

Research Paper:
The Depths of Water Sustainability

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Americans use “355,000 million gallons per day”ⁱ for our water withdrawals. Water issues are usually on the topic of clean water, but in the United States, the water crisis has started to become a supply issue. The United States has started to consume water faster than the rivers and lakes can be naturally refilled. According to studies by engineers Arjen Hoekstra and Mesfin Mekonnen at the University of Twente in the Netherlands, “the U.S. consumed the highest annual totals: 1,207 billion, 1,182 billion and 1,053 billion cubic meters, respectively, followed by Brazil at 482 billion.”ⁱⁱ Seeing that Americans use more than double the water than any other country, they can start to ask themselves, what are we using our water on?

Water usage is calculated by the country’s water footprint. Water footprint is “the amount of fresh water utilized in the production or supply of the goods and services used by a particular person or group.”ⁱⁱⁱ Water footprint can also be applied to businesses and urban/domestic water use to calculate how Americans are using water. By knowing how much water is being consumed, Americans can break down water use by individual or group to see how the water that is consumed can be lowered. By lowering how much water is consumed, this can help restore natural water sources to their normal water level and flows. The largest water consumers that are overusing water consist of companies or businesses, farmers, and common citizens. Businesses, farmers, and urban/domestic groups need to reduce the water that is consumed to help sustain natural water resources. Overusing water can dramatically affect the environment surrounding the water source.

Healthy natural water sources are vital in conserving ecosystems. Ecosystems that are located near lakes or rivers rely heavily on healthy, clean water to remain unaffected. Rivers

with “lower water levels can contribute to higher concentrations of natural and human pollutants.”^{iv} Restoring the rivers and lakes will benefit their surrounding ecosystems and will also be beneficial to Americans. Many Americans see river floods as a natural disaster. Companies usually try to be prevent river floods with levees. Levees are "an embankment built to prevent the overflow of a river,"^v and are built very close to the river’s edge. Over time, levees were moved back because they failed to hold the water back and usually made the flood worse.

River floods do have benefits and these benefits have been used to help civilians along the Tigris, Euphrates, and the Nile rivers. Rivers that overflow give the ground sediments that make the floodplains very fertile. What makes the floodplains fertile is the “sediment that is put into the soil makes it great farmland and can be used for growing food on the best soil...the soil also produces natural vegetation which is beneficial to the animals in the area.”^{vi} Due to floodplains being fertile, many levees have been moved far away from rivers to let the rivers flood while still protecting cities from flooding. Seeing the benefits from having healthy rivers and lakes, Americans can now see why they need to reduce the water that is consumed in order to not overuse our natural water sources. Now that Americans can see the benefits of having natural water, ethics can help solve America’s water problem.

Ethics

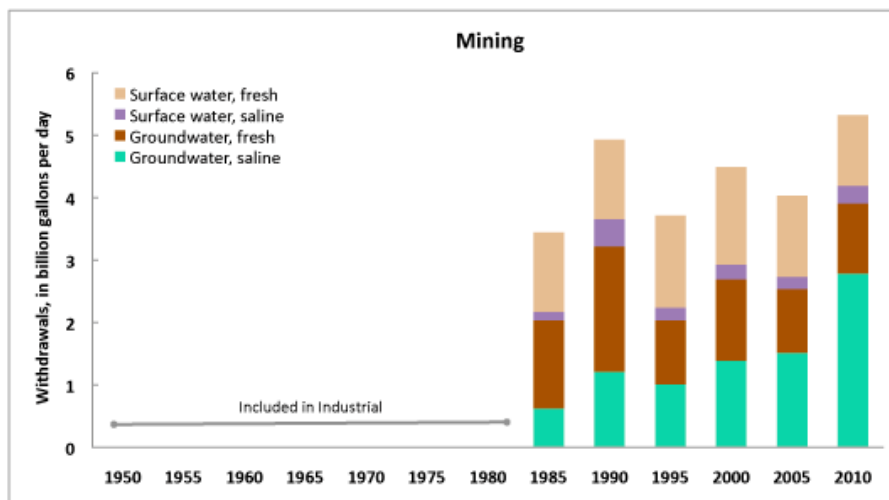
Starting to view the water decisions ethically can help reduce the overall consumption of America’s water. Ethics is the “moral principles that govern a person's behavior or the conducting of an activity.”^{vii} Looking at water use ethically can change people’s view of how

they should use water and how using that water will affect the environment. Adrian Armstrong, a member of the Royal Geographical Society, defines water ethics as “a thing is right if it preserves or enhances the ability of the water within the ecosystem to sustain life; and wrong if it decreases that ability.”^{viii} This view of what is “right and wrong” will change if Americans become aware of how their water use is affecting the environment. This will cause more Americans to start managing how much water they are using and hopefully reduce their water intake. Some American towns have already begun to change the way they use water to help conserve their ecosystems. Local environments have also started to improve due to businesses becoming aware of their water consumption levels and starting projects to reduce their water footprint. The newer concept has led to changes in how many businesses are changing to help sustain local water sources. Water resources, that have been diverted due to infrastructure projects, have recently been restored to their natural state due to the local population changing their ethics on water decisions.

