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Core 01

23 November 2015

Eat, Drink, and Be Merry:

Effects of Agriculture on California's Water

California is the country's third largest, and most populous state. It is unequivocal fact that California is in the midst of a water crisis, especially considering that no rain or snowfall has been predicted for the next two years. According to the California Department of Water Resources, the state currently has 19.9937 trillion gallons of water stored in reservoirs. When combined with the 4.719 trillion gallons of groundwater drawn this year the state has 24.7 trillion gallons of water for the next two years. Each year our state consumes 13.9 trillion gallons which over the next two years will become 27.8 trillion gallons of water. If we are to survive the next two years without running out of water we will need to reduce our consumption by eleven percent. At our current rate of consumption we will be out of water in approximately twenty months. Our total savings would total about 3.09 trillion gallons. Action to rectify our state's current situation is urgently needed. The state must begin to ration water to critical functions whilst reducing use by less critical applications. At the request of the governor, my fellow researchers and I, from the California Department of Water resources, have created a proposal which we believe will distribute our state's remaining water in such a way that it will have a minimal effect on the state's economy and reduce consumption by the requisite amount.

The most important sector of California's economy is Agriculture. Of all the sectors of California's economy, only agriculture can impact the entire nation's health. In the USDA

“California Agricultural Statistics 2013 Crop Year” California is listed as have produced more of eighty two commodities than any other state (2). The same report states that California is home to 77,900 farms (12). California’s top 20 commodities accounted for $38.7 billion in 2013 (3). In the area of Vegetables and melons California is in the top 10 producers of all twenty- eight categories, top five for twenty seven, and number 1 in twenty two of them (9). Again for fruits and nuts, California is in the top 10 in all twenty-eight categories, top five of twenty seven, and the country’s top producer of twenty one different commodities (10). Twenty one percent of all milk and cream products in the United States come from California cows (12). In a USDA Economic Research Service report, California is stated to produce twenty two percent of all US fruit, ninety percent of the nation’s lemons, fifty percent of the tangerines, sixty percent of fresh market vegetables, seventy-three percent of processed vegetables, and about one third of melons (USDA ERS). If California production of agricultural products declines, prices of healthy and nutritious foods will rise across the nation leaving the nation with an even larger national health problem.

Agriculture

As stated before, the importance of Agriculture is one of the most beneficial industries in California and the positive impact it has on the state’s food supply is undeniable. As was gathered by researcher Blaine Hanson from the University of CAlifornia, Davis, in a typical year at least 80% of the water usage in the state is given to agricultural development. Over 52% is utilized in a dry year, such as the current drought crisis (Hanson). Of the many areas where water is used for the production of agricultural goods, most is given to supply staple (edible) and cash (tradable) crops sold around the world and generating a significant income for the state’s economy, as noted by D.J. Waldie in his examination of agriculture’s effects on the state

(Waldie). It is indeed that cuts will need to be made to specific crops, such as almonds and there are irrigation methods proposed by farmers such as Matsumoto which can reuse some of the water used in the production back into the environment as a whole. In light of these benefits, agriculture should remain as a potent component of the state's economy and livelihood so that it can continue to contribute to our prosperity.

Water Usage for Agricultural Products

Area	**Usage/Citation**	**Math**	**Acceptable Cuts**
Staple Crops (Tomatoes, Strawberries, Rice, etc.)	2,280,957,000 gallons/year arb.ca.gov/fuels/lcfs/workgroups/lcfssustain/hanson.pdf Accessed on 11/13/2015	One Acre Foot=325,851 gallons 7,000 acre feet used for staple crops	An acceptable cut of 10% of the gallons of water used will still allow this product to be made efficiently
Cash Crops (Almonds, Walnuts, etc.)	6,256,339,200 gallons/year arb.ca.gov/fuels/lcfs/workgroups/lcfssustain/hanson.pdf Accessed on 11/14/2015	One Acre Foot=325,851 gallons 19,200 acre feet used for cash crops	An acceptable cut of 15% of the gallons of water used will still allow this product to be made efficiently

Total	8,537,296,200 gallons/year for the production of crops	Roughly 26,200 acre feet is used for all crops	A cut of roughly 25% to agriculture's water usage is acceptable

In context to these figures, a journalist from the New York Times, Jennifer Medina, found that it would be to cut at least 25% of agriculture's water usage in order to substantially contribute to the state's overall efforts at water conservation (Medina). Based on the current drought, it is undoubtable acceptable to have this percentage of water cut from production. However, a substantial amount will still be needed in order for food, namely the staple crops, to continue to be produced at healthy levels in order to continue to provide for the populous.

