California Water Action Plan

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Abstract

California has been facing a serious problem for the last five years. With very little rain and snow pack, we can see climate change taking its toll on California's wate supply. The extent to which global warming is happening has no end in sight, and consequently, neither does California's drought. California is using too much water and needs to take more action by looking into other alternatives of clean water before the state completely depletes its water sources. With serious cutbacks on water use and new laws/regulations being put into place, California is taking small steps, but is still facing the question of what to do next.

In this research essay we will explore the magnitude of California's drought, and some background as to how California got to where it is now. We will then move to see the legal actions California is currently implementing to cut water use, and finally we will explore the extent to which California has to go to if this drought continues. To do this we will be looking at many different water conservation techniques, solutions from areas that have experienced similar droughts, and finally looking at California's possible options. From constructing desalination plants, to domestic practices to save water, we will be structuring a water action plan for the state of California in such a devastating water crisis.

1. Introduction

Water is one of earth's most precious finite resources. Humans, animals, plants, almost every single life form depends on water in one form or another. Our planet is covered with it too, about 71% of earth's surface is water, but unluckily for humans, about 97.5% of this is saltwater. On top of this, it turns out that only about 2.5% of earth's water is available as freshwater and almost all of this is not accessible. Most of this freshwater is frozen in glaciers, and deep in the ground. There is a very limited amount of freshwater available for human use as it is, and with our current population, these sources of freshwater are being threatened and depleted. This finite resource our earth has offered is rapidly decreasing. What is the problem?

The problem is human impact on our finite resources. There are simply too many humans compared to the resources the earth has to offer. Human's population has always been increasing but within the last 50 years, the human population has multiplied more rapidly than ever before. To put this in perspective, let's look at the 2,500,000,000 humans in 1950. Now let's look at the human population, which exceeded seven billion in 2015. This exponential increase is predicted to continue and the earth is projected to have a 9,000,000,000 human population by 2050. This brings up the issue of whether or not our earth will continue to provide for us. We have been depleting its sources, raising its temperatures, polluting its land, water and air, taking what we need, and consequently have been causing alterations to its climate. These alterations include massive storms, heat waves, sea water levels rising, and something that we will look at, droughts.

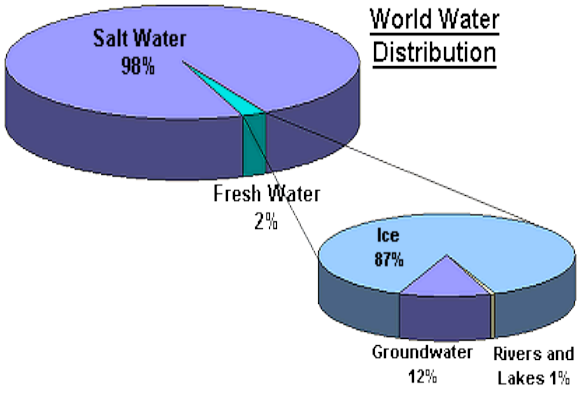

Figure 1: World Water Distribution
Source: ***Real Time Groundwater Level Monitoring Network***

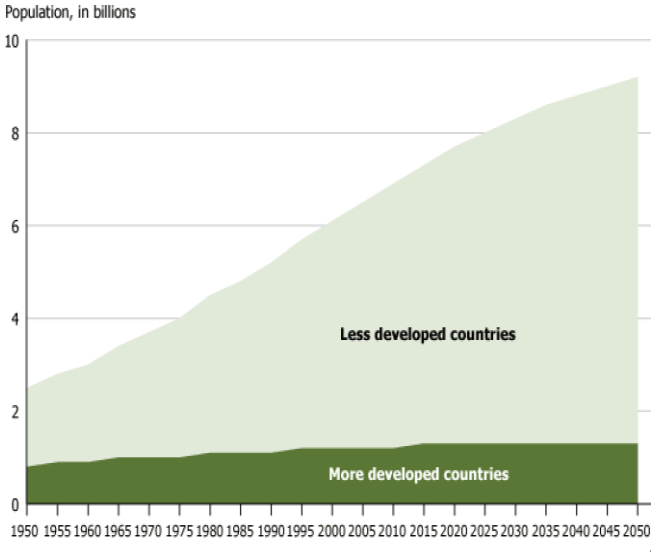

Figure 2: Population Growth 1950 –2050
Source: ***Population Reference Bureau***

One specific climate alteration that we will be exploring is the current drought in California. Climate change, warmer temperatures, and current water consumption within California is exploiting a huge problem that California has to not only face, but try to fix. In order to explore the drought, we first have to look at where California gets its water from, how much water the average American uses, and finally how much water California is using.

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2. Background

2.1 California Water Distribution

California's water distribution is complex because about ¾ of the annual precipitation falls north of Sacramento, while the demand for this water is primarily south of Sacramento. To solve this issue, there were projects created that redistribute this water throughout the state. The two biggest current projects are the State Water Project (SWP), and the federal Central Valley Project (CVP). These projects simply store the rain and runoff water in reservoirs instead of letting it flow away. This water is then sold to those who buy the water delivery contracts, mostly farmers and towns. The only problem being that when the water dries up, so do these contracts and many are left without their source of water. In 2015, farmers on the SWP were forecasted to get only 20% of their historical amount. Those reliant on the CVP are in no luck either; in 2015 the federal government stated that for the second year, they would not send any of its reservoir water to the Central Valley. This is leaving farmers no other options but to deplete our groundwater.

