CALIFORNIA WATER TRENDS

CE 394K GIS in Water Resources

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Environmental and Water Resources Engineering
December 2, 2016

Contents

I. Introduction

I.I Background

California is one of the most populace states in America; it hosts around 39 million people or about 12% of the entire U.S. population [6]. Even with such a high population it continues to increase steadily, at about 1% a year [3]. The state also hosts some of the most water intensive agriculture, such as almonds, walnuts, grapes, oranges, and dairy [1]. These two factors alone put a large strain on the amount of water the state has to supply, but in recent years another factor has put an even greater strain on the state: drought. California has been in severe drought conditions since 2011, and to complicate matters below average precipitation has occurred since 2007, putting an even larger strain on water supplies [4]. Although California is no amateur when it comes to droughts, having been hit on and off by them every few years, this is the first drought where emergency water restrictions have been sanctioned by the State Water Resources Control Board calling for a 25% urban water use reduction throughout the state [7].

These three factors then pose the question: Where is water being used in the state and how does this affect water supplies?

I.II Objective

The objective of this project is to look at water usage throughout the state of California, where it is going, and how has it changes through the years. This data can then be used to predict future water use and how this will affect the drought that is plaguing the state. The second objective is to see the effect water restrictions will have on California and if there are other aspects that need to be considered in order to conserve water and decrease the effects of drought raging throughout the state.

II. Methods and Results

II.I Data Acquisition and Processing

Boundary shapefiles for California's state and county lines were obtained from the ArcGIS Living Atlas.

Water use data was obtained from the USGS [5]. Water use data has been collected every five years from the USGS from 1985 to 2010 on a county level in either tab-delimited text files (.txt) or excel files. 2015 data was not available at this time, but should be available soon. The data includes water use broken down into different categories: public, domestic, industrial, irrigation, livestock, mining, thermoelectric, and aquaculture supplies. It is again broken down into groundwater and surface water withdrawals, and if possible fresh versus saline water withdrawals.

In order to process the data, state and county shapefile boundary lines were brought into a map on ArcGIS Pro. Once county lines were drawn the county water use data was inputted and joined with the county data for 10 year increment periods from 1990 to 2010. The data was then manipulated and analyzed to find trends and other aspects for these years.

For easier understanding a map of each California County is given in Figure 1.

Figure 1. Map of California Counties [2].

II.II Results and Discussion

II.II.I Total Water Use

The first trend considered is how total water usage has changed throughout the years. This lead to three separate graphs that show total water usage for each county in California, presented in Figure 2.

