Nick Aldrich, Elise Bossert, Bryce Currie

Abstract, Compilation, Conclusion, Bibliography

EGRS/EVST 373

May 2018

Abstract

Historically, humans have always acted in an anthropocentric manner, putting themselves before nature. Separating humanity from nature made it easier to exert power over it and people dominated any resource that they could get their hands on, especially water. Water kept being taken without any hazard of consequences because it was seen as an unlimited resource. The problem that this project addresses is the global freshwater crisis which has become a larger dilemma as the population has continued to increase. While the amount of freshwater on the planet has roughly stayed the same, the population has grown tremendously over a short time period with more people demanding freshwater, but less becoming available to us. Although this is a global issue, this project specifically focuses on the state of California, one of the most water-stressed and populous states in the country. The accumulation of droughts along with pollution, waste, an overdraw on aquifers, and other damaging practices have made freshwater particularly scarce in California.

In this new world in the year 2040, families and homes are now required to conserve and reuse water with the expectation that they cannot rely on finding more of it. This also extends into the commercial and agricultural sectors of everyday life. Large businesses as well as farms are required to utilize practices that will use less freshwater and also incorporate grey water into various tasks. While people may wish freshwater was unlimited, it is not possible so the strategies and technologies that have been used and will continue to be created make it possible to make better use of the water we do have, while putting nature first and turning domination into management. As a result, we no longer waste so much water and are more conscientious and thoughtful about our actions and their implications.

Over the last forty years or so leading up to 2040, water reuse has become a prevalent practice in an effort to save as much water as possible and several solutions have been put into place. Many people in California were using pure freshwater for purposes that could instead use recycled water as an alternative. By beginning to use recycled wastewater, the amount of wasted pure freshwater is reduced. None of the solutions seek to control or dominate nature, but rather try to work with nature to create new ways of treating water to be used in a way it would not have been otherwise. Some of the methods created from a public and commercial perspective include implementing greywater recycling systems outside of all homes and commercial buildings, limiting the amount of freshwater intake per month for each citizen, and building large wastewater recycling plants. For the agricultural sector, farms implemented micro-irrigation systems as well as hydroponics that provide the exact needs to the plants appropriately while conserving water. Finally in 2040, desalination plants have been created in California to utilize and treat sea water for everyday tasks.

In 2040, everyone in California grasps how precious a resource water really is. The systems implemented have helped citizens to better understand the freshwater crisis and make better decisions about using their water. These technologies not only reveal how valuable water

is, but they also mediate our relationship with water in a different way. We must keep recycling water and thoughtfully and carefully manage how we use it.

Compilation

Introduction:

The following digests in this compilation are meant to convey the perspective of the general public, scientific community and archival community on the topic of water reuse in California during the year 2040. These digests also contain rare insight and understanding into what it is like to live in 2040 and experience the water shortage and resulting changes. They were written and oriented to paint as accurate a picture as possible of what living in California in the year 2040 is like. Including not only the downsides of the new future, but also the positives that have come out of this crisis. Hopefully they cohesively work to share all of the struggles, experiences, and triumphs that occured over the course of the great water shortage. When delving into these excerpts and accounts, a reader should come across the idea of humans controlling nature. The citizens who wrote these pieces share first hand experiences of how controlling nature inevitably ends with people at the mercy of it. To pair nicely with this, the archivists' accounts will be able to provide a more grandscale perspective on how humans have made mistakes in trying to dominate nature and how those experiences have influenced and changed the ways that humans understand nature. Finally, excerpts from the scientific community will provide ample insight into how humans are now working away from dominating nature and towards managing nature sustainably with proper technologies.

Section 1: The Archivist Perspective

Digest #1

As an archivist, I have noticed a big change throughout the last few decades which has led to a global freshwater crisis. While the amount of freshwater on the planet has roughly stayed the same, the global population has grown tremendously over a short time period. In 2000, the global population was just over 6.1 billion people. Now, in 2040, it is roughly 9.2 billion. With the majority of our water being seawater, which cannot be consumed by humans, only a very small percent of it is fresh and less has been available to us as the population has grown and only continues to do so. Over the last forty years or so, water reuse has become a prevalent practice, especially where I live in California, in an effort to save as much water as possible. Many people in the state were using freshwater for purposes that didn't need it so using recycled wastewater helps to reduce this. Recently, the accumulation of droughts in California, one of the most water-stressed states, along with pollution, waste, an overdraw on aquifers, and other damaging practices have made freshwater scarce. Our state government has recently required that families conserve and reuse water with the expectation that they cannot rely on finding more of it. Being a historian and an expert on this topic, I intend to conjure up the history of water recycling, specifically in California, to see how we have gotten

to this point. I will also look at what current practices are being implemented to ensure that water is reused as much as possible.

Back in the earlier days of this century, the Environmental Protection Agency of the United States said that "water recycling has proven to be effective and successful in creating a new and reliable water supply without compromising public health" (EPA). I would agree with this statement since water reuse is even more prevalent now in the year 2040 than it ever was in its beginning stages. Everyone in California recycles non-potable water now, which can't be consumed, but can be used for other purposes. It has become very widely accepted over the last forty years as treated wastewater can be used for "irrigation, recharge of aquifers, seawater barriers, industrial applications, dual-distribution systems for toilet flushing, and other urban uses" (Angelakis & Snyder, 2015). With the implementation of treatment equipment throughout the state, I have noticed more communities moving forward in creating new systems to allow for even more uses of this reused water (M.W. Watermark, 2016).