Economic Benefits of Agriculture

Areas of Economic Benefit	**Statistics for Benefits**	**Math**
Employments/Earnings	Employment: 19,856,986 jobs Income: $1,159,872 Minimum Earning: $14/hour californiawater.org/cwi/docs/AWU_Economics.pdf	Average Employment for Processing/Production: 591,812 employees + the sub-division jobs detailed on californiawater.org/cwi/docs/AWU_Economics.pdf
Income from the Sales of Agricultural Products	Industrial Output: $3,223,296 californiawater.org/cwi/docs/AWU_Economics.pdf	Average Income from Output: $150,383+ the sub-earnings from other areas of

		production/processing detailed on californiawater.org/cwi/docs/AWU_Economics.pdf

The total economic output analyzed from Mechel Paggi, M.D.'s report from the California State University, Fresno reflects the tremendous benefits to the state's economy and opportunities for jobs that it gives to the state's laborers (Paggi). Without the necessary water and jobs, the overall production would decrease significantly and by extension the food supply of the state may face drastic stagnation. The amount of benefits portrayed here proves the importance of agriculture to the state as a whole.

Analysis

It is not a pretty picture to heavily reduce the water used in agriculture given the enormous benefits of its production. Above all, it is a process which is simply the most important to the survival of the state's population in these trying times for when the water goes, the food you eat goes with it. Knowing all this and how much we would be willing to cut in order to maintain these vital processes to the health of the state's population it should be no question that agriculture should continue to use whatever water we have to a sufficient capacity. After all, when the drought reaches its zenith and the people die of thirst they wouldn't want to be dying from starvation on top of it.

Residential

As my colleagues have demonstrated, it is vital that we maintain our agriculture if we wish to weather this catastrophic drought. However, it still remains that we must reduce our water usage, and if we cannot afford to cut water from agriculture, it must be cut from other areas, particularly residential use. Residential water use has proven to be a problem, because the logistics involved are, frankly, ill-conceived. In her lecture, "California Water Wars," Professor Martha Conklin explains that, "We've located...our cities, most of our population, in the places that get the least amount of precipitation" (Conklin). That means that when we try to meet residential demand, we waste a lot of supply along the way, and often, we do so for superfluous ends. Although we do need residential water for drinking, and, to some extent, for sanitation, our water usage for sanitation can be made significantly more efficient, and we can cut other aesthetic applications, such as lawn-watering, completely.

Sanitary

We can significantly reduce the amount of water used for sanitation. Obviously, we can't forsake it altogether. We don't want to replace our water crisis with a disease crisis. However, many sanitation activities could be reduced or done with recycled "grey" water. According to a report by the Natural Resources Defense Council, sanitation costs us about twenty-six gallons per person per day (NRDC). Our population is 38.8 billion people, so that means over a trillion gallons per day. However, fully 6.1 daily gallons per capita are used flushing toilets (NRDC) Unlike showering or washing dishes, which require good, pure water, we don't particularly care about the water we use in our toilets. As long as it isn't obviously begrimed, we hardly notice it exists. So, what if we did, in fact, use wastewater? We could entirely eliminate 6.1 daily gallons per capita if we were to redirect used water from our showers, laundry, and dishes. Additionally, we can significantly cut back on how frequently we shower. The NRDC report cites that people who are trying to use water efficiently are taking "4.7 showers per week for 8.7 minutes" (NRDC). That's pretty good. However, even that could be reduced. It isn't a popular proposal, but we could seriously cut back on showering. We could conveniently cut down to three 8.7 minute showers a day, saving fully three gallons per day per person. That may not sound like much, but over 38.8 billion people for two years, that three gallons rapidly expands to almost eighty-six trillion gallons. Similarly, we each run our faucets for about ten minutes daily (NRDC). That costs us 6.5 gallons per capita per day. If we can halve our faucet time by turning the faucet off when it is not absolutely necessary, we can save about ninety-three trillion gallons over a two-year period. Finally, if we run fuller loads of laundry, going from 2.7 loads a week to only once, we can reduce our water use from laundry from 4.7 to 1.7 gallons per capita per day. All told, that's 442,157,040,000 gallons just from cuts to everyday activities.