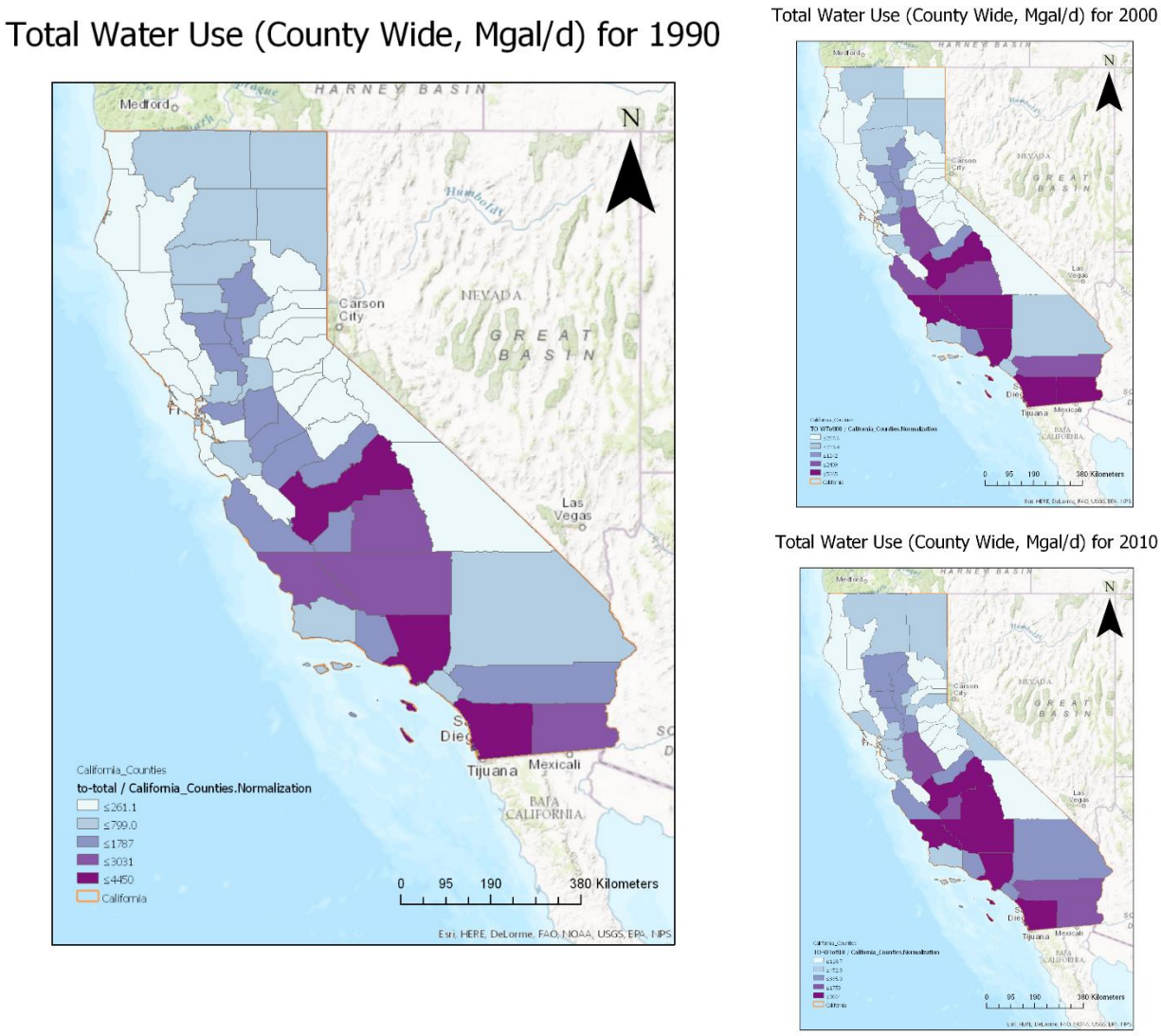

Figure 2. Total Water Usage, county wide, in 1990, 2000, and 2010 in Million gallons/day.

There is not an obvious trend when first looking at the graphs from 1990, 2000, and 2010. In some counties it can be shown that total water usage has increased, such as the lower coastal counties of Los Angeles and Kern, but has decreased in others, such as the Northern counties of Modoc and Lassen. In order to get a more accurate idea of how water usage has changed the total water usage from each county was summed and plotted, seen in Figure 3.

Figure 3 shows a very interesting trend in total water usage. It increases in 2000 to 51 billion gallons/day from 45 billion gallons/day in 1990, and significantly decreases in 2010 to 38 billion gallons/day. This increase and then decrease seem out of place- one would think that it would continue to increase steadily. Since there is an unusual trend in water usage breaking it down into its components will hopefully shed light onto why these trends are happening.

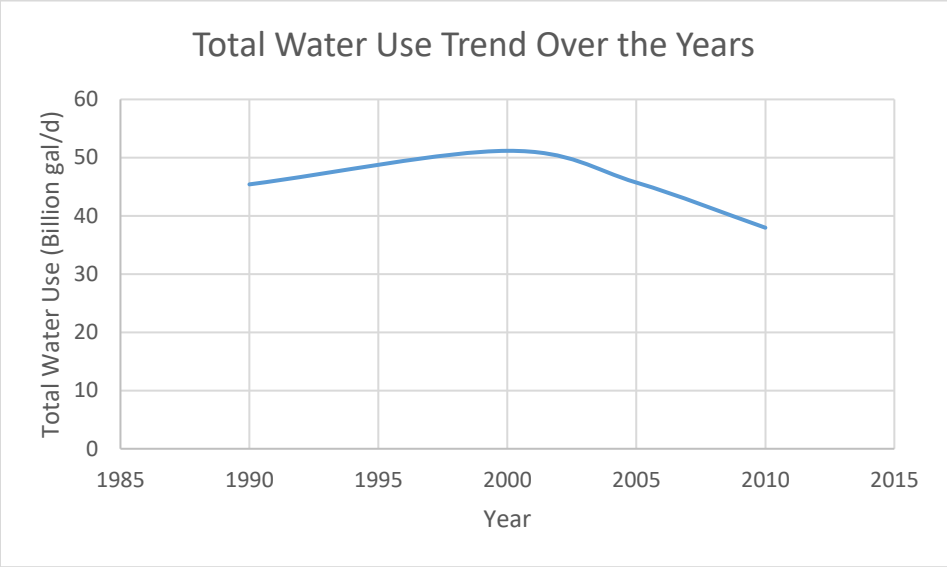

Figure 3. Total Water Use in California from 1990 to 2010 (Billion gallons/day)

II.II.II Municipal Water Use

Since California is the most populous state in the United States, population should have a large impact on water usage throughout the state. In order to confirm and visualize this hypothesis a map of municipal water use normalized by total water usage was generated, shown in Figure 4.