Figure 3:: **Example of a California Aqueduct**
Source*: California Department of Water Resources*

Figure 4: . **California State Water Project**
Source: *HD Image Gallery*

Another big source of California's water comes from the Colorado River Basin (CRB), which provides its resources to the heavily populated and arid southern California. This basin, covering more than 244,000 square miles (roughly 8% of the U.S.), provides freshwater to not only California but also six other states, and Mexico. Historically, California has received the highest percentage of the portion of water because of its dense population and water demand.

The CRB, being such a big supplier, has been carefully designed into a network of spider-web systems hitting the major cities of these states including the latter feeds of some diversions hitting Las Vegas, Los Angeles, and San Diego. As complex as these systems are, it is easy to understand that without the original source of water, precipitation, the distribution means nothing, and California is beginning to realize this.

2.2 America's Water Consumption

The average American uses around 100 gallons of water per day in their household. This goes to household services, such as dishwashing, showers, toilet use, washing machines, faucet use, and leaks within households. As if this isn't enough, these 100 gallons is only a fraction of the total average water use. The demand, about twice the global average, is around 2,000 gallons of water a day for an American. It turns out that household water use is only about 5% of the daily use. The majority of our water footprint is stemmed from our diet, energy consumption, and transportation use.

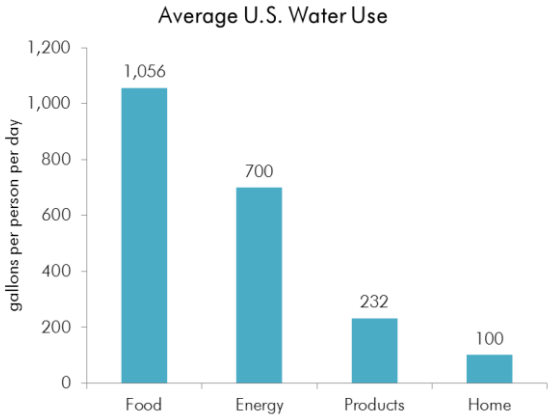

Figure 5: America's Water Footprint
Source: ***Wasatch Water Review***

How come these other factors require so much water? We can look at an example from each category. A hamburger, an American classic, can demand more than 600 gallons of water. This is attributed to growing the corn that is then fed to the cow. Other factors are included such as the transportation of that beef to your local supermarket. As much as 13 gallons of water have to be used for every gallon of gas from the pump. Even the clothes that one wears when they eat that hamburger account for more than 750 gallons of water between the cotton field and how it is processed in the factory. As far as energy consumption, energy production causes hundreds of gallons of water to be used. Power plants need water for plant cooling, fuel extraction, fuel refining and processing, so many processes within electricity generation use utilize millions of gallons of water in order to output energy. Overall, comparing this average American use to our current American population of 321,000,000 Americans we can see that our water use is out of control.

2.3 California's Water Consumption

Targeting California specifically, we find that California's main water demand is for agriculture. To be exact, around 77% of California's consumption goes to agricultural production. The reason being, that California's produces a lot of water-intensive crops, including almonds, pistachios, alfalfa, and generally the production of yield is directly related to the crops water necessity. These thirsty crops are in high demand not only in our nation but also on the global market. For example, almonds have become a $4.8 billion dollar market, so it is easy to see why farmers follow the economic trend when their land can produce it. California's Mediterranean climate, along with its fertile soil makes the state a powerhouse for agriculture but with current trends of less and less available water, farmers are turning to other options.

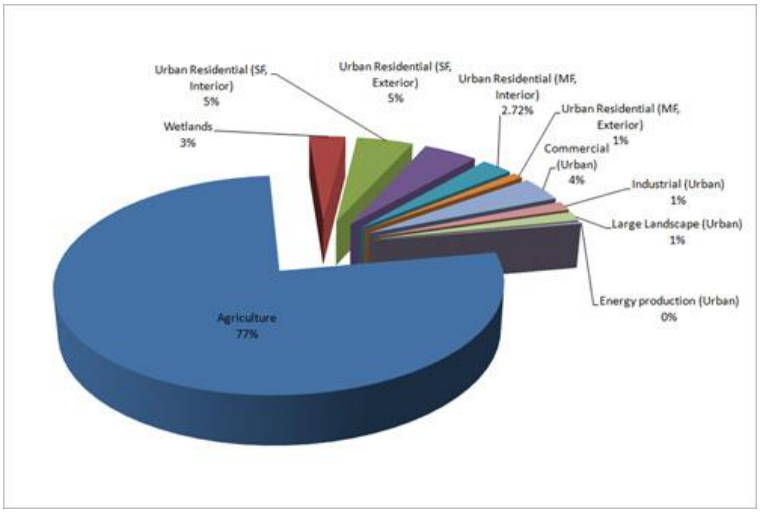

Figure 6: : **Freshwater Use in California**
Source: *UCLA Institute of the Environment and Sustainability*

With demand for agriculture increasing alongside population growth, California's farmers have had to find ways to get their water, and their solution has been groundwater. These underground reservoirs that these farmers are taking from are what analysts call "the savings account" and argue that it should not be touched. With current trends, farmers are relying more and more off of pumping our stored water and this opens up lots of problems. The biggest being the question of what happens after all of the groundwater is gone. According to NASA, "GRACE data reveal that, since 2011, the Sacramento and San Joaquin river basins decreased in volume by four trillion gallons of water each year (15 cubic kilometers). That's more water than California's 38 million residents use each year for domestic and municipal purposes. About two-thirds of the loss is due to depletion of groundwater beneath California's Central Valley." As an Australian visitor said while driving throughout the Central Valley, "If this was an Australian drought there'd be nothing growing and there would be dead cattle everywhere. You don't see that here because everyone is drawing on their savings account. But in the end you can't draw on it forever" (Bloomberg). California is

using too much water for the crisis it is currently in and nothing is going to change unless humans do something to change it.