Luxury

We can cut even more from the luxury and aesthetic water costs. The NRDC report cites that by replacing high water- demand vegetation or removing it altogether, we can save up to fifty gallons per capita per day (NRDC), meaning a full 1.4 hundred billion gallons of water over the two years. However, that number was derived with the assumption of a maximum 70% reduction. What is to stop us from cutting this frivolous waste of water entirely? A complete cut of the water wasted on people's yards would yield 200 billion gallons in savings. And that's not all. There are other frivolous things we can cut entirely. Notably, we could replace bathing with showering. People are taking 2.24 baths per week, at about eighteen gallons apiece (NRDC). If we exchange baths for showers, we can cut back that eighteen to twelve and a half. Or, we can cut the excess bathing and showering altogether. We can fully eliminate 5.8 daily gallons per capita. That's 164 billion gallons. In total, that means we are wasting about 364 billion gallons of water on luxuries. Which sounds easier, giving up your lawn, or giving up your food?

Analysis

It isn't pleasant, but if we are to survive the drought we have to make some sacrifices. Residential water use is inefficient, and often pointless. If we increase our efficiency in more crucial areas like sanitation, and we fully eliminate our wasteful luxury water costs, we can eliminate about 800 billion gallons of wasted water, significantly improving our chances of making it through the drought.

Industrial

Although there are many industrial uses for water in California totaling 6% of total California water use, this section will focus on industrial sector water use in two sub-sectors: the Hydraulic Fracturing Industry, and Thermoelectric Power Generation. The metric for water use will be measured in three ways: Effects on water reserves, annual consumption of water, and water efficiency. For each sub-sector, alternatives that improve on one or more metrics will be considered and explored at depth.

Thermoelectric Power

Thermoelectric power in the United States uses 73,365,000 million gallons annually, equivalent to 56% of total water use in the United States. California's thermoelectric power uses a comparable percentage, equating to 17.4% of total water consumption. In order to reach the target of a minimum of 12% reduction of total water usage in California's industry, alternatives must be considered. The average Californian household uses 29 Kwh daily. Multiplied across an average of 15 million households, California's domestic power use can be estimated as 435 million Kwh per day. One can see how thermoelectric energy, supplying 90% of grid power for domestic use is an overly taxed resource that California cannot afford to continue using during the drought.

Thermoelectric power also has a low water efficiency compared to alternative sources of power. Thermoelectric power's "water efficiency" can be calculated as the amount of "work" each gallon of water provides in Kwh. Dividing our total water usage of thermoelectric power by the power generated, we get roughly 15 gallons of water for every 1 Kwh. Compared to solar energy, which does not require water to generate power, a transition to solar power could greatly multiply California's water efficiency in the domestic power sector, saving 15 gallons for every Kwh of solar energy.

This transition could be achieved in a number of ways. Domestic Solar panels can achieve an average generation of 5 Kwh. Assuming an average household size of 2.5, with 5 Kwh saved per household, which saves 75 gallons a household, multiplied across California's population of 38.8 million, 1.164 billion gallons of water can be saved yearly. In combination with household batteries like the Tesla Powerwall, all 5 Kwh can be guaranteed to be used (no energy is wasted during off hours.)

However, this is only the household savings. Dedicated solar energy sites, otherwise known as solar farms, can generate upwards of 1,100 GWh every year. One GWh is equivalent to 1,000,000 Kwh. Assuming a saving of 15 gallons for every Kwh, a single solar farm the size of Topaz Solar farm can generate 1.64*10^10 of saved water. If 10 Solar farms of similar scale can be constructed in California, the drought can be ended overnight. Although it may be costly, transition to solar energy is of paramount importance to California in regards to the current water crisis.

