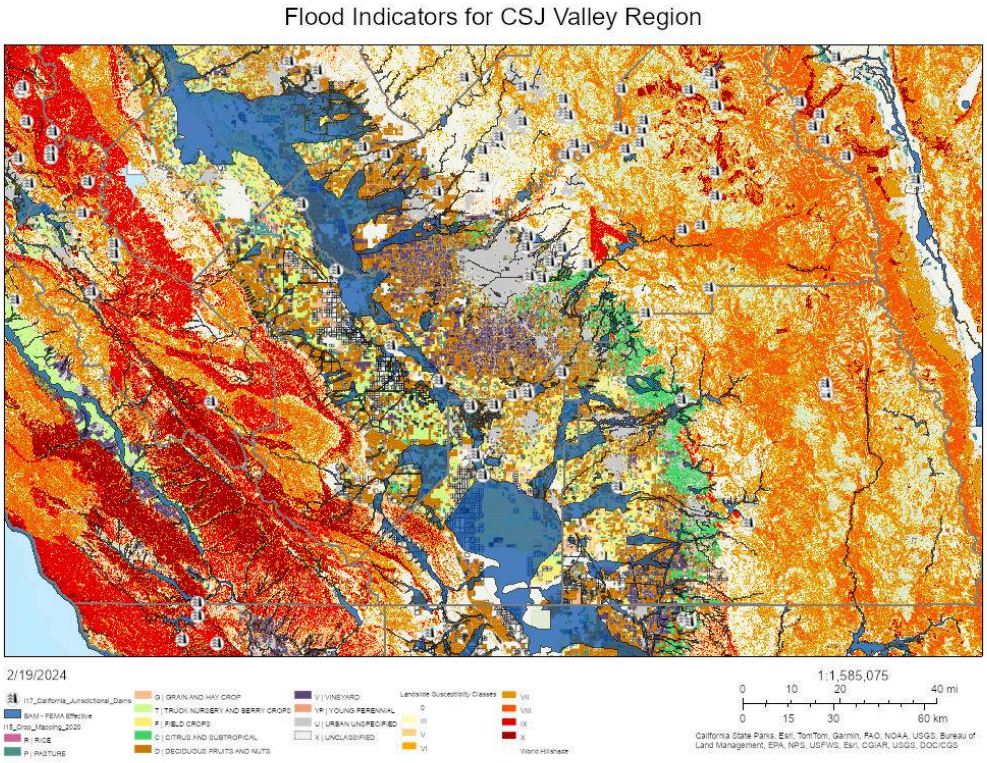


Figure 4.4.1 Flood Indicators for CSJ Valley Region

As seen in the above figure 4.4.1, the CSJ Valley region faces significant flood vulnerabilities, particularly in areas nestled between mountain ranges where landslide vulnerabilities are prevalent. Compounding this risk is the high correlation between current dam locations and flood vulnerability zones. According to a study from *Nature Communications*, the presence of dams can exacerbate flood risks by altering natural river processes, such as sediment transport[12]. Damming leads to the removal of fine particles from the water, causing riverbeds to coarsen, which impedes river flow and exacerbates flooding potential. These floods pose a threat to the region's agricultural sector, with deciduous fruits and nuts such as apples, apricots, cherries, walnuts, and almonds being among the most vulnerable crops. The interplay between geological features, infrastructure, and agricultural practices underscores the urgent need for comprehensive flood mitigation strategies in the CSJ Valley region.

[12] https://www.nationalgeographic.com/environment/article/is-building-more-dams-the-way-to-save-rivers#:~:text=While%20conventional%20thinking%20holds%20that,river%20flow%20and%20worsen%20flooding.