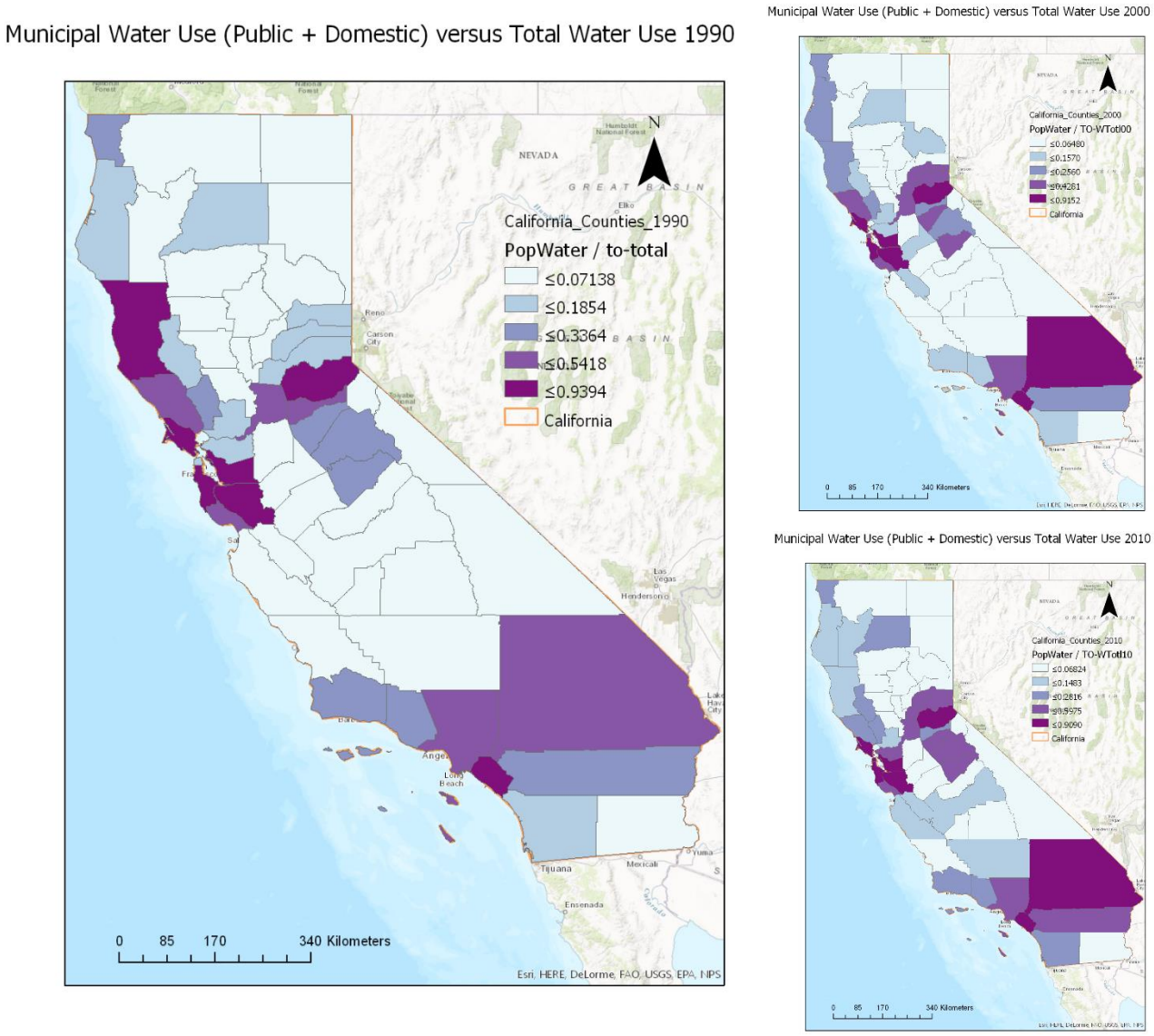

Figure 4. Municipal Water Use versus Total Water Use for 1990, 2000, and 2010.

In Figure 4 there are multiple places where population has a large impact on water usage (more than 50%). These include lower coastal counties such as Los Angeles, Orange, and San Bernardino and the upper coastal counties such as Mendocino, Santa Clara, and El Dorado. It can also be shown that the regions that started with a high percentage of municipal water use in 1990 have continued to increase until 2010. Although the total percentage of water used by municipal means has steadily increased through the years it does not explain why total water usage has fluctuated between these years.

In order to rectify this discrepancy a graph of average water use per person was generated (Figure 5). This graph shows that even with a steady increase in population (Figure 6) the average water use per person has decreased linearly throughout these 20 years, and since there is a greater decline for water use per person than increase in population, the total amount of water used has declined. This can account for part of the reason total water usage decreased between 2000 and 2010 as seen in section II.II.I.