Hydraulic fracturing

Hydraulic Fracturing, otherwise known as "Fracking," uses an average 5 million gallons of water per well through a fracking well's lifetime. A 2011 EPA report estimates that fracking uses 70 to 140 billion gallons of water across 35,000 wells in the United States. It is estimated that California possesses one quarter of all fracking rigs in the United States (8750 rigs), although the amount of actual rigs is uncertain, due to ND agreements and other protections for the fracking companies. As a result, it is difficult to get an accurate prediction as to the water use of fracking in California.

Assuming one quarter of all rigs in the 2011 EPA report exist in California today, and a minimum of 70 billion gallons of water is used annually by oil rigs in the US, California's fracking efforts consumes 17.5 billion gallons of water annually. California's fracking efforts are often not fully considered, however. More than 17.5 billion gallons of water are consumed annually, due to the nature of contamination of water supplies due to fracking.

Fracking contamination is not well documented on a large scale, however many studies have begun releasing information on the adverse effects of fracking to groundwater reservoirs (Mooney, 2). As the bore cracks trapped natural gas and oil to be channeled up the hose via fracking fluid, the hazardous materials beneath the surface compromise and taint the freshwater reservoirs that the bore passes through.

According to Elizabeth Ridlington of Frontier Group in her report 'Fracking by the Numbers" as much as 280 billion gallons of wastewater have been produced nationally in 2012. Assuming that California produces ¼ of the wastewater of the nation (since California has at least ¼ of the fracking rigs) a transition from fracking to alternative methods of natural gas and energy could save as much as 70 billion gallons of water from contamination each year. Combined with the 17.5 billion gallons consumed annually, as much as 87.5 billion gallons of water can be saved if alternative methods to fracking are pursued by California.

There are many alternatives to fracking for natural gas. Methane can be harvested via biodigesters; biodigesters are devices designed to trap degrading landfill waste to channel natural gases via specially designed tubes. The remaining biomaterial can be recycled as fertilizer. As to oil, there are alternatives to harvesting oil via hydraulic fracturing.

Portugal has utilized tidal power to compensate for a loss from minimal natural gas and oil use to great success. Tidal power converts tidal energy into electricity to power a variety of uses. When utilized in combination with transition from fossil fuels (or in this case, water contaminating harvesting procedures) tidal energy can act as more than a valid substitute. Tidal rigs can produce up to 440 TWh (Tera-watt hour) annually, according to Renewable Northwest. The use of tidal rigs may not produce oil, however the incredible amount of power harvested from tidal rigs can mean that fossil fuels may not be necessary to power traditional combustion transportation like diesel locomotives. The potential 440 TWh/year can power all commercial trains several times over in California.

A diesel locomotive can needs only 1 gallon of diesel to move 1 ton of freight 500 miles. There are multiple factors playing into diesel efficiency, however; this distance can be achieved more efficiently via electric engines Kwh. The weight possible to be pulled by a train can be calculated as:

$$W = F_{pull} r$$

Assuming a ratio of 1 ton per gallon, a diesel locomotive with 100 gallons of fuel should be able to pull 500 tons for 100 miles. Diesel has 141MJ/gal.

W=(141*10^6)(100)(0.45)=6.3*10^9 Joules

In order to perform the same trip, an electric locomotive powered by tidal generation needs to generate 6.3 *10^9 Joules. 1Kwh equals 3600000J. thus, in order to power a 500 ton locomotive, 1750 kWh is needed, which is 6.3 *10^9 Joules although this may seem like a lot, tidal power can generate 1.21 TWh per day. This is equivalent to 1,210,000,000 Kwh at maximum efficiency. 1.21 TWh can power 691,429 500 ton locomotives for 100 miles. This could save 69,142,900 gallons of diesel fuel, which in turn saves water.

Fracking uses 38 gallons of water to produce 12 gallons of diesel fuel. Thus, the efficiency of fracking can be stated as 141 MJ/3.2gal water equals 44.06 MJ per gallon. Although fracking may produce substantial energy per gallon of water, tidal energy can do the same work at no freshwater, reservoir, or groundwater cost.