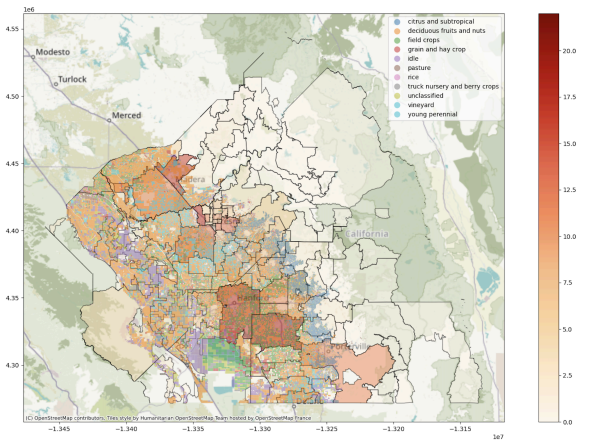


Figure 4.4.2 Crop Mapping and Heat Overlay

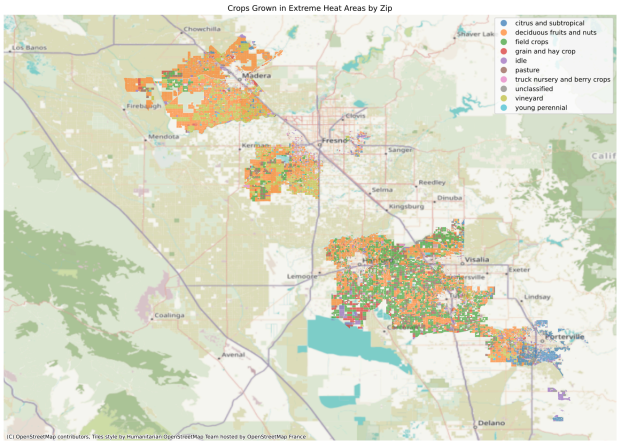


Figure 4.4.3 Crops Grown in Extreme Heat Areas

In assessing the environmental sustainability of the CSJV region against extreme heat, we focused on using three indicators: crop mapping, ozone, and particles less than 2.5 micrometers (PM2.5). As seen in Figure 4.4.2 and Figure 4.4.3, we utilized the UCLA Heatmap for excess ER visits for extreme heat as a proxy to determine which regions (zip codes) were most affected by extreme heat. Overlaying this data with the crop mapping dataset from DWR, we found that in areas with a rate of over 10 daily excess ER visits from extreme heat, there was a higher focus on field crops, vineyards, and pastures compared to the overall region.

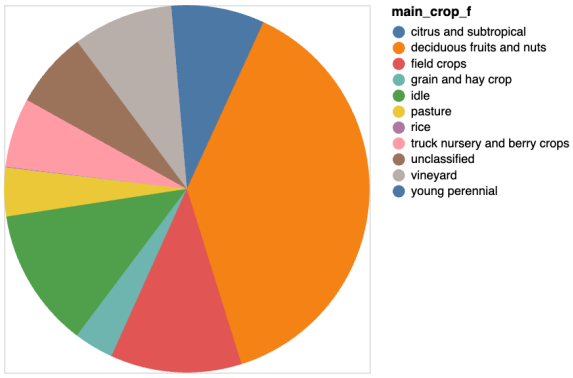


Figure 4.4.4 Crops in Overall CSJ

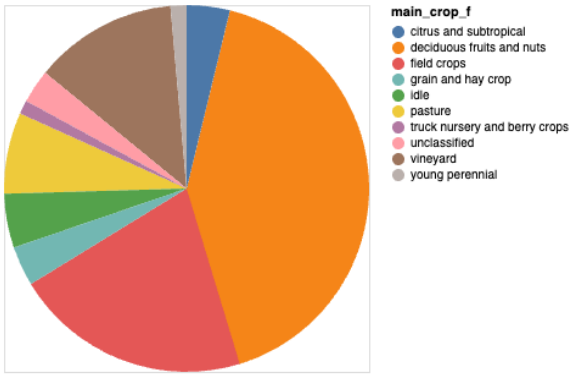


Figure 4.4.5 Crops in Extreme Heat Areas

More specifically, field crops (11% -> 21%), pasture (4.2% -> 7.6%), and vineyards (8.8% -> 12.7%) each grew by a large margin and showed possible vulnerabilities to extreme heat in the area where studies show that higher temperatures could lead to reduced yields in crops.