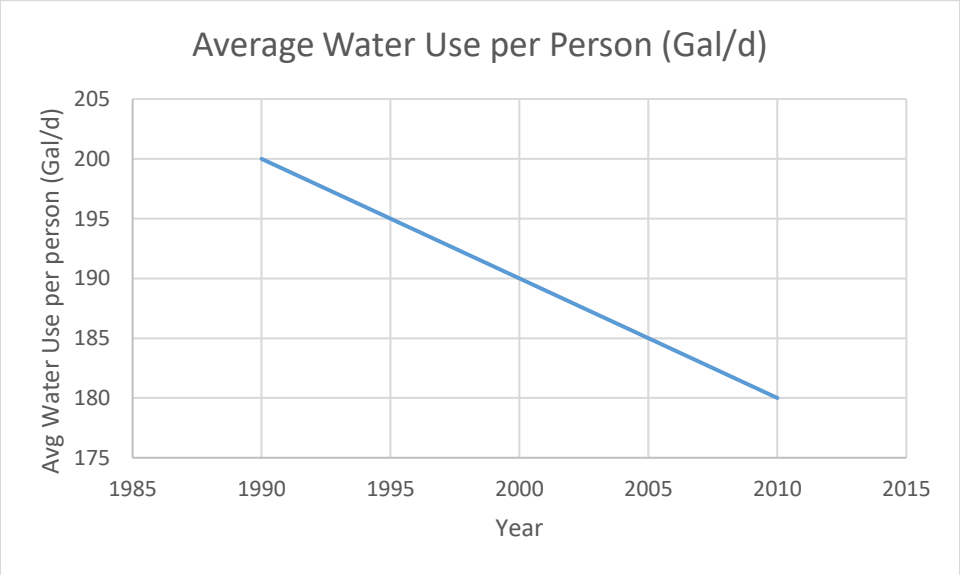

Figure 5. Average Municipal Water Use per Person from 1990 to 2010 (Gallons/day)

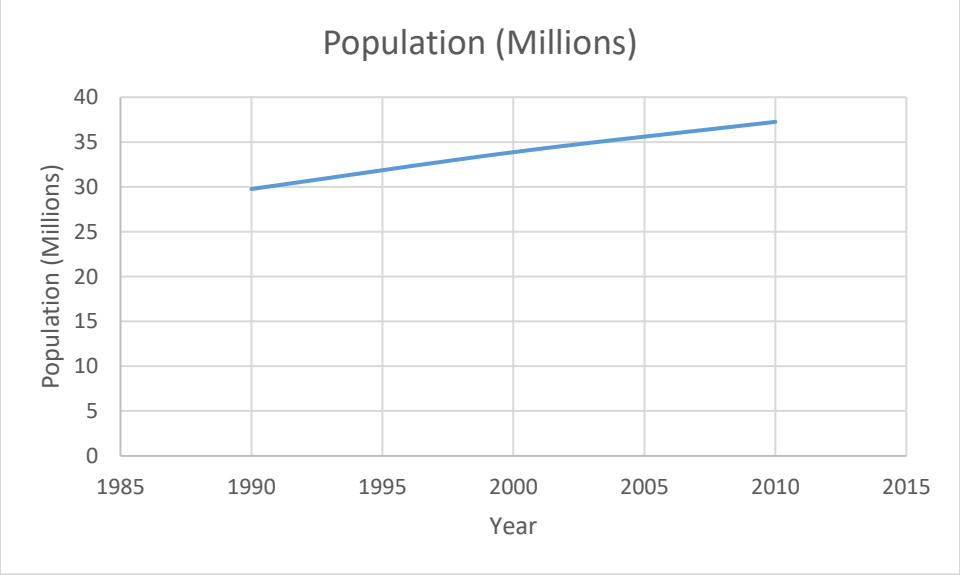

Figure 6. Total Population in California from 1990 to 2010 in Millions

II.II.III Agricultural Water Use

The second factor that is considered to have a large aspect on water use in California is agriculture. California is a host to a large amount of water intensive crops, such as almonds, walnuts, oranges, and grapes. It also has extensive dairy and livestock farms [1]. In order to look at agricultural effects on total water usage graphs were generated and analyzed, as shown in Figure 7.