In order to further understand why California is in its drought, we will look at California's precipitation and the current trends toward less rainfall and snowpack.

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3. Current California Drought

3.1 The Nation's Impact

The current California drought is believed to be the most severe drought California has faced in over a 1,000 years. California, the United States most populated state, is facing a crisis that currently has no expiration date. Why does this matter? Well, to start off this drought is the Nation's problem. Agriculture is currently a global $50,000,000,000/year business in California. According to American Prospect,

"What's grown in California doesn't just stay in California. Alfalfa watered with Sierra Nevada runoff fattens cattle in Japan; Salinas Valley strawberries sweeten fruit salads in New York, and Central Valley almonds end up, well, everywhere. The state supplies 80 percent of the world's almonds and California farmers produce about half the fruits, nuts, and vegetables that grace Americans' tables." (http://prospect.org/article/why-californias-drought-nations-problem)

Current calculations have indicated that prices are already going up for food grown in California, meaning more money out of consumer's pockets. With California producing 25% of the nation's food, we can easily see why no water for agricultural production is a problem. This drought clearly goes past the Californian border and into a deeper national problem.

In fact, the absence of rain and snowfall that we will explore is not isolated to the sunshine state. According to CNN coverage, as of "late September, 30% of the Lower 48 faced at least a moderate drought, particularly in the Southwest states neighboring California and in Texas." This dry spell is affecting Nevada, Washington, Arizona, Oregon, and New Mexico, but not nearly close to the extent that it is putting California in. The source of California's water, rain and snowfall, are simply not providing its normal surplus, and there is no indication of any to come.

3.2 Recent Rainfall/Snowpack in California

California's current rainfall and snowpack has been drastically lower than the average for the last few years. On January 17, 2014 when California's Governor, Jerry Brown, declared California as in a drought emergency, our water supply was already in critical condition. Ironically, the land that Brown gave his press conference usually averaged around five feet of snow for that time of year but that day there was absolutely no snow on the ground. The snowpack has hit an all-time low. According to the California Department of Water Resources,

in 2015 “California set a new ‘low water’ mark with its early-April snowpack measurement. The statewide electronic reading of the snowpack's water content stood at 5 percent of the April 1st average”. Not only did the snowpack hit a low, rainfall is just as scarce.

As of 2015, rainfall is significantly lower than the average. According to the California Department of Water Resources, in 2015 “between those early-February storms and late March, less than two inches of rain was recorded at the eight stations DWR regularly tracks in Northern California, where precipitation is captured for distribution by the State Water Project and federal Central Valley Project. Historically, at least 10 inches of rain would have fallen at those stations during that period. Conditions were even drier in the San Joaquin and Tulare regions of the Central Valley; precipitation there was less than 45 percent of their historical averages by late March”. These examples of below average rainfall and snowpack are a very common theme across the state. The 2015 Water year has been one of the worse the state has seen in hundreds of years and who is to say it will be the last.

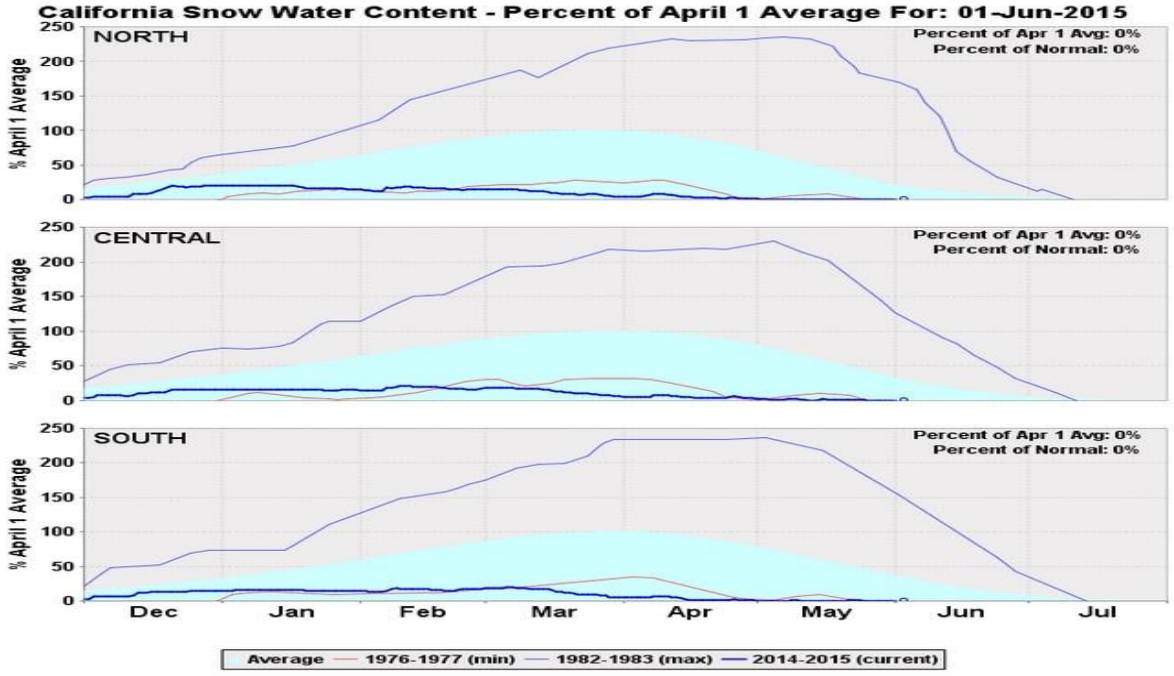

Figure 7: 2015 California Snow Water Content
Source: *The California Weather Blog*