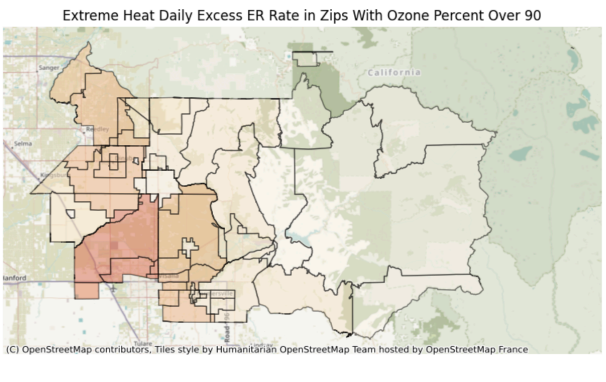


Figure 4.4.6 Over 90% Ozone Data

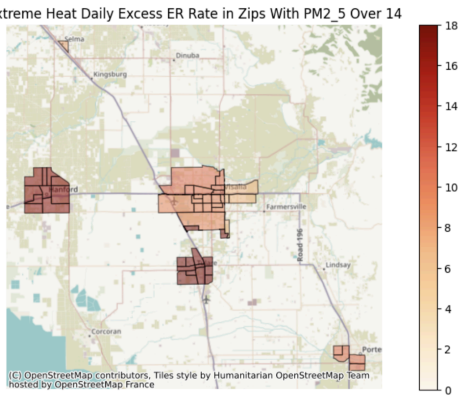
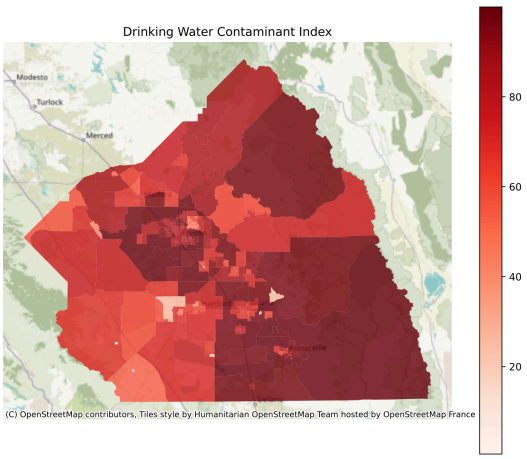


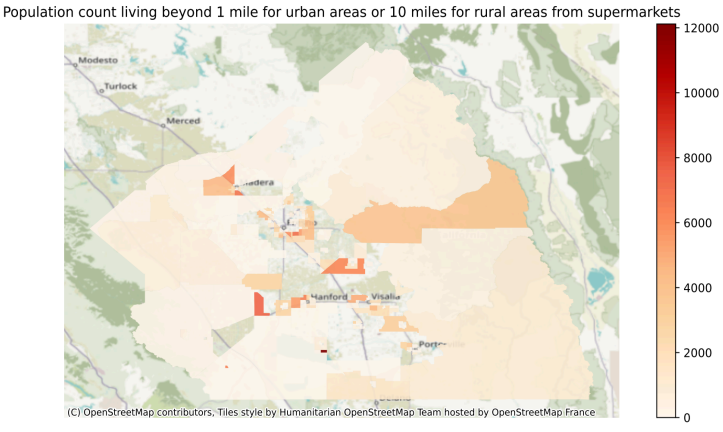
Figure 4.4.7 PM2_5 over 14 Data

Finally, using the CalEnviroScreen 4.0 dataset, we were able to locate zip codes where the ozone percentage was over 90 and PM2.5 was over 14. Overlaying the heatmap data for extreme heat, we found that in areas where the ozone % was over 90, the mean daily excess ER rate was 4.81 compared to the overall county mean of 3.13 (std. dev. 4.48). Furthermore, in areas where PM2.5 was over 14, the mean was a much larger 12.56 compared to the overall 3.13. This data clearly shows a high relation between ozone percentage and PM2.5 to extreme heat incidents within the area. Since both ozone and PM2.5 are known to cause damage to respiratory and cardiac systems, people within these areas may be more vulnerable to extreme heat due to their existing conditions.