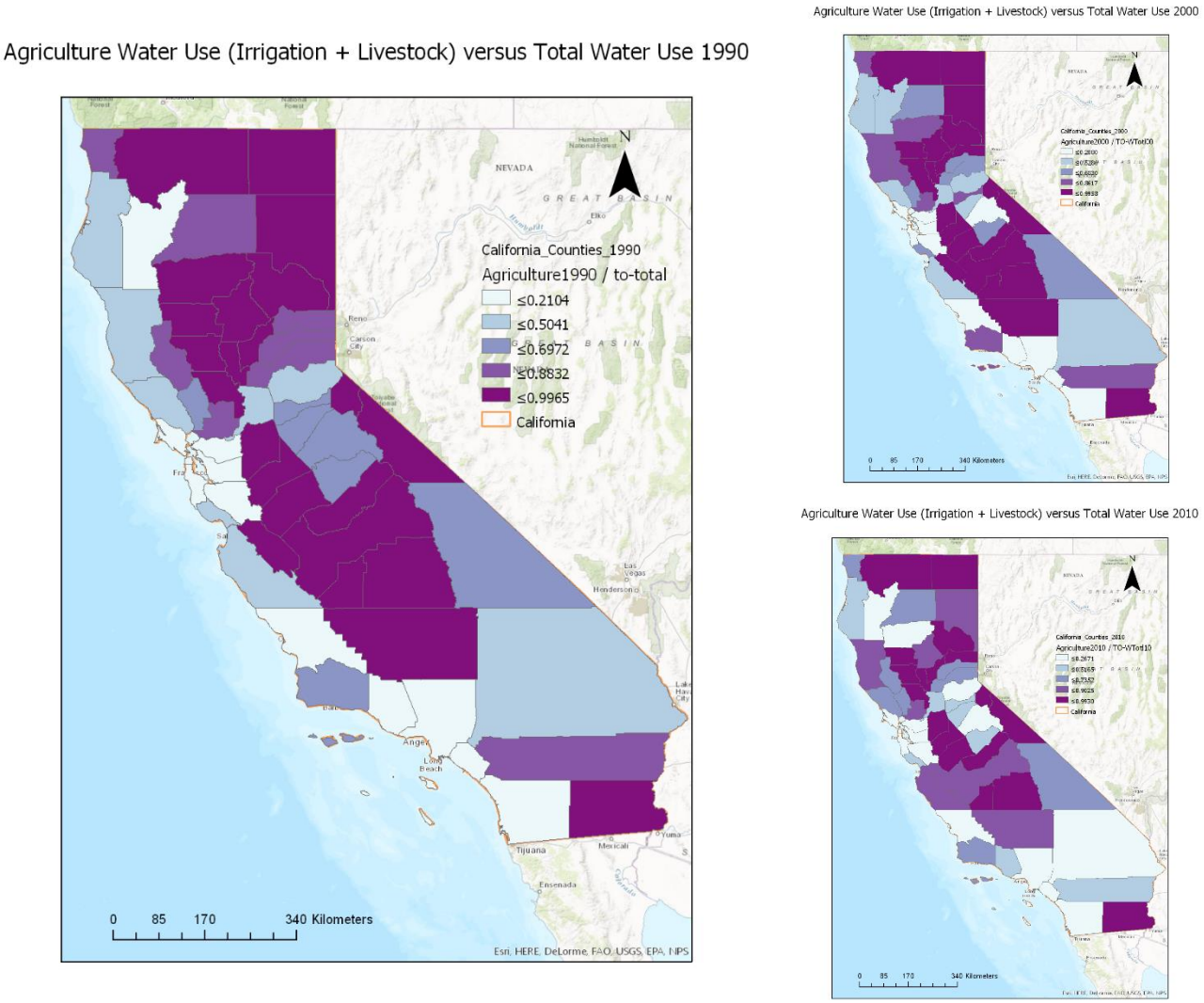

Figure 7. Agricultural Water Use versus Total Water Use, county wide, for 1990, 2000, and 2010.

As displayed in Figure 7, agriculture is a large portion of total water use throughout the entire state, most notably in northern and central California counties. It can also be shown that over the years agricultural water use decreases. Many more counties are less than 50% of the total water use in 2010 than 1990, especially in the central region of the state. This interpretation can be confirmed in Figure 9 where the total agricultural water use increases in 2000 to 31 billion gallons/day and steeply declines to 23 billion gallons/day in 2010.

This graph closely follows the shape of the total water use trend in Figure 3 with an increase in total water use in 2000 and large decrease in 2010, meaning that agriculture is a large factor in determining how much water the state uses.

Although the total water used for agriculture has decreased, the average water use per acre has drastically increased, as shown in Figure 8. The average water use per acre is steady between 1990 and 2000 at around 2800 gallons/day, but increases up to 3700 gallons/day in 2010. This means that although agricultural water use has gone down more can be done in order to conserve water throughout the state for agricultural purposes.