Looking back on the origin of recycling water, I've seen that "wastewater treatment and reuse is not new, and knowledge on this topic has evolved and advanced throughout human history" (Angelakis & Snyder, 2015). Going way back to prehistoric times, civilizations like Mesopotamia used wastewater for irrigation. Later on in Europe in the sixteenth century, it was used for crop production. The first modern wastewater treatment systems came about in the mid-nineteenth century, but the practice of water reuse began in 1932 when treated water was used to irrigate Golden Gate Park in San Francisco. As a proud Californian, this is a fact I love to tell people! There has since been a lot of progress in our state. With an increase in global water demand by 55% since the year 2000, with much of the demand driven by agriculture, Monterey County has become an inspiration (Smedley, 2017). In 1998, the area started to use reclaimed water to irrigate 12,000 acres of crops. This project still operates to this day and has been very prosperous (M.W. Watermark, 2016). Monterey County's practices have since inspired Californian farmers all over the state to follow suit and use reclaimed water in this way to decrease the amount of freshwater needed and still grow crops successfully.

A little over twenty years ago, which feels like forever ago considering the significant changes that have been made in California since, the rate of reuse was "nowhere near enough to provide the supplemental resources needed to help reduce the state's vulnerability to droughts and other water-supply constraints" (James, 2016). In 2011 to 2016, Californians suffered the state's worst drought in 1,200 years (Smedley, 2017). "Its major aquifers receded at a combined rate of 16 million acre-feet per year, and roughly 1,900 wells ran dry. Then, in the first three months of 2017, rain fell at 228% more than its normal level" (Smedley, 2017). I remember when the Oroville Dam had become so overwhelmed by the rush of water at the end of this record rainfall, that its spillway eroded and residents in the county had to be evacuated. A friend of mine living just a few miles from the dam had said that he was just one of almost 200,000 people who had to leave. Despite the magnitude of the rainfall, it did not refill the aquifers. Only

after ten years of rainfall did they fill back up. Citizens in California, myself included, were ready to bring water recycling into their daily routine.

A survey conducted in California in 2016 "found that 76 percent of respondents believe recycled water should be used as a long-term solution, regardless of drought" (James, 2016). Not only did people want to reuse water, but they were required to in 2030 when our state government called for every household to have water reuse systems outside their home. In the first quarter of the century, greywater reuse systems were implemented, but as the freshwater crisis became more severe, a wastewater reuse system was heavily researched and implemented throughout. The state government also began putting limits on the amount of freshwater intake per month for each citizen. Knowing that the average person uses roughly 80 to 100 gallons of water each day, the government set a limit of 2,000 gallons of water to be used per month by each resident of the state (Perlman, 2016). Based on what I've seen in the last forty years, this is much better than just telling people to use less water, which does not work. Also, limiting freshwater intake per person as opposed to doing it per household allows for better management and is more equitable. For instance, some families which may only have two children will be held equally accountable as families with four children. In Los Angeles, large scale water recycling plants were implemented less than five years ago. It is possible that in the near future, desalination plants to purify seawater will be built in California and other parts of the United States. Australia's drought that lasted for twelve years at the beginning of the century had state governments there building these plants, which has inspired California to do the same (Phillips, 2015). Additionally, farmers and owners of large commercial buildings have been urged to look into possible leaks and faulty pipes in their irrigation systems. More efficient irrigation methods have been put in place recently, such as micro-irrigation systems, which use lower pressure and flow than a traditional system. Since the start of the twenty-first century, there has been an increase in the science and technical understanding of the water industry, as well as an improvement in the quality of wastewater (Cotruvo, 2015). The current practice of water reuse is very positive in California, and its future looks promising. It has been and will continue to be an integral part of how citizens in this state live their everyday lives here on out.

Digest #2

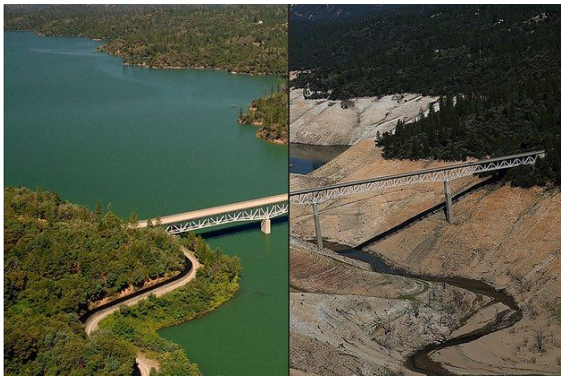
Here in 2040, we are in the midst of dealing with the worst California water crisis in recent history. How did we get here? There are a few specific factors that have developed over time that have pushed us to the breaking point, and then beyond that to where we are now. One of these factors is the exponential population growth that has gone unchecked. In 2000, the global population was just over 6.1 billion people. Now, in 2040, it is roughly 9.2 billion. Now while all of these people need water for consumption and hygiene, the real issue lies with the amount of food needed to support that population, and the amount of water that the traditional agricultural process takes. In fact, 70% of the water consumed around the period of 2018 was

consumed by agriculture. As time has passed, and what was once a passing drought (referring of course to the mid 2010s California drought) has now become the status quo, forcing us to adapt.