(4-5) Access to Resources

In order to evaluate the community's access to resources against flooding, we focused on access to drinking water, access to food, and access to housing. Data visualizations in this section are implemented via geospatial data tools and libraries from python.

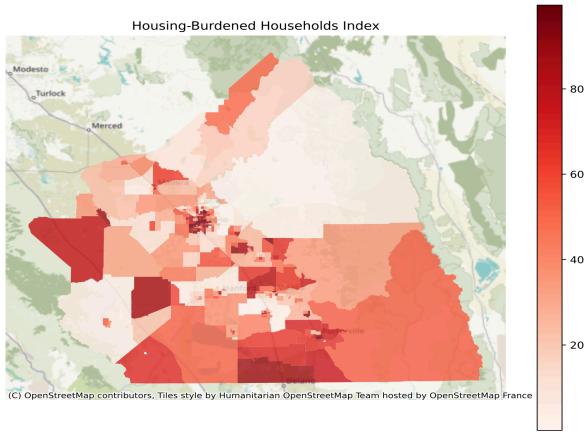




According to the CalEnviroScreen 4.0 report, an estimated 98% of Californians received water from public sources in 2013 (SOR, 2015). The report also mentions rural residents of the

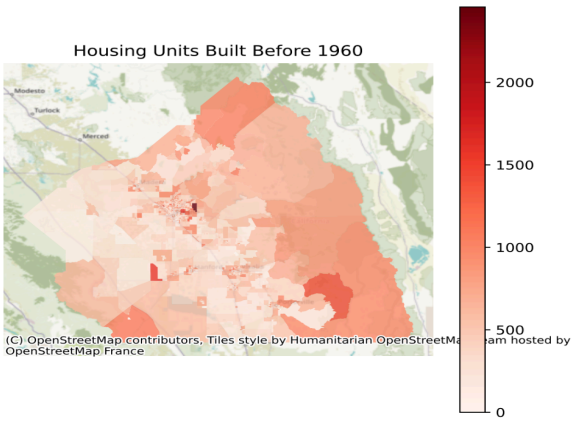
San Joaquin Valley receive water primarily from shallow domestic wells. However, the agricultural community in this area is extremely vulnerable to the contaminants in their drinking water, due to fertilizer application and animal waste which can leak into the groundwater. The figure (left) also shows a high drinking water contaminant index in the agricultural area on the east side.

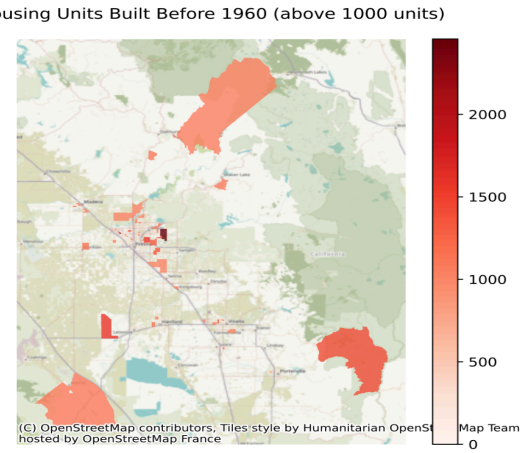
The right figure above shows communities with low food access. Low food access is measured by the population count living beyond 1 mile in urban areas or 10 miles in rural areas from supermarkets. The dataset is from the Food Access Research Atlas dataset from the USDA Economic Research Service. The information in the middle of the central valley is missing; for the rest of the shown area, a large area in the east part shows more than 2000 people living beyond 10 miles from the supermarket. Also, although there is a lack of information in the middle, the area near the highway shows higher counts than people living in the outer area. Food access is critical in that for flooding, food contamination is one of the major problems after the hazard.



