Water Vulnerability in California

Water Vulnerability Score
High: 4.375
Low: 2.2

Central Valley
County Lines

Introduction

With climate change widely accepted as one of the most pressing issues of our time, exhaustive scientific research has shown that it is most likely the result of human interventions such as land use change and industrialization. In particular, water scarcity is expected to grow as climate change increases the prevalence of droughts and extreme weather events. In California, a severe drought from 2012 to 2016 highlighted the precariousness of its water supply. California’s largest water consumer, the agricultural sector, stands to be heavily impacted by water scarcity. Although only 5% of the land is used for agriculture, it accounts for roughly 65% of the California’s total water use (USGS, 2015).

Agriculture primarily occurs in the Central Valley, one of the most productive agricultural regions in the world that produces one third to one half of all fruit, nuts and vegetables grown in the United States (Bittman, 2012). The Central Valley is extensively irrigated with man-made canals and reservoirs to divert snow-fed rivers to farmland. The water is allocated based on arcane laws that give senior water rights to the first users and, in many cases, has resulted in extreme overallocation of most of the rivers. Groundwater extractions from private wells has also come under recent regulation to replenish depleted aquifers, limiting the potential water supply available to farmers (PPIC, 2017).

Population growth, expanded irrigation and a shift in crop production to perennial crops has added to the water stress of agricultural sector. In order to address the impending water crisis, sustainable water management practices such as low-flow irrigation and conservation practices will help alleviate water stress during times of uncertainty.

The project aims to graphically illustrate water scarcity through the application of a water vulnerability index made up of ten indicators. This allows for the identification of Californian communities most at-risk and can give insight into the contributing factors like climate, agriculture and population growth.

Methods

After identifying the spatial question, a list of potential indicators were selected and data collection began. Once ten variables were identified, they were uploaded and projected into a common coordinate system. Precipitation and Evaporation were already rastered and only needed to be clipped before reclassifying. The dam location and almond acreage data were geocoded and attached to the county boundaries using spatial join. Point density was then used to derive a density map of the dam locations. Almond acreage was summed by county to create a choropleth map. The data from USGS was tabulated and calculations were made to determine changes between 2000-2015 as indicated. Following data scrubbing, the excel was joined to the county shapefile and it was exported and saved to make a new chart for each indicator.

The vector maps were then converted to rasters using the feature to raster conversion tool. Once all ten variables were converted to rasters, each one was reclassified using quantile categorization and 1-5 rankings. “1” was associated with highest water vulnerability, whereas, “5” meant low water vulnerability. Precipitation, Dam Density and Sustainable Irrigation were ranked in reverse as they decrease water vulnerability. The idea is that more precipitation and more dams would mean there was wider density map of the dam locations. Almond acreage was summed by county to create a choropleth map.

Population Change
Domestic demand
Water Consumption
Water Use by Sector

Analysis & Conclusion

The resulting map from the weighted raster analysis demonstrates a spatial trend that agriculturally focused regions of California are most susceptible to water vulnerability. Over the past twenty years, irrigation as a percentage of overall agriculture has greatly increased and the shift towards perennial crops has sharply raised water consumption. Should these current trends continue, the agricultural areas face worsening prospects in terms of water shortages, ultimately creating massive economic ramifications at both the individual and state level.

California’s Central Valley is particularly at risk due to a combination of climatic, demographic and economic related factors. At the southern border of California, the Imperial Valley, perhaps faces an even greater water shortage as it relies on water from the Colorado River instead of runoff from the Sierra Nevada Mountains. Outside of the State’s agricultural areas, the north has less water vulnerability than the south, likely a result of less population and more precipitation. Meanwhile, the coasts to the west and mountains to the east of the valley experience much less risk than the valley.

Water vulnerability in California is a pressing and urgent concern for many. Using spatial analysis, policymakers can determine where the highest risk lies and respond in a methodical and targeted way. In this case, there is evidence that the irrigation and population growth increases susceptibility. As such, ongoing management of California’s water resources should prioritize sustainable water use within agricultural communities.

Solutions to promote water conservation and reduce the impact of future droughts include regulation of water diversions and extractions, infrastructure development of water re-use treatment and new technologies such as micro irrigation or bio-char for soil moisture improvement.

Sources: USGS, PRISM, CGIAR, ESRI & NID
Projection: NAD 1983 California (meters)
Coordinate System: GCS North American 1983