Among those adaptations is water reuse, a technology that has existed since before our crisis began. In the past, water recycling was approached fairly unenthusiastically, but the initial California drought really opened the door to the beginning of public acceptance of this technology. This was the lasting impact of this historic drought, critical in shaping the world we have today. After enduring receding aquifers and restrictive living conditions, along with the general unease of living water-limited, Californians were eager for a long term solution that would provide them with greater water security and also allow them to more efficiently use the fresh water that they did have. And so, wastewater treatment plants began springing up, recycling greywater and other wastewater into nonpotable clean water that began to find huge success in irrigation and industrial uses.

In addition to the implementation of water recycling systems, the state government of California has also begun to enforce a 2000 gallon per month per citizen freshwater use limit, in order to deter wasteful habits. With these measures in place, the state of California is currently holding steady, however, the government is still looking towards the future, specifically the possibility of government subsidized farm conversion, transforming traditional farms into large scale hydroponics operations in order to further save on water usage in the state.

Archived Photos:



The long infographic on the left is an example of information dispersed to the public during the great drought of California. The image in the bottom right shows the drastic changes in water level during the same drought in the early twenty first century. Finally the top picture depicts an example of a water reuse system being implemented in a water recycling building.

Explanation:

To clearly understand the freshwater crisis, it is crucial to have a historical account of the timeline. The archivists above provide in depth analysis into the development of the water shortage in California explaining possible causes such as population booms and improper agricultural processes. Along with the causes, the archivists are able to display the temporary and lasting effects of the California drought. If you look at the picture above that an archivist dug up from the early 21st century showing a dam before and after the great drought, one is able to clearly visualize the issue at hand. In order to act appropriately to any situation, it is important to understand what past courses of action were. The archivist provides detailed accounts of the transition to and implementation of new technologies such as water reuse systems into Californian life up until present day in the 2040s. Combining causes, effects, problems, and solutions into one report is pivotal to keeping this crisis as a reminder of what could happen going forward into the second half of the twenty first century if humans stray from their new sustainable path.

Section 2: The Perspective of the People

Digest #1

The year is 2040, and a lot has changed since 2018. Although some great things have happened in medical care and transportation, one of the most influential worldly changes is the fact that we are currently running on absolute final reserves for conventional fresh water. I look back with awe at the times when I used to brush my teeth and leave the sink on the entire time; to do so today would be a major faux pas. In 2018, people used water as if it was a limitless resource, they'd water their lawns, spray off their dogs in the summer, fill entire swimming pools, etc. In retrospect, it was absurd to think that an exponentially growing population on a planet that was already struggling to fulfill water demand could just ignore the issue until it went away. In 2040, new, fresh water is a precious commodity, one that not everyone can afford.

About 5 years ago was when the crisis first really took root in the minds of Californians. In response, the state government passed a few key pieces of legislation, almost unanimously due to the public outcry.They based it on the plan implemented in the 2010s in California in response to drought. Through a cap and trade system, businesses and corporations are required to remain under a predetermined maximum monthly water consumption limit. As per cap and trade, they are able to buy and sell water credits either back to the state government or to other businesses with high water consumption needs. For homes and personal use, the government employed command and control style legislation by creating a tiered system of allowed amounts based on

the number of people dwelling in a residence. The limit resets monthly. These regulations have produced some remarkable changes in the way that things are done;and in how daily life is conducted.

As a farmer in California, I have been affected immensely by both the shortage and of course the resulting legislation. In order to keep the agriculture industry from going under, the state subsidized the conversion of traditional farms such as mine into hydroponics facilities. Hydroponic facilities use a closed water loop, recycling the same water continuously with minimal replacement. Growing lettuce in a hydroponics system uses 10% of the water that a traditional farm would use. But that's not the whole story. While they may be more efficient, hydroponics systems are more expensive upfront and also the maintain than a traditional farm. Even with the subsidization that I receive from the state, I'm still struggling to stay afloat. It's often hard to look at the bigger picture and understand why my life became so much harder. I'm reminded of it constantly even in daily life, even the smallest things are different from how they once were. For example, water is no longer free at restaurants. Public fountains have been shut down; the water in them has been reallocated. Hand sanitizers and controlled water spritzers have replaced sinks in public bathrooms, and toilets have multiple flush settings on them depending on need. Every time I shower now I take a navy shower just a little bit more. The most visible sign of the times can be seen from your car window. Lawns as they were in 2018 are a thing of the past. Today, people either allow them to grow in naturally or they lay down turf-like surfaces that mimic grass. Landscaping that involves ultra low water maintenance plants such as cacti and other desert plants.

Another development that this crisis has produced is a relative ubiquity of "recycled water", water that was disposed of as wastewater and then was chemically sterilized and filtered back to its original clean state. This practice had long been employed in water-poor but economically wealthy places such as Singapore. In fact, Singapore's NEWater membrane filtering technology was the system first implemented through the water scarcity legislation. NEWater is available from the tap and in bottles sold everywhere (filled and sold upon request, so as to avoid a surplus of inventory and thus the possibility of wasted water) that used to sell Poland Springs. NEWater is much more affordable than fresh water, and is actually often cleaner than the original water; however, one of the biggest struggles in this crisis was actually not technological or policy related, it was the fact that many people simply turn their nose up at the idea of drinking recycled water. When the program kicked off and original water began to increase in price, a class divide began to emerge between those with the means to continue buying original water and those who were essentially forced to rely on recycled water.This divide caused deep problems, as the "dirty" recycled water became increasingly associated with people of lesser means. Personally, I've never had an issue with actually drinking the stuff, they run more than enough chemicals through that water to kill any and everything in it. But I'll admit it doesn't feel great knowing that while I'm struggling to handle the upkeep on my new and very

expensive farm and drinking something that was once in a toilet, there are still people who have the money to remain largely unaffected by this.