From the CalEnviroScreen 4.0 dataset, it is shown that housing-burdened low-income households are more in the west side of the area. This community is more vulnerable to flooding because it is more difficult to restore their properties after the hazard.

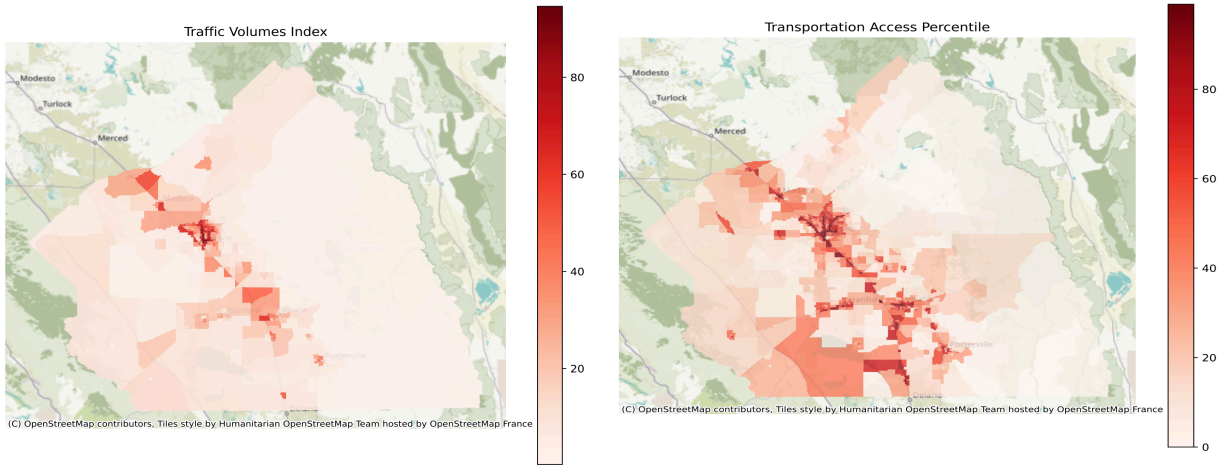
As the indicators to measure the community's access to resources resilience against extreme heat, we focused on access to strongly built housing, access to clean air, and access to transportation.





People living in old buildings are more vulnerable to extreme heat. The vulnerability is measured by counting the population living in the houses that were built before 1960. The figure

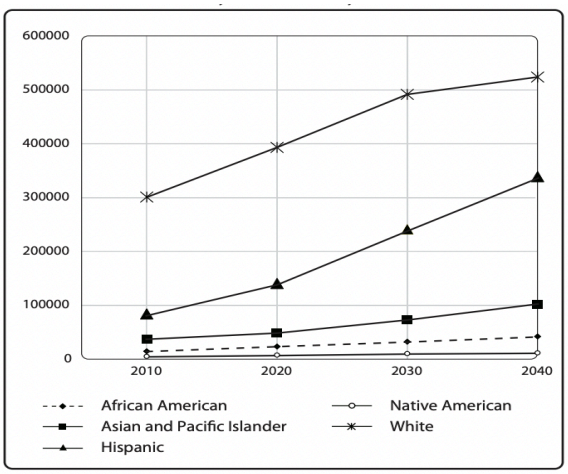
(right) highlights the area where more than 1000 housing units built before 1960 are present. It is noticeable that the area overlaps with more rural areas and the center of Fresno County.



The traffic volume index shows the accessibility to clean air. High traffic volumes directly contribute to the quality of air, which relates to extreme heat vulnerability. Exhaust from vehicles is a critical source of air pollution. Ironically, the area overlaps with that with high transportation access. A high percentile/index of transportation access shows higher resilience against extreme heat since transportation services from the government can provide shade and air conditioning systems for the users during extreme heat. The transportation access and pre-1960 housing units are obtained from the EPA (Environmental Protection Agency) EJscreen dataset, while the traffic volume index is from CalEnviroScreen 4.0.