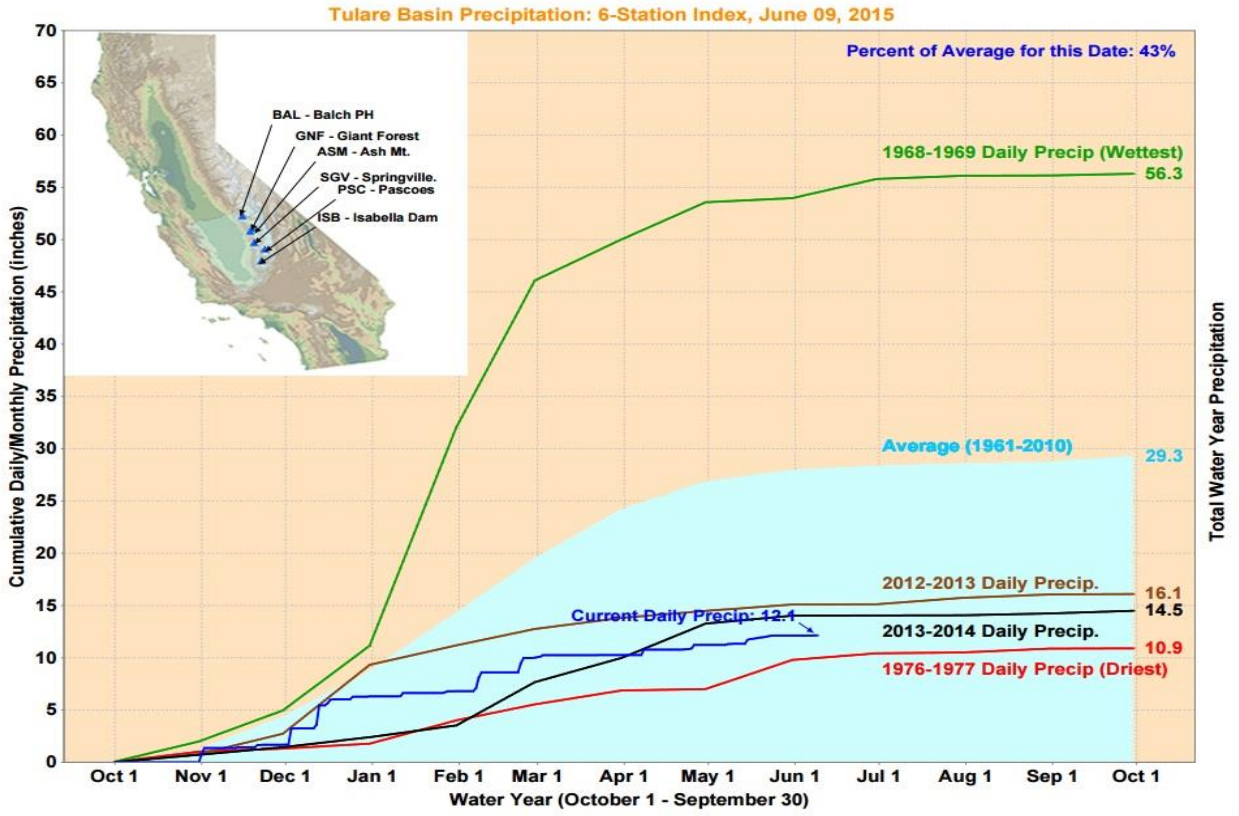

Figure 8: Tulare Basin Precipitation
Source: *Northern Sierra Precipitation Index*

3.3 Prospective Future

California has been in a drought for the last four years. Starting in 2011, California has been experiencing abnormally dry conditions and every year since has gotten worse.

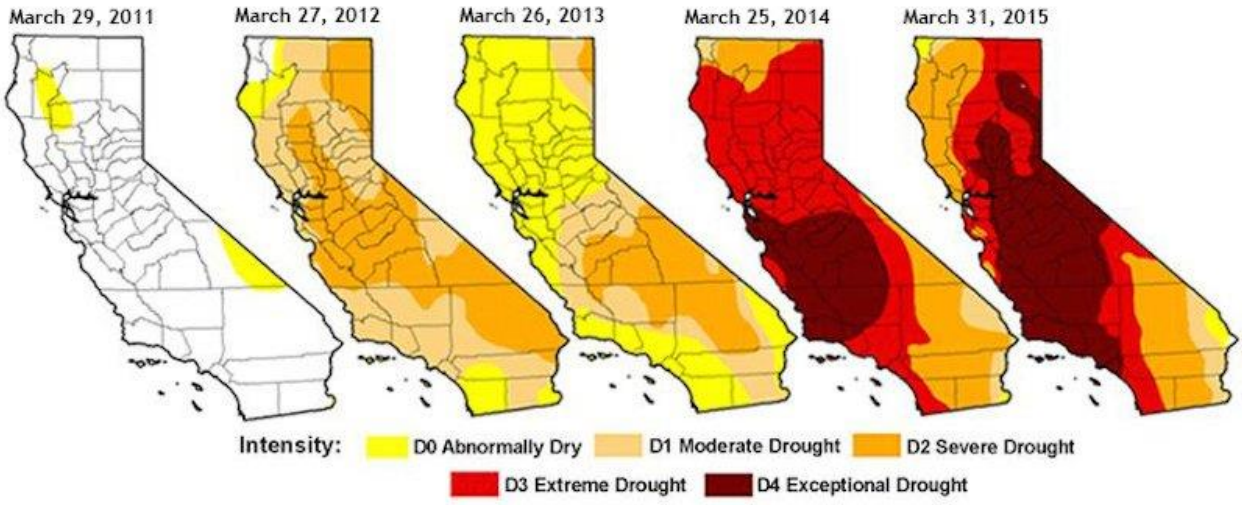

Figure 9: California Drought Monitor
Source: *U.S. Drought Monitor Map Archive*

The big question for California is what next? At California's current rate of consumption and with the sky not producing our rain or snow, California is set to simply run out of water. There is no scientific evidence that there will be wet trends coming to California and according to a recent NASA article, "It will take about 11 trillion gallons of water (42 cubic kilometers) -- around 1.5 times the maximum volume of the largest U.S. reservoir -- to recover from California's continuing drought" (NASA). With current trends we are simply set to run out of water in 2016. What happens then? We can see that something needs to happen. California's last drought extended from 1928 to 1937, 5 years longer than what we are experiencing now. Hoping that the sky will provide for us isn't enough; California needs to take action.