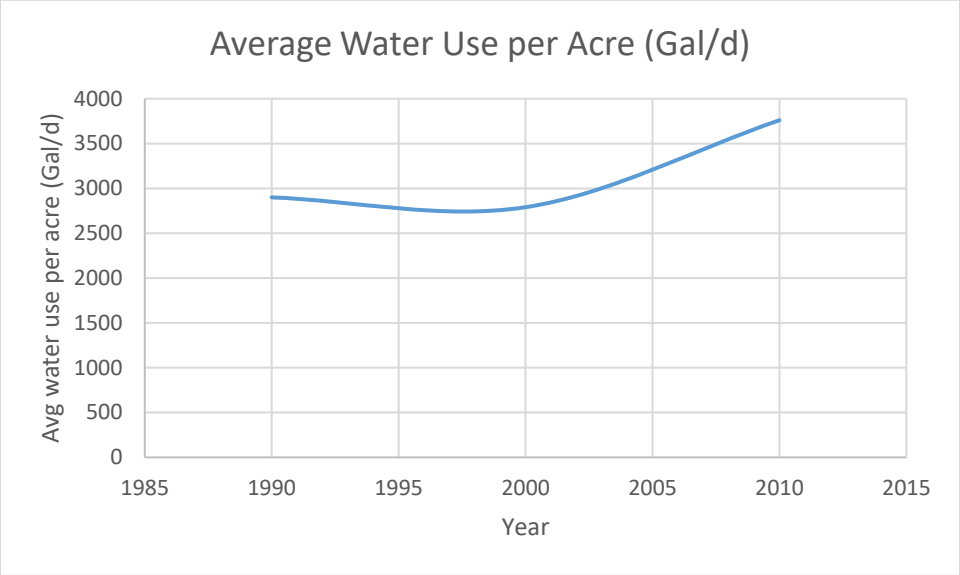

Figure 8. Average Agricultural Water Use per Acre of land from 1990 to 2010 (Gallons/day)

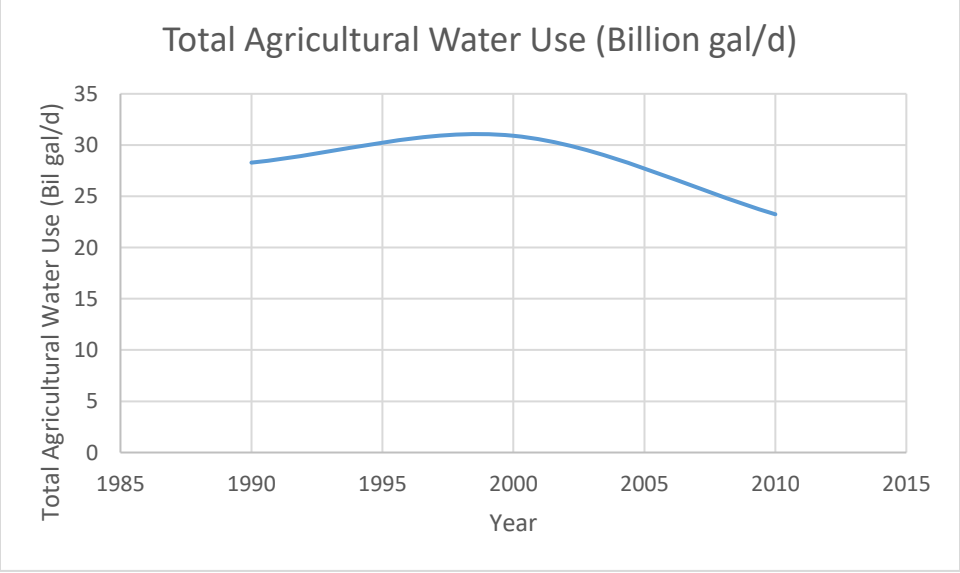

Figure 9. Total Agricultural Water Use for California from 1990 to 2010 (Billion gallons/day)

II.II.IV Other Water Use Factors

While population and agriculture are big factors that influence water usage throughout the state there are other factors involved, such as industrial, mining, thermoelectric power, and aquaculture water use. Also, although population and agriculture may be large factors on water use, to what extent they affect total water use needs to be analyzed. Table 1 breaks down the weight each factor has on total water use throughout the state as an average from each county.

As hypothesized agriculture and municipal water use are the two biggest factors that affect water usage, with agriculture being much more significant at around 65% than municipal use at around 20%. It can also be shown that in recent years agriculture is declining and municipal use is increasing moving from 21% in 1990 and 2000 to 25% in 2010. All other factors that affect water usage are under 10%, with the most notable contribution as thermoelectric water use in 1990 at 10%.

One discrepancy, though, is that 1990 data does not include aquaculture water use data, but extrapolating from water use data shown between 2000 and 2010 it is negligible.