(4-6) Underserved Communities and Climate Justice Implications

Through various indicators, we identified several disadvantaged or underserved communities within the counties. Dissecting our region, our total population has a racial distribution with the majority of Hispanic (57.52%), followed by White (26.25%), Asian (8.01%), Black (5.47%), Multirace (1.84%), American Indian (0.43%), and Other (0.1%). Gender groups are similarly distributed with 50.62% of Male and 49.38% of Female residents.



Source: Counting California (1998)

For the Age groups, 68.17% of the population in SJV is between 10-64 years old, while there are 17.71% of the 65+-year-old elderly population and 14.12% of the youth (<10 years) population. The age distribution is noticeable that Tulare County and Fresno County are ranked seventh and eighth of the 58 California counties as having the highest percentage of elderly living below the poverty line. The figure from Counting California (1998) reveals the increasing Central San Joaquin

Valley population projections, focused on 65+ year olds by race and ethnicity.

Examining SJV by industry sectors, we found that 5.90%, or 53,700, working in *Accommodation and Food Services* (equivalent to Food Preparation and Serving); 2.10%, or 20,897, working in *Agriculture, Forestry, Fishing and Hunting* (equivalent to Farming/Fishing/Forestry); and 25.51%, or 113,119, working in *Health Care and Social Services* (equivalent to Healthcare support).[13] These industries are disproportionately affected by extreme hazards due to their nature, for instance, agriculture is affected by both extreme heat and flood such that potential crop yield is dramatically decreased. In the Accommodation and Food Services industry, damage to natural resources and ecosystems can have negative impacts on the tourism experience resulting in increased displacement in the hospitality industry[14]. Finally, extreme heat and flooding can exert significant strains on health systems, simultaneously increasing demand for health services and impairing the system's ability to respond. Significant attention must be given to these industry sectors to improve their odds during these natural hazards.

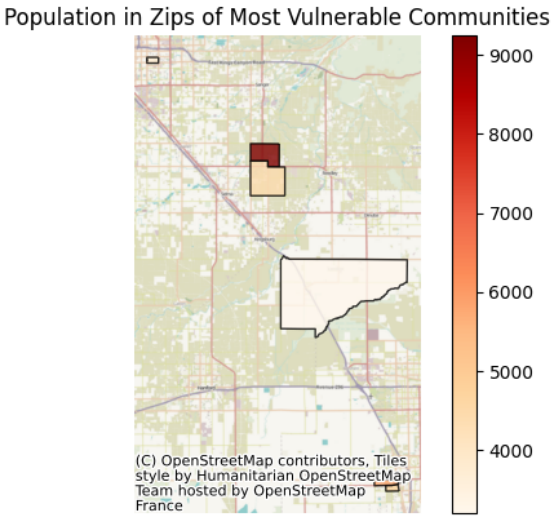
Given the agriculture-concentrated feature of SJV, and considering the demographics of the region, we hypothesized that **low-income, Hispanic, Agricultural workers residing in harsh environments (air quality, water quality)** would be most vulnerable to extreme heat and flooding.