My biggest fear is how this divide will scar our political and social spheres; as someone whose livelihood was directly affected and as a member of that "underclass" that was left to drink recycled water when nobody else would, I certainly identify with that kind of tension. What began as a push to solve an urgent problem that faced all of humanity, somehow still managed evolve into a way to divide and value/devalue people. But I think that although those feelings hold validity, the larger problem at hand trumps it, and leaves us with little choice other than to do what we must in order to leave any sort of world for our grandchildren.

Digest #2

For generations my family has been proud farmers in California. With such diverse and expansive land, California is one of the largest producers of crops and livestock all over the world. GIven the magnitude and variety to agriculture here in California there are a number of different problems that farmers here face regularly. We have seen our fair share of challenges and triumphs with harvests, animals, and weather. Wildfires, runaway livestock, and mudslides are just a few of the many situations we have encountered. However, no challenge can compare to the water shortage crisis that we have been dealing with since the second decade of the twenty first century.

It all started back when I was a boy growing up on my father's farm. Just after my thirteenth birthday in 2011, the drought began. From 2011 to 2016, the drought raged on depleting the water level all over California. A lack of rain and an overuse of water led to dangerously reduced water tables and aquifers which in result affected the all crop and livestock production. This led to times of turmoil with farms running out of water and water limitations per farmer being put into place. Many people turned and blamed farmers for the conditions as we use the most water. But how else were we supposed to produce the very food that the people of California needed to survive? To blame us was just to find a scapegoat for a situation that we thought was out of our control. Even after heavy rains in the years following the drought, the tables and aquifers never recovered, leaving many people stuck between a rock and a hard place. Many thought that there was no option and no way out. Thankfully, they were wrong-- there was an option and it was just on the horizon.

My family's major crop is almonds which is one of the most water intensive crops to produce. I can distinctly remember year after year losing more and more acres of almond trees due to our inability to provide sufficient amounts of water to all of the trees. We essentially were faced with a choice of life or death, deciding which trees we wanted to gamble on to survive and which trees we had to let go. The situation worsened until the mid 20's when talk of a new method of irrigation came into existence. Previously just a method of speculation, the new technique referred to as micro irrigation was finally here and ready to initiate change. It provided a whole new perspective of looking at the way that we farm everyday. Many farmers,

such as my father, were hesitant to transition to a new way of irrigation as they had been farming for decades and were quite set in their ways. However, like many things it only takes one success to change the way that people think about and act on a new idea. I begged and pleaded with my father to try micro irrigation because it might have been the only hope that our crops had left. After showing him case study after case study, I convinced him to give it a shot. To his surprise, and also in a way mine too, the experiment was a complete success. We enjoyed yields and quality that had not been seen in ages. More importantly, we were able to do this while still reducing the use of water on our farm, effectively helping to be less of a cause to the water crisis and more of an aid to the solution. All throughout the 30's we used our newfound technique of water management to shrink our impact on the water crisis while simultaneously building our farm back up the level that it once was. I can confidently say that without micro irrigation our farm would not have survived the past and in no way could survive the future.

Explanation:

At the heart of this crisis there is a natural component but also a human component. The most fundamental piece of the human component is the citizens of California. California is home to all different people from all different walks of life such as movie stars, business tycoons, industrial workers, and of course farmers. One thing that relates all of these people together is water and so the water crisis had an impact on all people, but mostly farmers. Unlike the average Californian who simply relies on water for washing and cleaning, farmers rely on water for large scale production and irrigation. The water shortage for the average public citizen could be solved through a greywater reuse system, but not the farmer. As stated by the scientific community, the by far largest portion of water usage in the state of California is agriculture. From the early years of the Gold Rush until present day in the 2040s, people have and always will need food and thus will always need some form of agriculture. Farmers must adapt to what changing times bring to them. In this case, changing times have brought water shortages unparalleled in recent history. As the farmers above explained, humans were forced to adapt. Farmers took new advancements from the scientific community and instead of dominating the source of water and irrigating their crops with no caution, they began to work to implement new technologies such as micro irrigation and hydroponics to produce crops more sustainably and at a rate that is no longer destroying the very aspect of nature it relies so heavily upon.