Analysis

In total, the savings from a transition from thermoelectric generation to solar generation could be saving up to 56% of California's water use, since thermoelectric generation consumes roughly half of all water use in California (although not 100% of the used water is wasted.) a modest estimate from a combination of domestic and industrial solar power generation could place a 40% reduction on California's thermoelectric generation over 2 years, which is the scope of this plan. that would equate to roughly 30% of California's water consumption of 13.38 trillion gallons, or 4.17 trillion gallons of water saved. additionally, there is room for optimistic growth: solar panels have steadily increased in efficiency since 2005.

a theoretical savings of 69,142,900 gallons of diesel fuel will equate to direct saving from the water spared that would otherwise be used to harvest the fuel. since it takes roughly 3.1 gallons of water to produce 1 gallon of diesel fuel, saving 69,142,900 gallons of diesel fuel due to a transition from diesel powered locomotives to electric powered locomotives will save 218,491,564 gallons of water.

Conclusions

If we are to survive these coming years in which no rain or snow has been forecast, we must take action now. Water use must be cut down in every facet of our lives to ensure that the state will not run dry. Based on the current use and application of water in the state of California, my fellow researchers and I have come to the conclusion that the state will need a total savings of 3.09 trillion gallons. Agriculture can reduce consumption by 25% resulting in savings of 4.3 billion gallons. When combined with the 800 billion gallons cut from residential and the massive savings created by converting to solar power, we have managed to reduce our state's water consumption.

Works Cited

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CORE 1 QUANTITATIVE #2 TEAM PLAN

Before beginning the assignment, each group must collaboratively complete this form (pages 4 and 5) and share a copy with each group member and your instructor. Make sure signatures are done by hand or with PDF electronic signature.

Team Members:

(1) Gordon Frederickson- Excel, intro, and conclusion

(2) Kameron Kashani- Justification for agriculture's water use

(3) T.R. Salsman- Residential and urban water use

(4) Grant Morgan- Industrial & energy sector water use

Team Procedures

• Days, times, and places for regular team meetings:

Wednesdays at 1:00PM at Kolligian Library, group collaboration on Google Docs

• **Method of communication** (e.g., e-mail, phone, wiki, CROPS Discussion Board, PB Works page, face-to-face, before/after class) in order to inform each other of team meetings, collected information, updates, reminders, drafting, problems:

- Email
- group chat messaging
- before and after class

• **Methods for setting and following meeting agendas:**

(1) Who will set each agenda? When? Who will be responsible for asserting it during team meetings?

Group consensus about agenda is set after each wednesday meeting, where we address what will be needed for next meeting

(2) What will be done to keep the team on track, in and outside of meetings?

Group Policing

(3) Strategies to ensure cooperation, collaboration, collective input, and equal distribution of tasks:

evenly divided effort via sectioning of paper in the following way:

Excel, intro, and conclusion

defense of topic

conservation of water in one sector

conservation of water in one sector

In each section, every member is responsible for writing their section, researching, collecting data etc.

Proposed Roles & Responsibilities

Carefully examine the assignment and determine ways to "divide and conquer" the task, in terms of specific categories of information and analysis for which the assignment asks.

Team Member	**Research/Reporting Areas**
1. Gordon Frederickson	Excel, Introduction, and Conclusion
2. Kameron Kashani	Defense of Agriculture
3. T.R. Salsman	Conservation of water: residential/domestic

4. Grant Morgan — Conservation of water: Industrial/energy sector

<u>Proposed Report Composition</u>

Who will be responsible for drafting specific parts of the report? And/or, will the team draft all parts of it together?

Everyone will add their part to the google doc, and the outline will develop over time into the essay. Gordon Frederickson will format the essay contributions into MLA format.

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a) *I participated in formulating the standards, roles, and procedures as stated in this contract.*

b) *I understand that I am obligated to abide by these terms and conditions.*

c) *I understand that if I do not abide by these terms and conditions, my assignment grade will be negatively affected.*

d) *I understand that I am obliged to report <u>any</u> breach in this contract by a fellow team member to my instructor.*

Signed:

1) T.O. Salsman date 22/11/15

2) Gordon Frederickson date 11/22/15

3) [illegible] date 11/22/15

4) Grant Morgan date 11/23/15

CORE 1 QUANTITATIVE #2 ACTIVITY LOG:

I*n working on the assignment, a designated team member must keep detailed records of the group's communications, tasks (individual and collaborative), and meeting. All group members will submit this ACTIVITY LOG with the completed assignment on the day it is due.*

Time/	Team Member(	List & Description of Task(s)