Before looking at what California should do, let's look at what legislation has already been implemented in response to California's water crisis.

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4. Water Policy

4.1 California's Mandatory Cutback

As concerns have risen from the current water crisis, the state's officials have responded. California Governor Jerry Brown, after declaring the state in a drought emergency, took action by asking Californians to voluntarily cut back their water use by 20%. Although only a plea, experts say that a plea instructed by a governor has been effective in the two other statewide drought declarations since 1987. Did the plea work? Yes, but not to the extent in which Brown hoped for. As we see on the State Water Resource Control Board, the goal of a 20% cutback was met only one month since the implementation, and to kick off 2015 we were still below normal water usage but not nearly as close to the desired 20%.

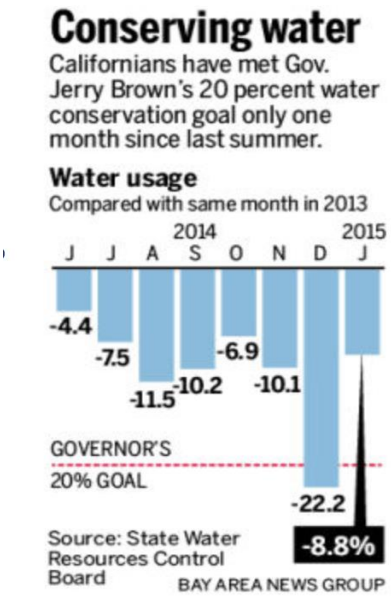

Figure 10: 20% Cutback Outcome
Source: *State Water Resources Control Board*

With the drought getting significantly worse since Brown had previously issued his voluntary cutback, Brown then responded by imposing an immediate mandatory water restriction this last April (2015). The restriction orders cities and towns to reduce usage by 25%, impacting residents, businesses, and farms. The cut would be equivalent to around 1.5 million acre-feet of water (487.5 billion gallons) over the following nine months. Brown's executive order would also impose cuts on large landscapes including campuses, golf courses, and cemeteries. His order will:

- "Replace 50 million square feet of lawns throughout the state with "drought-tolerant landscaping."
- Create a temporary, statewide consumer rebate program to replace old appliances with water efficient models.
- Prohibit new homes and developments from irrigating with potable water unless water-efficient drip irrigation systems are used.
- Ban watering of ornamental grass on public street medians.

- Require agricultural water users to report more water use information to state regulators, increasing the state's ability to enforce against illegal diversions and waste."

As Brown says, "the idea of your nice little green grass getting lots of water every day, that's going to be a thing of the past. This historic drought demands unprecedented action" (CNN). As great as half of a trillion gallons of water being saved would be, the estimated 11 trillion gallons needed to recover from the drought is still staggering over our politician'sheads.

Figure 11: **Example of Drought Tolerant Landscaping**
Source: *Mooch Exterior Designs*

4.2 Emergency Drought Package

In late April, 2015 Governor Jerry Brown, prompted with the continuous drought, signed Assembly Bills 91 and 92 allocating more than $1 billion towards drought relief and critical water infrastructure projects. According to the California State Water Resources Control Board, the package will accelerate more than $110 million towards direct assistance of communities and workers affected by the drought. Another $267 million will go towards bond funding for Proposition 1 that will deal with safe drinking water and water recycling. The majority, around $660 million, will go towards Proposition 1E focusing on flood protection in urban and rural areas. This package is the largest known to California in regards to direct drought relief.

The Californian government can only do so much; it is truly up to the population to really cut back their water use. In order to do so, Californians need to understand what water conservation techniques they can follow in order to save the most amount of water possible.

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5. Water Conservation Techniques

5.1 Agricultural Production

With over three quarters of California's water being used for agricultural production, there are many agricultural techniques that have been used in order to save massive amounts of water. Our main focus will be on irrigation and how water is dispersed to agriculture. To start off we will explore drip irrigation.

Drip irrigation differs from traditional watering in that only what water is needed for the plant is dispersed to it. It consists of long tubes small slits along those tubes at the location of the plants. Whenever watered, the water slowly drips out the slits and gets absorbed into the small surrounding area of the plant, as opposed to water being flooded all around the plant. It is easy to understand why this method saves water, and in fact it saves hundreds of gallons of water. It is by far the most efficient way of getting plants their water.

Figure 12: Drip Irrigation
Source: ***Africia Agribusiness***
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Figure 13: Example of Watering Technology
Source: *Gadgetify*

Technological advancements in agriculture are also a huge step forward to water conservation. Mobile apps can be downloaded by farmers to set scheduled water time. Likewise, a farmer can easily turn off scheduled irrigation if rainfall does supply the crops. Having a set schedule, at night for less evaporation, and at the most minimal amount that the crops need, adds up a huge savings not only for water conservation, but more money in farmer's pockets. Many other techniques such as rotating crops, leaving plant residue in fields, and no-till farming can save just as much.