Section 3: The Perspective of the Scientific Community

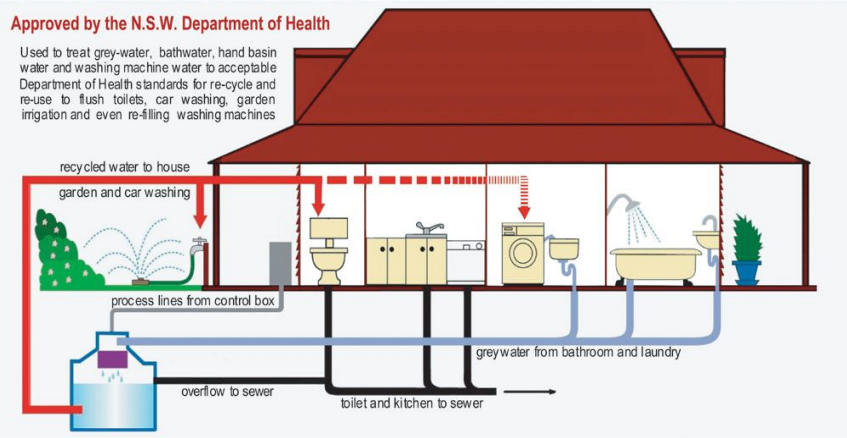
Digest #1

People always ask how did we get into this crisis, what are we doing now to combat it and what more can we do to change our present situation. From years of studying our current water crisis, I know that there is no one simple answer to any of these questions. All of these questions have layers upon layers of technical data, complex events, and various factors that go into their answers.

Starting at the beginning of the crisis does not paint a clear enough picture for a true understanding of what is going on. The water crisis is rooted deep within human nature and traditional water practices. From early on, the scientific community defined water as a renewable resource. For those without a scientific background, a renewable resource is a resource that once used, is not destroyed. For example, you wash your dishes or clothes with water, but after the process ends, the water can be taken and cleaned returning to its original clean state. Likewise, when runoff water soaks into the ground or collects in a body of water, it can evaporate and go throughout the water cycle to be, in a sense, "reborn" into the fresh water falling from the sky or joining a natural spring or reservoir.

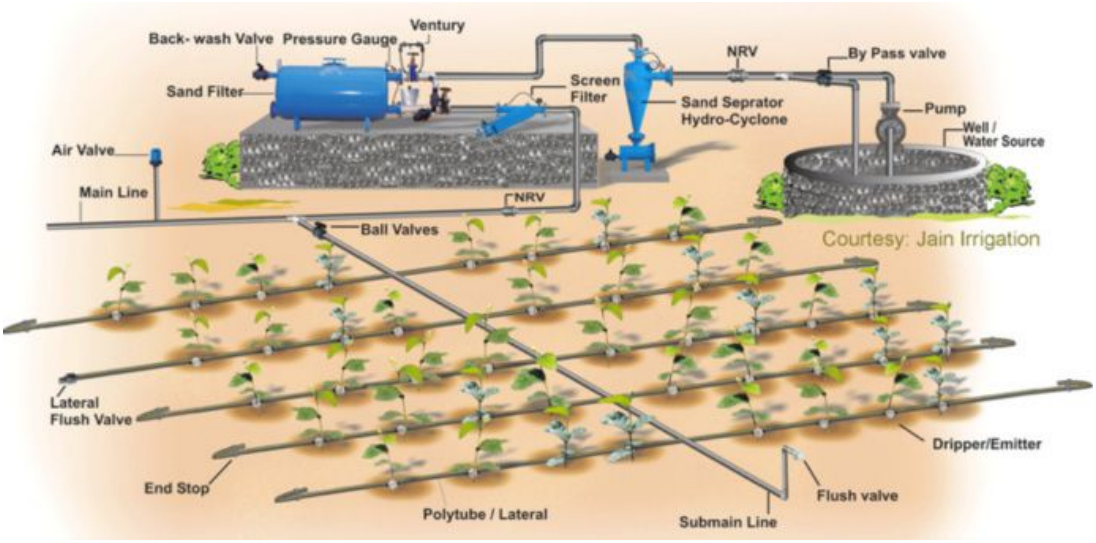
This is all acceptable, but what humans often underestimate is the amount of time that this process takes to occur. Since humans developed habits of using fresh water as it is in infinite supply, they also developed a serious fresh water shortage. We irrigated with a lack of planning and execution, wasting crucial water that could have been the difference between constantly running on empty or having reserves to go to in the case of disaster. This attitude and approach of constant usage has left our fresh water systems extra vulnerable to drought and disaster. As seen in California during the first two decades of the 21st century, a drought can be devastating to a population already short on water. From 2011-2016, California experienced a drought like no other. With little access to fresh water from overtapped reservoirs and wells, farms suffered, the housing market suffered, and most of all the people of California suffered. In order for these people to survive, scientists determined that a limit must be placed on the amount of water that each household may use over a given period of time. Following this temporary adjustment, scientists worked to determine a better way to manage the extreme water shortage faced by the citizens of California.

The answer that scientists found was simple but proved to be a revolutionary technique in water reuse and management. Scientists determined that approximately two-thirds of a household's water could easily be recycled using a gray water recycling system. Gray water is defined as the relatively clean waste water from baths, sinks, washing machines, and other kitchen appliances. So starting in 2016 near the tail end of the worst drought in years in California, a new technology was mandatorily implemented into all new housing development projects. This technology was a gray water reuse system, it took the relatively minor wastewater from the baths, sinks, and appliances of a house and cleaned it so that it could be reused in the house without having to be sent out to the water treatment plants miles away from the housing developments. This system provided a multitude of benefits to society. For example, since it allowed for water reuse, it provided the opportunity for houses to get more water usage out of their rationed amount of water per month. In fact, this technology became so successful at saving up to two-thirds of a house's water for reuse that by 2020 it was state mandated that not only all



new housing projects, but also all new commercial projects, must include a grey water reuse system. Along with this, less dangerous chemicals had to be used to treat the wastewater at large scale plants to decrease the chance that a dangerous chlorine chemical would leake in the surrounding natural areas. The picture below depicts the functioning of a average household grey water reuse system.