Tues 11/10/15	Gordon T.R. Kameron	Storage information/data recerrch, number crunching, outlining Research, Finding sources, Making a data table
Wed. 11/11/15	Group	Group meeting discussed format Math & progress check
Fri 11/13/15	Kameron	found Statistics for water usage and economic benefits
Wed 11/18/15	Gordon	Intro & conclusion

Fri 11/20/15	Gordon	Works Cited
Nov 12	Grant Morgan	Collected Sources: • "How much electricity?" • "water footprint of energy" • "The truth about Fracking"
Nov 16	Grant Morgan	Wrote the following section • Thermoelectric generation
Nov 18	Grant Morgan	Wrote the following section • Hydraulic Fracturing Added my sources to document

CORE 1 QUANTITATIVE #2 GROUP AND SELF ASSESSMENT

Each individual group member will submit this separately on turnitin.com the day the essay is due. This should not be done together to ensure a confidential and reliable assessment of how everyone worked together.

NAME: Grant Morgan

• **Roles & Responsibilities**

Which group members did which things—and how much of them—for the assignment?

Team Member **Research/Writing/%**

1. Gordon Frederickson, ¼ of report- intro, conclusion, and data work/MLA

2. Kameron Kashani, ¼ of report- agriculture, agriculture data, and sources for ag.

3. T.R. Salsman, ¼ of report- residential/urban water, data and sources for residential

4. Grant Morgan, ¼ of report- industrial/energy water use, data and sources for ind.

• **Process: Describe your experience working collaboratively.**

1. What worked well?

The google doc allowed us all to share information and collaborate in real time. The use of multiple documents increased efficiency, as we could share ideas that may be used, and agree on the final version together without discouraging contribution.

2. What could have gone better?

Although we met atleast once a week during the duration of our collabopration, it was hard to arrange times where everyone could meet due to conflicting schedules.

P***lease complete the following assessment for yourself and for each group member***

• Group member being rated: SELF

Rate each of the following on a scale from 1-5 (with 1 being low and 5 being high):

1.	Contributed their equal share to group projects	___5_____
2.	Adhered to the agreements outlined in the group contract	____5____
3.	Contributed to my development as a writer/college student	_____5___
4.	Offered inventive/important insights	_____5___
5.	Contributed to researching the project	_____5___
6.	Contributed to writing the project	_____5___
7.	Was supportive of group activity	____5____

TOTAL

/35

Comments:

• Group member being rated: ______Gordon Frederickson_______

Rate each of the following on a scale from 1-5 (with 1 being low and 5 being high):

1. Contributed their equal share to group projects ____5____
2. Adhered to the agreements outlined in the group contract ____5____
3. Contributed to my development as a writer/college student ____5____
4. Offered inventive/important insights ____5____
5. Contributed to researching the project ____5___
6. Contributed to writing the project ____5___
7. Was supportive of group activity ____5____

TOTAL

/35

Comments:

Gordon contributed equally, was punctual, and always had something to contribute and came prepared to meetings.

• Group member being rated: ____T.R. Salsman__________

Rate each of the following on a scale from 1-5 (with 1 being low and 5 being high):

1. Contributed their equal share to group projects ____5____
2. Adhered to the agreements outlined in the group contract ____5____
3. Contributed to my development as a writer/college student ____5____
4. Offered inventive/important insights ____5____
5. Contributed to researching the project ____5____
6. Contributed to writing the project ____5____
7. Was supportive of group activity _____5___

TOTAL

/35

Comments:

T.R. did a wonderful job being responsive and providing valid criticisms to improve my portion of the project. T.R. also was ready to contribute in meetings.

• Group member being rated: Kameron Kashani

Rate each of the following on a scale from 1-5 (with 1 being low and 5 being high):

1. Contributed their equal share to group projects ____5____
2. Adhered to the agreements outlined in the group contract _____5___
3. Contributed to my development as a writer/college student ____5____
4. Offered inventive/important insights _____5___
5. Contributed to researching the project ___5_____
6. Contributed to writing the project ____5____
7. Was supportive of group activity ____5____

TOTAL

/35

Comments:

Kameron did a wonderful job of assembling his data and creating some coherent goals in terms of the amount of water we should save (in relation to agricultural water use). He also came prepared to meetings.