5.2 Recycling Greywater

Nationally, the United States population uses around 30% of their residential water for landscape irrigation. If we look at the Western United States this number is significantly higher with 70% of residential water going towards landscape irrigation into yards, backyards, gardens, and other landscaping applications. If we compare this to our average 100 gallonsof water a day per person being used for domestic purposes, we are looking at upwards of 40 gallons of water a day (subtracting water leaks and toilet use) being used and then simply thrown away. If we look at an average family of gout (4) this is as much as 58,000 gallons of water per year that is used just once for simply washing our bodies, clothes, dishes and other accessories.

This water, after its first use, has small particles in it such as traces of dirt, food, grease, hair, and certain household cleaning products, but as dirty as the water looks, the 58,000 gallons that are used just once in a household called “greywater” can go back into landscape irrigation, or be used for toilet water. How – through commercially sold systems. These systems known as ‘greywater recycling’ systems not only conserve water, but also help save on water bills, and even offset pollution into our rivers and lakes. If the greywater from a household is released into these water sources its ‘nutrients’ become pollutants, but if fed into irrigation the nutrients become valuable fertilizer to plants. As Greywater Action, a coalition of educators, reports, “Reusing greywater for irrigation reconnects urban residents and our backyard gardens to the natural water cycle.” The systems, a bit pricy at first, pay themselves off within a few years and more importantly save tens of thousands of gallons of water.

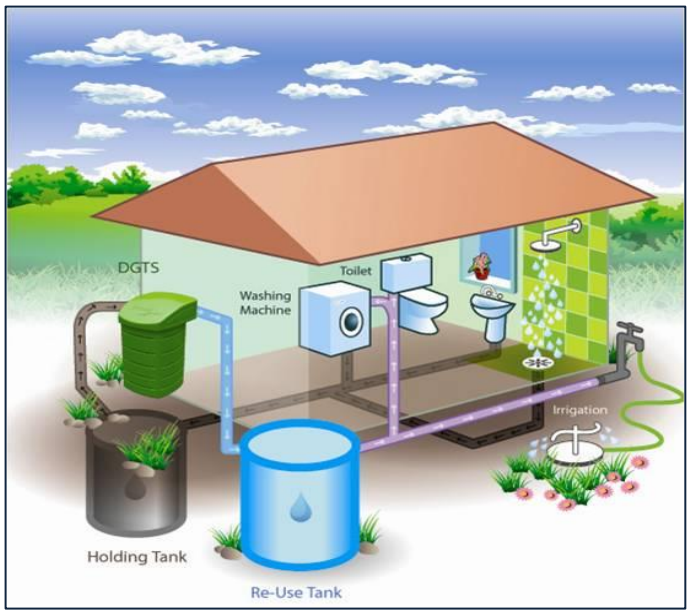

Figure 14 . Greywater Recycling System
Source: *Master Craft Design and Build*

5.3 Household Installations

Beyond implementing greywater systems, there are countless household techniques and initiatives that homeowners can implement for saving water. We can explore these conservation techniques by breaking them up into two categories, installations and practices. Let's start first with what homeowners can install in order to save the most water possible.

The majority of residential water goes to washing clothes, dishes, and the residents themselves. Installing aerators on sinks, low-flow showerheads, high efficiency toilets, water efficient dishwashers, and water efficient clothes washer, ensures that the least amount of water is used for these necessities. All save hundreds of gallons of water each so let's look at each individually:

- Aerators on sinks: costing less than $10 per sink, can average out to saving a family 700 gallons a year.
- Low-flow showerheads: costing no more than $20 a head, can save a family close to 3,000 gallons a year and even save energy by reducing demands on water heaters.
- High efficiency toilets, costing around $300 per toilet, reduce water use by 20-60%, averaging around 13,000 gallons of water per year. Although pricy at first, a water efficient toilet could save more than $2000 over its lifetime. The U.S. Environmental Protection Agency even calculated that nationally if all inefficient/old toilets were replaced with high water efficient models, the United States "could save 520 billion gallons of water per year, or the amount of water that flows over Niagara Falls in about 12 days."
- Water efficient dishwashers: costing around $400 per dishwasher, can save at least 1,600 gallons of water over its lifetime compared to older models of dishwashers. If a house does not have a dishwasher, installing one can save around 5,000 gallons of water a year compared to hand washing dishes. Also, a dishwasher uses half as much energy and cuts the time it takes to do dishes significantly.
- Water efficient clothes washers: costing around $400-500, not only save energy, but use only 13 gallons a load compared to a standard machine using over 20 gallons a load. This averages out to more than 3,000 gallons of water saved a year for a typical family.

5.4 Household Practices

We can see that thousands of gallons of water can be saved every year if these items are simply implemented, but there is still plenty room for more conservation. We will now look at certain practices homeowners and residents can start in order to save thousands of more gallons. They include:

- Cutting shower times in half.
- Turning off faucets while brushing teeth and shaving.
- Not washing dishes off before putting them into the dishwasher.
- Fixing water leaks around the house (toilets/washers).
- Collecting cold water in buckets while waiting for the shower to warm up.
- Xeriscaping (planting drought-resistant plants).
- Replacing lawns with more water efficient designs (rocks, dirt arrangements)
- Watering the lawn only twice a week at night only and waiting until 48 hours after a rainfall before watering again.
- Not washing cars.

On top of these practices, there are also major steps to be taken with what a homeowner's local area offers. For example, cities like Sacramento "offer rebates to residential and commercial customers to help pay for water efficient upgrades to homes or businesses." This includes rebates to high efficiency dishwashers, clothes washers, toilets, and river-friendly landscaping. These rebates and services exist all over the state. For example the San Francisco Bay Area offers rebates as well as a service called the free 'Water Wise House Call Program'. This service sends a surveyor to a household and checks their water usage, teaches the homeowner how to read the water meter, surveys the irrigation system, offers replacing toilet flappers leaks, provides a personalized irrigation schedule, and even installs free showerheads. Homeowners should check with their local water companies to find services and rebates such as this to further help save our finite resource.