Table 1. Percent Breakdown of Average Water Use to Total

	Agricultural	Municipal	Industrial	Mining	Thermoelectric	Aquaculture
1990	0.64	0.22	0.02	0.01	0.10	-
2000	0.65	0.21	0.07	0.0	0.09	0.04
2010	0.6	0.25	0.02	0.01	0.07	0.05

II.II.V. Comparison of Water Use Factors

Since agricultural and municipal water use are the two biggest factors that influence water use throughout the state it is interesting to compare how they influence each other. Figure 10 shows both the agricultural and municipal water use as a percentage of total water use in 2000. By putting them side by side it is easier to compare how they relate to each other.

There is an inverse relationship between population and agriculture, where the counties that have low agricultural water use have a high municipal water use. Again it can also be shown that there is much more agriculture spread throughout the state than people and this makes sense since most of the population in California is condensed in large cities, such as Los Angeles and San Francisco near the southern and central coast of California. This inverse relationship is also shown in Table 1 in section II.II.IV where an increase in population decreases the amount of agriculture and ultimately the amount of water needed to sustain crops.

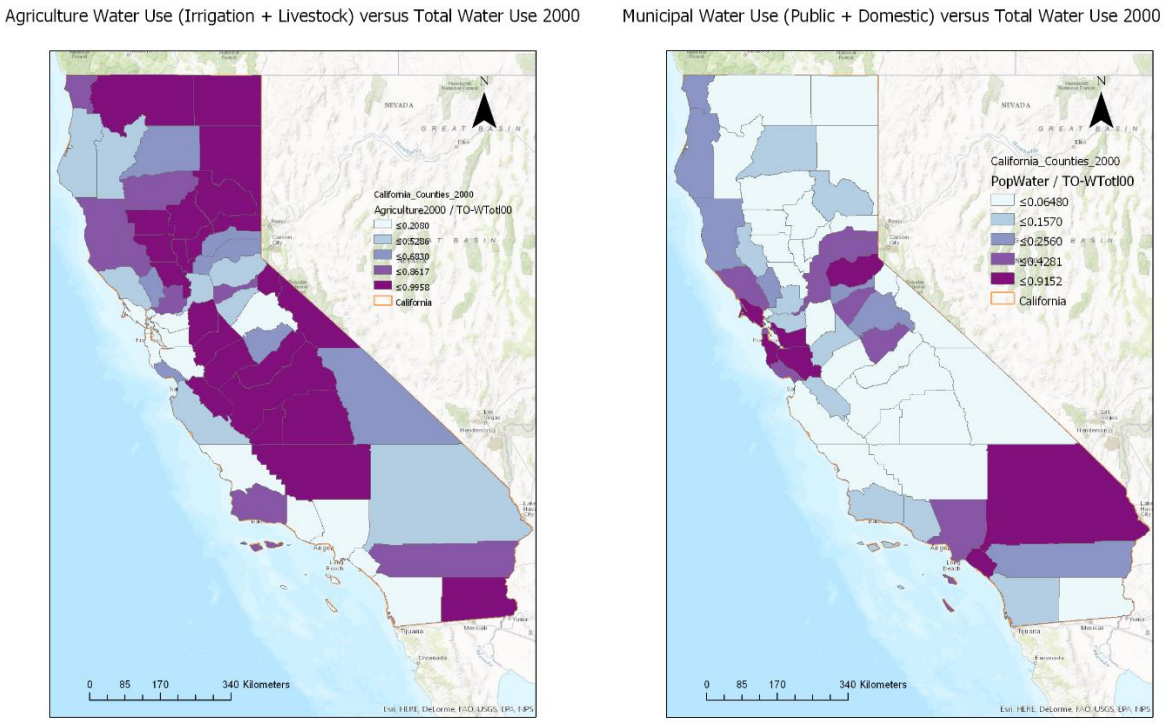

Figure 10. Agricultural versus Municipal Water Use Comparison to Total Water Use.

II.II.VI Future Trends

California is currently going through a major drought and this has called for emergency water restrictions to be placed on the state. California Governor Brown issued an executive order on April 1, 2015 to reduce urban water usage by 25% and it is compelling to see how much of an impact this reduction will have on total water usage for the state, all other factors constant [7].

Assuming water usage for the state of California to be the same as 2010 values and the only factor changing is population, taking an increase of 1% a year, and using average water use per person of 180 gallons/day from 2010 a graph was produced to see what total water usage would be until 2020 with and without a 25% reduction in urban water use [3]. This graph, shown in Figure 11, can be interpreted to have a difference of around 1.8 billion gallons/day saved with a 25% reduction up until 2020. Although this might seem like a lot, as a percentage of the whole water usage for the state it is small, at around 4.5%. It is a great ambition to reduce water use for every person, but agricultural water use needs a large water reduction initiative as well in order to conserve water throughout California.