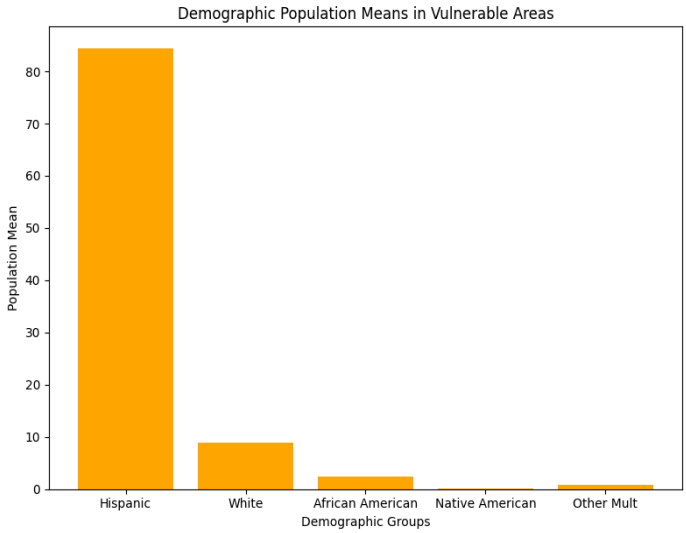
Using the CalEnviroScreen 4.0 data set, we filtered the zip codes with the poverty index higher than 70, an Ozone percentile higher than 85, the PM2.5 index higher than 13, and the drinking water contaminants index higher than 75. These indicators are selected since they directly show how vulnerable the community is to the natural hazard.

	County	TotPop19	Poverty	PovertyP	OzoneP	PM2_5	HousBurdP	DrinkWatP
1981	Tulare	3205	72.1	98.090452	91.051649	13.561705	66.514575	96.902710
2004	Tulare	4702	76.7	99.007538	88.699440	14.580554	48.517110	76.333208
2045	Tulare	5765	72.2	98.115578	88.699440	14.331669	81.520913	76.308230
2946	Fresno	3791	74.0	98.542714	88.699440	13.863187	89.835234	98.826027
2949	Fresno	9242	71.3	97.751256	88.699440	13.410631	55.487959	76.158361
2950	Fresno	4420	70.2	97.374372	88.699440	13.378924	89.569075	93.855377

We identified 3 zip codes located in Tulare County and 3 zip codes located in Fresno County for a total of 31,125 vulnerable members of the population, of which 2,506 were elderly over 65.

[13] https://properties.zoomprospector.com/california/community/Central-San-Joaquin-Valley-CA-/r1703/business
[14] https://stratfordjournals.org/journals/index.php/Journal-of-Hospitality/article/view/1742





As seen in the above figures, the demographic makeup of these communities was on average above 85% Hispanic, far beyond the county average. Poverty disables and discourages these people from utilizing cooling resources and unhealthful surrounding environments worsen their health conditions to make them more vulnerable to extreme heat. Against flooding, many studies find that poverty exponentially increases damages from flooding due to insecure housing and those in poverty living in areas with weaker infrastructure for drainage, water, or sanitation. Thus, these people are powerfully impacted by these natural hazards and show a higher rate of vulnerability.

(5) SWOT Analysis

Goal	Strengths	Weaknesses	Opportunities	Threats
Identify Weak Points and Strengthen Heat Resilience in CSJ Valley Region	- The large agricultural sector improves heat resilience by increasing the soil's carbon content which mitigates the effects of climate change. - Relatively smaller populations and cities reduce the number of urban hotspots in the area. - Cooling centers are available in multiple locations; the locations are well-listed on the city website.	- Relatively high ozone and PM2.5 count in the region create a vulnerable population against extreme heat. - Inevitable environmental weakness exists in the agricultural sector; animal waste and fertilizer leach into groundwater - Lack of education in rural areas along with language isolation issues are present.	- Concentrated industry sector enables actionable policy conduct. - Promoting the existing resources may highly increase extreme heat resilience. - Recent investment boosts to the region may have a trickle-down effect and help with social issues.	- Large agricultural sector can be greatly affected by crop/livestock damage - Low-income population will be less likely to utilize government cooling supplies due to utility bill concerns - About ⅛ of the population are elderly who are more vulnerable to extreme heat.