This new technology proved effective for the following decade, but as the large scale population growth of the state of California continued, the need for more water recycling increased and by the late 2020's, a new change was needed. With a need for more effective water reuse, scientists turned to what could possibly recycle the remaining one-third of household water usage, also known as heavy waste water. Heavy waste water is sewage along with the water used in manufacturing of goods. Scientists developed more effective large scale water recycling plants that were safer and more efficient than past water recycling processes. These could be implemented in a variety of locations from cities to the suburbs to deal with the recycling of heavy waste water. After tackling the commercial and residential sides of water reuse, it came time to address the elephant in the room that was agricultural water usage. Though periods of heavy rain followed the extensive droughts of 2011 through 2016, the underground reservoirs and aquifers remained at a dangerously low level. This was a monumental problem because with a growing population, more food production was needed, and not only for the state of California, but also for the United States as a whole. California is the leader in the production of many foods throughout the continental United States and thus must be able to produce, otherwise a shortage might occur. The scientific community spent years researching and eventually deduced a micro irrigation system that was extremely effective in conserving water and increasing plant growth. An example of one of these revolutionary devices is pictured below.



The advantage of these systems was that they could also use a rain barrel in order to conserve extra water from rainfall and save it for further irrigation. This way, instead of heavy rainfall creating runoff, it created a bountiful reservoir to draw from for irrigation. The final change that has been implemented thus far in the year 2040 is a water limit per household based on the number of occupants, instead of just a flat rate per household. Scientists discerned by structuring the system this way it would create equity and those with larger families would not be punished over those with smaller families.

For now, the scientists believe the state of California is doing just enough to survive, but in order to thrive more changes and innovation must occur. Examples of these range from water desalination plants, to an in-depth look into aging water pipelines and systems. Water desalination plants harness the power of the most abundant source of water on Earth, the oceans. By taking water from the vast nearby Pacific Ocean and desalinating it, scientists are able to produce excess fresh water for usage in farming and everyday life, taking some of the strain out of mandatory limits and systems. Possibly the easiest solution that scientists such as myself are beginning to look into is a thorough check of the existing water systems. An aging system can lead to leaks and cracks, essentially wasting precious water that can be utilized to help our people. If we are able to locate and fix these cracks can save crucial amounts of water. Amounts that very well can be the difference between the survival or collapse of California's infrastructure in the future.

Digest #2

Since the year 2018, the water recycling systems available to us have changed dramatically. After California's worst drought in history from 2011 through 2016, scientists and engineers like myself proposed the idea of limiting the amount of freshwater intake per month for each citizen. 2,000 gallons of water would be the maximum amount available for any one

person for each month. However, this could not be the only way to manage how we use our water and how much of that is fresh versus gray. Earlier in this century, small scale waste water recycling systems were researched. After California's long, severe drought, these were implemented as a mandatory recycling method. This system was a great way of managing water reuse at the time because it took grey water from appliances in bathrooms and laundry rooms like sinks, washing machines, and showers, and channeled it into a treatment system on the homeowner's property in order to clean it and bring it back into the house to be reused. This system made it possible for reused water to be put to use for many different things. However, the wastewater from toilets would be brought to the sewer, as well as any overflow from the wastewater system, meaning that this water would not be reused at all.

Since the late 2020s, the global population as well as within the state of California has grown drastically causing the need for more effective ways of reusing water. Scientists and engineers came together to research how to provide an option that reuses all of the water in every household, including grey water as well as heavy wastewater. Our goal was to have this new system be very safe and require as little chemicals as possible to treat the water. Less than five years ago, we developed large scale water recycling plants in Los Angeles which have since been implemented in a few other cities such as New York and will soon be brought to more areas as well. Wastewater treatment plants remove a lot of the pollutants from the water before releasing it to local waterways. "At the plants, physical and biological processes closely duplicate how wetlands, rivers, streams and lakes naturally purify water. Treatment at these plants is quick, taking only about seven hours to remove most of the pollutants from the wastewater" (NYCEP). The wastewater gets treated in five stages. The first, preliminary treatment, is where the water from the sewers flows into the plants through several upright bars which aim to remove large pieces of trash. In the next process, called primary treatment, the wastewater goes into sedimentation tanks where light and heavy solids either float to the top or settle to the bottom. These solids are then taken off of the surface or if they are at the bottom, this primary "sludge" is then pumped through degritters. The water flows to the secondary treatment system where air is pumped into the tanks in an effort to stimulate "the growth of oxygen-using bacteria and other tiny organisms that are naturally present in the sewage" to consume the remaining pollutants (NYCEP). Next, the water flows to more tanks to have its solids separated once again and the sludge that is present gets processed further elsewhere. The wastewater goes to "chlorine-contact tanks mixing with sodium hypochlorite" which further disinfect the water, an essential step (NYCEP). The water is released to local waterways after going through this treatment process.