Figure 15: Water Rebates
Source: *Rain Bird*

5.5 Personal Initiatives

As we explored earlier, domestic water use is only about 5% of our total use. The majority of our use comes from what some call 'virtual water', the water we never see directly used. This virtual water stems from two main categories: diet and energy consumption/transportation use. In this section we will focus on what absorbs the majority of water use, diet. Diet engulfs around 2/3 of our total water footprint. As Grace Communication Foundations writes,

> "Let's take a look at a typical lunch. A loaf of bread requires about 240 gallons of water, and a pound of cheese takes about 382 gallons. So a simple cheese sandwich takes about 56 gallons of water. Throw in a small bag of potato chips at 12 gallons and you just ate about 68 gallons of water. Add some turkey and it jumps to 160 gallons! Thirsty? Rinse your sandwich down with an ice cold soda and you can add an extra 46 gallons of water onto your tab."

If we were to follow this for every meal, it is easy to see why diet is the major water consumer. Diet will never fully be 'water-proof' but there are many different ways the human population can drastically drown this major footprint.

A good place to start is eating lower on the food chain. This means eating more fruits and vegetables rather than animals and dairy. According to the United Nations Food and Agriculture Foundation, "it takes nearly ten times as much water to produce a kilogram of beef as it does to produce the same amount of wheat. Switching from a meat-centered weekly menu to a diet rich in vegetables and grains could save 2,500 liters of water a day. Choosing grass-fed meat can also save water because pasture requires less irrigation than feed crops to maintain." In fact, someone who eats vegan (doesn't eat meat or dairy) is consuming 600 gallons of water less than a person who eats an average American diet per day. If not willing to go vegan, like most of the population, a good place to start is implementing 'Meatless Mondays' in households.

Another initiative is to stop eating certain foods that require massive amounts of water to grow including nuts (almonds/walnuts), coffee, processed foods, eggs, rice, avocadoes, and soybeans. These crops are very water intensive and even one cup of coffee indirectly takes 55 gallons to grow the coffee beans. More importantly, a huge initiative people need to make is not wasting their food. The United Nations Food and Agriculture Organization reported that approximately 1/3 of all food that is produced for humans are wasted through storage, production, consumption, disposal, and transportation. This is equivalent to 11 trillion gallons of

water annually that is simply lost through food waste in the United States alone. That number, 11 trillion gallons, looks familiar because it is the amount of water needed to get California out of its drought. If people are more conscience of not wasting their food in their fridge, pantry, and freezer, and simply buying what they need and nothing more, this takes a huge chunk out of water use and can help California out drastically.

Figure 16: Global Food Waste
Source: *The Chicago Council*

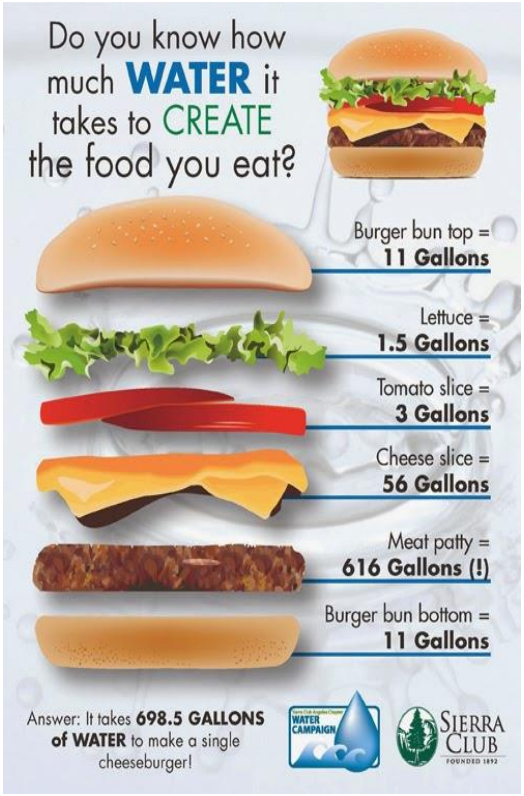

Figure 17: Watering Your Diet
Source: *Ithaca College*

An important thing to consider is how certain areas have dealt with similar droughts. By looking at previous solutions we can take into account what is possible in regards to how California needs to act.

6. Previous Drought Solutions From Around the World

6.1 Israel

Israel has recently dealt with one of the most severe droughts in its modern time. It began in 2005 and peaked in the winter of 2008-2009. According to a NY Times article, Israel's main water sources, the Sea of Galilee and their mountain and coastal aquifers, were severely depleted and were threatening an almost irreversible deterioration of their water quality. Fast-forwarding to 2015, Israel has plenty of water. How did Israel get itself out of its water crisis?

What Israel first did was heavily tax household water consumption, targeting families with pools, leaky pipes, and lawns/gardens. The country was placed under a microscope and the population was forced to cut their shower times and even not wash their cars with hoses. These measures, taken at the beginning of the drought crisis, were saving water but Israel's national solution came from ultimately desalinating the Mediterranean seawater and recycling the wastewater the country was already producing. The country, even if it were to undergo another drought, now has enough water for its total needs. It's estimated that over 50% of Israel's household, agriculture, and industrial water is currently artificially produced.