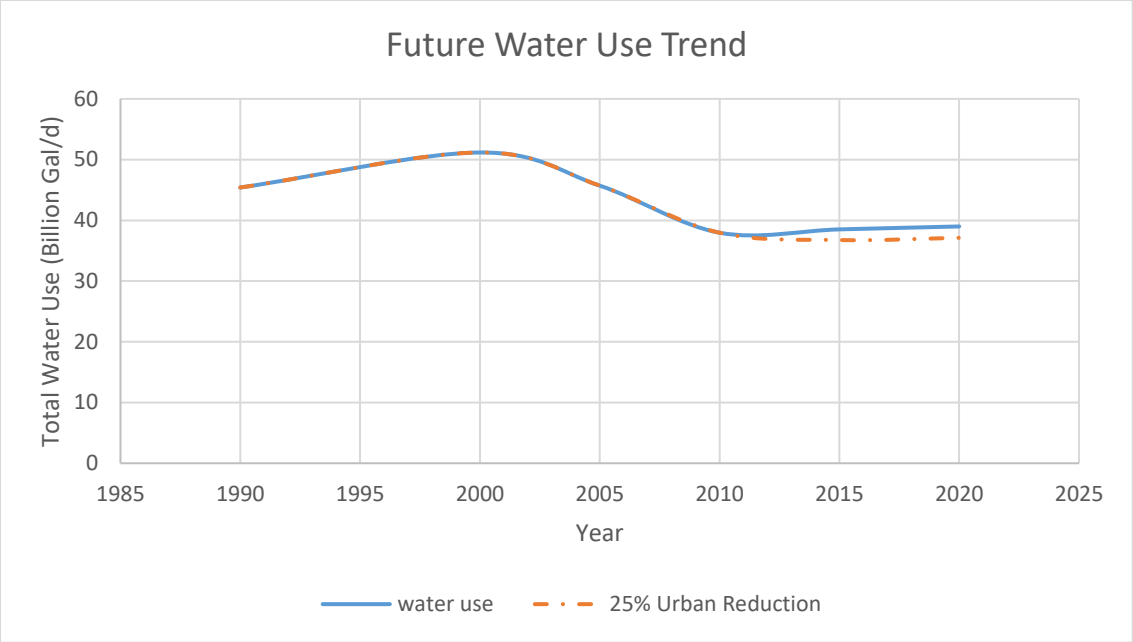

Figure 11. Future water use trends in California with and without a 25% state sanctioned reduction in urban water usage (Billion gallons/day)

II.III Limitations

As in any study, there are limitations. The biggest limitation of this analysis is that there was no data available for water use for 2015, which may have impacted the results of this study, especially when looking at future trends. 2015 water use data would be useful to look at in order to gauge how water use has changed throughout the state with such strained water availability since 2011, and even before because water levels have been low since 2007 with very little precipitation falling through these years.

Another limitation of the study is the extent of the data collected and analyzed. It can be shown from the data that different categories have been collected in recent years compared to years before, such as aquaculture, and it makes one wonder about what kinds of water usage data is being left off of the report that may be included in reports in the future.

III. Conclusions and Future Work

Putting all of the data and analysis together it can be shown that total water usage throughout the state of California is dependent on many factors, but the two biggest are population and agriculture. Both agricultural and municipal water use have a trade-off associated with them and in recent years population has steadily increased while agriculture has declined. The effect on a decreasing agriculture has especially affected total water use, contributing about 65% of the total water use throughout the state. Although agricultural water use has declined, the average water use per acre has significantly increased. Conservation in agriculture needs to be considered, especially since it has such a large impact on water use through the state and with such a prolonged drought a reduction is necessary to sustain water storage levels.

Population has also greatly affected total water use, contributing to about 20% of the total. Also, while population has increased steadily over the years the average water use per person has steadily declined, decreasing the total water use each year.

Other factors each contribute less than 10% of the total water use and have a small impact on water use compared to either population or agriculture.

Drought greatly affects water use in the state, especially in terms of water availability. This trend is apparent when looking a future water use with the emergency water reductions in order to conserve water in urban areas. It is a great effort, but more water conservation methods need to be put in to place in order to reduce water, especially in agricultural areas as it contributes to more than half of the total water use and has been increasing its average water use since 2000.

Future work on this study can be done when 2015 water use comes out and comparing it to data already collected to see if there is a pattern that can be established. It can also be used to see how the 2011 drought has affected water use throughout the state over the past 5 years.

Another area of study to consider is the sustainability of this water use. If a pattern is established, what is the water available to the state and how much can California use before they run out of water entirely and what measures can be taken to reduce water use in order to make sure it does not happen.

IV. References

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