With "much of the demand [for water] driven by agriculture, which accounts for 70% of global freshwater use," scientists saw that systems were necessary in reusing water when growing crops and producing food (Smedley, 2017). In 2035, "food production [had grown] by 69% to feed the growing population" in California (Smedley, 2017). This increase has required more water to be used, so why not utilize recycled water that could serve the same purpose as fresh water while still being a safe and clean option? Telling farmers to look at possible leaks

and faulty pipes in their irrigation systems did not do enough. Micro irrigation systems, the latest and best system to date, not only use lower pressure, but also less flow than other systems. Also known as drip irrigation, this system has small drip emitters close to the roots of the crops, which allows for more efficiency and control. Water is released from the very small sized emitter slowly. The "emitters are directly connected to the water source by feeder hoses" (McFadden, 2017). Several engineers believe this system will be used by more and more farmers because its benefits outweigh its costs.

In thinking about the future, engineers have been generating ideas about even more ways of recycling and reusing water. I think water desalination plants will be next on our list of things to tackle, but for now, we must encourage and maybe even require, everyone in California to recycle water in the ways that have already been implemented. We must also bring the large scale wastewater treatment plants to cities and regions around the country and world to make an even larger impact in reusing water. Us engineers and scientists have already created these methods, but it is up to the citizens to follow through and practice them.

Explanation:

As seen in the above pieces from the scientific community, the transition from practicing dominating nature to managing nature lies heavily in the technologies available to the people of California, specifically the farmers. The scientific community both recognized and assessed the damage being done to the environment of California and then developed solutions to the issues. Years of water overuse from large scale farming with improper irrigation lead to disastrous effects on the water tables and aquifers in the region. To combat the escalation of these issues, the scientific community came together to engineer systems such as greywater recycling systems and micro irrigation techniques that properly reuse and save water to take the strain off of nature. The keys that made the difference between humans dominating nature and managing nature were the development of technologies that supported the environment and the practice of taking the strain away from nature and putting it on humans to be more sustainable.

Summary:

The goal of drawing upon the perspectives of archivists, scientists, and citizens of California was to not only identify the root causes and problems with the water crisis but to also understand how the crisis was reached. As heard from the accounts of the archivists and farmers, there had been a serious issue of humans attempting to dominate nature. For years the popular practice of humans was constant usage and taking from nature with no care or mindfulness. This was a result of humans having the mindset that nature is simply meant to provide for them. It was an idea that everything in this world is centered around humans. Mankind soon came to realize that this was not a sustainable approach as it affected not only their ability to farm and produce crops in California, but also their ability to live there. Through science and technology, humans were able to shift their thinking and actions from those of domination to management

and sustainability. New micro irrigation systems worked to waste less and use more, while water recycling systems focused on taking the strain off of the natural aquifers and placing it instead on human practices. In learning to manage water instead of dominate it, the people of California not only gained insight into their past mistakes but also into a possible sustainable future for years to come.

Conclusion

In the year 2040, many things about our world are different. One area that has seen tremendous transformation is our water consumption as an eco-socio-technical system. In the years leading up to California's great drought, and even further into the past, people considered themselves to be entitled to clean, available water in any and all quantities. It was understood that if you wanted water, all you had to do was turn on a tap. In 2040, the people of California are distinctly aware of just how fragile water is as a resource. Despite the fact that we have advanced significantly in technical solutions to water scarcity, the most important thing to understand about our evolution since the great drought is how these technologies have shaped our thinking, and our understanding of the issue.

One way that our new system has done this is the way in which it reveals the nature of water to us. As previously stated, the older system positioned water as an effectively endless uniform resource that was constantly at our disposal. Our new system of water recycling and personal consumption limits reveals water to be more precious; it is something that we must recycle over and over because it is too valuable to use to any potential less than its maximum.

Additionally, our new system shifts the dynamic of control in our relationship with water, and how that relationship is mediated. One specific aspect of the system that demonstrates this is the implementation of personal consumption limits. This policy shifted the relationship from one of limitless beck and call to one of thoughtful and careful personal management. Whereas our wants and needs (pertaining to water) were once all the priority, it has now become normal and necessary to prioritize our wants and needs.

As we look forward beyond 2040, California is moving towards mass hydroponic farming as a further technical solution to our water crisis, having already seen successful implementation so far. This technology would completely alter the way in which we understand farming, our lands, and of course our water. We look forward to what the future will hold.

Bibliography

Anderson, J. (2003). The environmental benefits of water recycling and reuse. IWA Publishing,3(4). Retrieved April 3, 2018.

Angelakis, A., & Snyder, S. (2015). Wastewater Treatment and Reuse: Past, Present, and Future. *Water*, *7*(12), 4887–4895. doi:10.3390/w7094887

Beveridge, R., Moss, T., & Naumann, M. (2017). Sociospatial Understanding of Water Politics: Tracing the Multidimensionality of Water Reuse. *Water Alternatives,10*(1), 22-40. Retrieved April 4, 2018.

Binz, C., Razavian, N., & Kiparsky, M. (jan. 2018). Of Dreamliners and Drinking Water: Developing Risk Regulation and a Safety Culture for Direct Potable Reuse. *Water Resources Management,*511-525. Retrieved April 4, 2018.

Ching, L. (2016). A lived-experience investigation of narratives: Recycled drinking water. *International Journal of Water Resources Development*, 32(4), 637-649.

Commons Micro Irrigation Systems. (2018, January). Retrieved from http://www.limerickgardentrail.com/micro-irrigation-systems/filedripirrigation-wikimedia-commons-micro-irrigation-systems/

Cotruvo, Joseph. (2015). Potable water reuse history and a new framework for decision making. *International Journal of Water Resources Development*. 32. 1-11. 10.1080/07900627.2015.1099520.