Improve Flood Resilience in CSJ Valley Region	- Numerous dams in the area control the amount of water released, reducing the likelihood of severe flooding - Preservation of wetlands and natural floodplain areas supports flood resilience by providing natural buffers against floodwaters and enhancing ecosystem services that help regulate water flow. - Much of the region is dedicated to agriculture, which often includes floodplains and areas that can absorb excess water during floods, mitigating their impact.	- Most low-income populations have their properties as the losables (housing, livestock, etc.). - Located between mountainous regions that have a high likelihood of landslide that may incur flooding - Language isolation issue limits information reach from the government	- Low percentage of people living in housing units built before 1960s – people are living in safe buildings - Shift towards smaller scale farming may promote better land use further from floodplains - Strengthening land use planning and regulation to limit development in flood-prone areas and promote resilient building design standards can reduce exposure to flood hazards and minimize potential damage during flood events.	- Study suggests that damming removes fine particles from the water and causes riverbeds to coarsen, which can impede river flow and worsen flooding - Floods could incur large losses to farmers in the area who grow deciduous fruits and nuts (apples, cherries, almonds) - Drinking water contamination is inevitable in the future, due to agriculture-focused characteristics.

(6) Policy Recommendations and Strategies

1. Increase public funding to regional labor oversight and policing to ensure that all workers, including those undocumented, receive fair pay.
2. Increase funding to the region's colleges and universities to diversify regional industries and grant access to those typically unable to afford it.
3. Reduce utility costs to those with a demonstrated need to enable air conditioning and fan use.
4. Provide free economic literacy training for those most vulnerable to encourage holding wealth in non-physical assets that natural hazards can not harm.
5. Invest in local and regional public transportation projects to reduce tailpipe emissions from Highway 99 and Interstate 5.
6. Upzone the residential parts of the region to allow for dense and mixed-use development with ample new housing away from floodplains.
7. Provide low-interest and accessible loans to local, small-scale farms.
8. Strengthen land use planning and regulation to limit development in flood-prone areas and promote resilient building design standards to reduce exposure to flood hazards and minimize potential damage during flood events.

Works Cited

"California Healthy Places Index." *Map.healthyplacesindex.org*, map.healthyplacesindex.org/?redirect=false.

CDC. "Healthy People - HP2020 - Leading Health Indicators at a Glance." *CDC.gov*, 2019, www.cdc.gov/nchs/healthy_people/hp2020/hp2020_indicators.htm.

"CENTRAL SAN JOAQUIN VALLEY ca Businesses | State of California." *Properties.zoomprospector.com*, properties.zoomprospector.com/california/community/Central-San-Joaquin-Valley-CA-/r1703/business. Accessed 20 Feb. 2024.

"Community Report - Fresno County, California | National Risk Index." *Hazards.fema.gov*, hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06019. Accessed 20 Feb. 2024.

"Community Report - Madera County, California | National Risk Index." *Hazards.fema.gov*, hazards.fema.gov/nri/report/viewer?dataLOD=Counties&dataIDs=C06039. Accessed 20 Feb. 2024.

"Is Building More Dams the Way to Save Rivers?" *Environment*, 10 Oct. 2022, www.nationalgeographic.com/environment/article/is-building-more-dams-the-way-to-save-rivers#:~:text=While%20conventional%20thinking%20holds%20that.

"Living Wage Calculator - Living Wage Calculation for Kings County, California." *Livingwage.mit.edu*, livingwage.mit.edu/counties/06031. Accessed 20 Feb. 2024.

"Living Wage Calculator - Living Wage Calculation for Tulare County, California." *Livingwage.mit.edu*, livingwage.mit.edu/counties/06107.

Miltiades, Helen, and Flores. *Aging in the San Joaquin Valley: Present Realities and Future*

Prospects.

Shimizu, Ralph Romualdez, et al. “Natural Hazards and Their Effects on the Tourism and Hospitality Sector in Philippines.” *Journal of Hospitality and Tourism Management*, vol. 6, no. 4, 30 Aug. 2023, pp. 12–22, stratfordjournals.org/journals/index.php/Journal-of-Hospitality/article/view/1742#:~:text=Natural%20disasters%20result%20in%20a, https://doi.org/10.53819/81018102t5226.