Figure 18. Israel's Part-Desert Climate
Source: *The Seattle Times'*

Israel currently has five desalination plants producing over 130 billion gallons of clean water annually and Israel plans to be pumping 200 billion gallons by 2020. Alongside this, the country treats over 85% of its domestic wastewater, putting 55% of it into agricultural use. According to Water Authority Data, the United States stands at recycling only 1% of wastewater, well behind Israel and many other countries. Israel's solution was fast paced and provided a reliable source of water to its population, fixing the drought crisis they were in. Disregarding environmental impacts, Israel provided a solution that could very well be implemented in California.

6.2 Australia

Australia has also recently undergone one of its worst droughts on record. In particular, the city of Melbourne, housing 4.3 million people, experienced an all-time low capacity of its water level (only 25.6% of water level before drought started). Even though this situation was the worst the city has ever seen, Melbourne ended up reducing its water demand per capita by 50%, letting them ride out the dry spell. How did Australia do this?

The answer is by simply implementing some programs and policies. According to the Scientific American, Australians did the following:

- Prior to the drought, in the late 1980s, the city passed legislation that set the groundwork for an integrated government response in case of a drought. Federal entities provided funding to the state of Victoria, which in turn distributed money to the city of Melbourne. A regional water manager had the power to force water utilities, city agencies and reservoir managers to cooperate.
- The government invested millions in infrastructure. That included a pipeline that would deliver water over mountains and a water treatment plant. It also invested more than $6 billion in the construction of the Wonthaggi Desalination Plant, which to this day has never been used.
- Rebate programs for residential graywater systems—used for gardening—were implemented.
- The government invested heavily in increasing the use of recycled water for both the agricultural and urban sectors.

On top of this, the population had a significant impact. Water restrictions were implemented and many educational programs were created, informing the public on the drastic crisis. In fact, at the end of the drought around 34% of the citizens in Melbourne invested in rainwater holding tanks. Preceding the drought, the average resident in Melbourne used around only 41 gallons of water a day (compare this to the average 100 gallons of Americans). Australia's solution to its drought varied from Israel's but put them in a position to ride out the dry skies. Compared to Israel, Australia never touched its desalination plant. According to the Scientific American, Australia's desalination plant "created an environment where there was some water security. In case the other stuff, which was more experimental and environmentally friendly, didn't work, they could always turn on the desalination plant. It created an environment where they were able to innovate, whereas without it, they might have been more reactionary." Melbourne simply prioritized its conservation efforts and kept its Plan Z (desalination), at its rightful position.

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7. California Action Plan

7.1 Preparing For the Worst

The mentality that California should have right now is that there is truly "no end in sight". A true statement, but going past a mentality, this is how the action should be shaped. As we explored in Australia, they set themselves up with a sense of security. Their desalination plant was their last resort and created an environment where they had a plan B but preferred a healthier, different plan. Focusing on California, we already have that 'security'. The State Water Resources Control Board has already approved statewide standards for the regional production and operation of desalination plants and currently we already have desalination plants up and down the coast. Although none are currently running, plans for production started in the Fall of 2015. Projects like the Carlsbad Desalination Plant (projected to start production in 2015) will be providing 50 million gallons of freshwater per day to southern California. As good as this may seem, it is too early to resort to our security action. There is plenty that California can do before running expensive, and un-friendly environmental options. California needs to manage what is already has.

7.2 Managing What California Already Has

New regulations, fixing infrastructure (leaks/spills), and simple conservation should be on the top of California's list. Why buy a brand new car when all you have to do is fix a part on your old one? Desalination is this new car. What California needs to do before it goes and invests in something it doesn't quite need yet is to try and fix its initial state. California needs to learn to manage what it already has, not what it might not need. The state has a lot of water that is wasted, whether it's from a domestic setting or from a city pipeline, there are millions of gallons wasted everyday through leaks/misuse. Fixing simple infrastructure in towns/homes is a great place to start.

Another huge implementation that the California government needs to act on is management of groundwater. At the moment there is no recorded or managed groundwater that officials can look at. Farmers are completely depleting the water that their land is on because their sources are either running out or being prohibited by the government. What needs to happen is managing the water that we do have in our 'reserve' by regulating, managing, and taxing it while also doing all we can to recharge the source when its completely out. Just because

groundwater is directly below a parcel of land does not give the population living there the right to deplete it entirely. Rather, groundwater should be managed as a public resource and be regulated just as most surface water is.

Figure 19: Groundwater Irrigation
Source: *The Sentinel*

7.3 Social Obligation

The last thing to touch on is how the public sector of not only California, but also the world views water conservation. As we saw in Australia earlier, 34% of the citizens in Melbourne invested in rainwater holding tanks after the drought was over. They did this because they were informed through the public about the entirety of the drought. It's really up to the population to teach the rest of the population about how we can conserve our precious water. Whether it's commercials, billboards, classes in schools, raising water prices, connecting houses directly to own water source, word of mouth or actions in legislation and towns, we can all come together to significantly decrease the impact of the world's periodic droughts. There are countless initiatives and countless emerging ways to offset dry spells created by climate change and it takes the cooperation and knowledge of the public to fix our problems.

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8. Conclusion

There is absolutely no doubt that California is in a major water crisis. There is also no guarantee that water will be coming from California's skies anytime soon. This is why California, along with every other region in the world should start focusing their attention on water conservation. There are trillions of gallons of freshwater on this planet but with human population and current rate of consumption there is absolutely no way humans will be able to maintain this precious resource. What we are learning here in California has happened before, thousands of times around the earth, but as climate change worsens we can be expecting even more severe droughts. Planning, executing, and leading this water war is a crucial aspect of preparing for the future and without a plan our rivers, lakes, and reservoirs are going to simply dry up. As Thomas Fuller said, "we never know the worth of water until the well is dry."

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