Freshwater Crisis. (2017, January 27). Retrieved April 08, 2018, from https://www.nationalgeographic.com/environment/freshwater/freshwater-crisis/

Gov. Jerry Brown Issues Calls For Mandatory 25 Percent Water Reduction With No End In Sight

For Drought. (2015, April 01). Retrieved from http://sanfrancisco.cbslocal.com/2015/04/01/governor-jerry-brown-issues-executive-order-calls-for-mandatory-25-percent-water-reduction/

Hui, I., & Cain, B. E. (2017, August 30). Overcoming psychological resistance toward using recycled water in California. *Water And Environment Journal*, 32(1), 17-25.

Hydroponic systems – a way to save water. (n.d.). Retrieved from https://www.energyinwater.eu/hydroponic-systems-a-way-to-save-water/

In Home Water Recycling System. (2015, May 20). Retrieved April 05, 2018, from https://www.youtube.com/watch?v=h7yUHa-v0wk

James, K. (2016, October 5). Water Reuse in California: Overcoming the Barriers to Its Expansion. Retrieved April 08, 2018, from https://www.newsdeeply.com/water/community/2016/10/05/water-reuse-in-california-overcoming-the-barriers-to-its-expansion

Klich, C. (2018, January). Mandate grey water systems in all new home construction. Retrieved From https://www.change.org/p/california-state-house-california-state-senate-california-governor-mandate-grey-water-systems-in-all-new-home-construction

Kunz, N. C., Fischer, M., Ingold, K., & Hering, J. G. (2015). Drivers for and against municipal wastewater recycling: A review. *Water Science and Technology*, 73(2). doi:10.2166/wst.2015.496

Landers, J. (2008). Singapore Plans Two More Reuse Plants, Increasing Its Reliance On Reclaimed Water. *Civil Engineering*, 78(7). Retrieved April 3, 2018.

Marks, J. S., Martin, W. C., & Zadoroznyj, M. (2006, March). Acceptance of Water Recycling in Australia: National Baseline Data(Rep.). Retrieved April 03, 2018.

McFadden, C. (2017, May 6). How Exactly Does Drip Irrigation Work? Retrieved April 11, 2018, from https://interestingengineering.com/how-exactly-does-drip-irrigation-work

Naidus, A., & Sullivan, J. (2014, September 2). 7 Powerful Photos Before And After The California Drought. Retrieved from https://www.buzzfeed.com/alexnaidus/california-drought-images?utm_term=.ivQE6Vn36#.qs9J6qPZ6

New survey reveals Californians' overwhelming support for recycled water as a long-term drought solution | Xylem US. (2016, March 14). Retrieved from https://www.xylem.com/en-us/about-xylem/newsroom/press-releases/new-survey-reveals-californians-overwhelming-support-for-recycled-water-as-a-long-term-drought-solution2

Overview of the History of Water Reuse. (2016, April 21). Retrieved April 05, 2018, from http://www.mwwatermark.com/en_US/overview-of-the-history-of-water-reuse-2/

Pan, Q., Chhipi-Shrestha, G., Zhou, D., Zhang, K., & Sadiq, R. (2018). Evaluating water reuse applications under uncertainty: Generalized intuitionistic fuzzy-based approach. *Stochastic Environmental Research and Risk Assessment,*1099-1111. Retrieved April 4, 2018.

Perlman, H., & USGS. (2016, December 02). How much water does the average person use at home per day? Retrieved April 08, 2018, from https://water.usgs.gov/edu/qa-home-percapita.html

Phillips, K. (2015, April 07). The history and future of drinking water, from the Roman Empire to desalination. Retrieved April 05, 2018, from http://www.abc.net.au/radionational/programs/rearvision/the-history-and-future-of-drinking-water/6374830

Schmidt, S., Hawkins, D., & Phillips, K. (2017, February 13). 188,000 evacuated as California's massive Oroville Dam threatens catastrophic floods. Retrieved April 08, 2018, from https://www.washingtonpost.com/news/morning-mix/wp/2017/02/13/not-a-drill-Thousands-evacuated-in-calif-as-oroville-dam-threatens-to-flood/?utm_term=.028e5c6bce29

Smedley, T. (2017, April 12). Is the world running out of fresh water? Retrieved April 04, 2018, from http://www.bbc.com/future/story/20170412-is-the-world-running-out-of-fresh-water

Smith, M. H., Jeffery, P., Brouwer, S., & Frijns, J. (2018). Public responses to water reuse - Understanding the evidence. *Journal Of Environmental Management,*43-50. Retrieved April 4, 2018.

Surendran, S., & Wheatley, A. D. (1998). Grey-Water Reclamation for Non-Potable Re-Use. *Journal Of The Chartered Institution Of Water & Environmental Management*, 12(6), 406.

The City of New York. (n.d.). New York City's Wastewater Treatment System. Retrieved April 11, 2018, from http://www.nyc.gov/html/dep/html/wastewater/wwsystem-process.shtml

United States Environmental Protection Agency. (n.d.). Water Recycling and Reuse: The Environmental Benefits. Retrieved April 03, 2018, from https://www3.epa.gov/region9/water/recycling/

WATER TREATMENT PLANT & MACHINERIES. (n.d.). Retrieved from http://www.alliedknowledge.com/water_treatment.html