Cities around the United States have manipulated rivers to where they are no longer visible to the population. Many rivers have been buried underneath the cities infrastructure. Recent infrastructure plans have been making changes to “daylight” the rivers. Daylighting water is “is the redirection of a stream or river into an above-ground channel...in an attempt to restore the stream or river to a more natural state.”^{ix} The reason for cities to push for water daylighting is due to their ethics on water being changed due to the benefits of un-Earthing the rivers. The benefits of daylighting water are “water quality improvements and flood mitigation.”^x The water quality is improved by restoring water to its natural flows which reduces stagnant water in the river. Stagnant water in rivers is bad because if the water is not

flowing properly, the water starts to become contaminated with bacteria. Cleaner water is not the only way daylighting is beneficial, “instead of having to build water runoff areas or culverts, cities have started to make all the excess rainwater flow back into the now exposed river.” Cities have helped rivers return to their natural states through changing policies. Other cities have had to use policies to help protect rivers from being contaminated.

Mining in America accounts for “5,320 million gallons per day”^{xi} and most of the water cannot be reused. The chart from the United States Geological Survey, shows how “water use in mining has been increasing since the 1985.”^{xii} Water is used in mining to help extract minerals.



These minerals such as “coal, iron, sand, and gravel; liquids, such as crude petroleum”^{xiii} are useful in industries. Industries benefit from receiving these minerals,

but extracting these minerals contaminates the water. Water that is contaminated also increases significantly with the introduction of mountaintop removable mining. This new form of mining is where “explosives are put in the mountain and blow up the top of the mountain.”^{xiv} David Groenfeldt, Director of the Water-Culture Institute, says that “everything that is not coal is pushed into the valleys below.”^{xv} This affects the water sustainability for rivers due to rocks and other minerals reducing the river’s flow rate and contaminating the water. David also says that along with rocks, “sulfuric acid and heavy metals are pushed into the rivers.”^{xvi} This

contaminated water has caused some communities to take action and start pushing for new water ethics in mining. Mining water ethics is changing due to new policies being implemented to reduce the amount of water intake that is involved in mining. Water ethics has also affected how thermoelectric power has used water when generating energy.

Thermoelectric power is the main use of water in the United States accounting for “45 percent of total water withdrawals.”^{xvii} Water used in thermoelectric power plants is used in “generating electricity with steam-driven turbine generator.”^{xviii} This process does not contaminate the water but instead heats the water and uses the steam to power the generator. When the steam eventually condensates back into water, the hot water is then dumped back into the river. The hot water increases the overall temperature of the river and this causes issues for the river. The health of the river decreased due to “fish downstream from a power plant releasing the hot water would get very upset,”^{xix} and the fish began to leave the rivers. This caused thermoelectric plants to change how they used water. The government began to force thermoelectric plants to make new systems that would keep the rivers at their natural temperatures.

Thermoelectric plants began to use cooling systems to try and help reduce the water temperature. The cooling systems “circulated water through heat exchangers, cooled using ponds or towers, and then recirculated.”^{xx} This system has helped solve the environmental issue of water ethics and has even reduced the total water consumption of thermoelectric power plants. Since these systems have been implemented, they have “reduced water consumption from 201 to 160 million gallons per day.”^{xxi} Changing policies based on water ethics helped thermoelectric plants become more efficient and help sustain their local rivers.

Water ethics has also caused big companies to implement new policies to reduce their water supply.

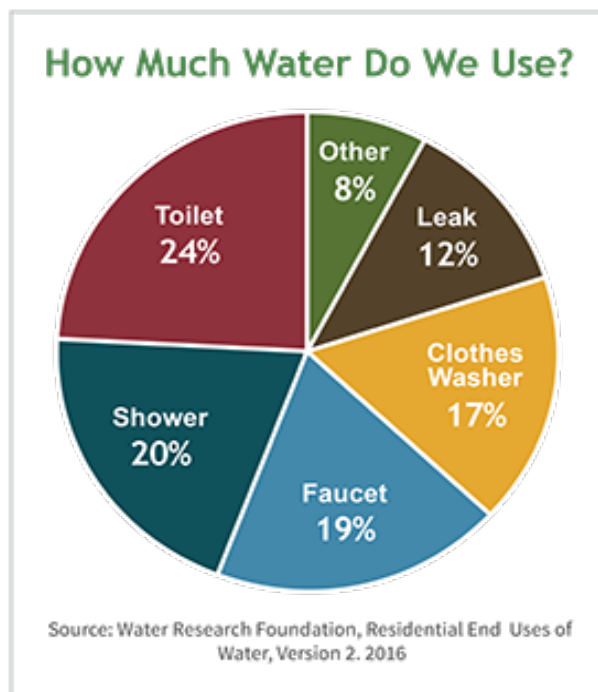
Some major businesses have started to analyze their water footprints and have made ethical decisions to start reducing their water consumption. Companies like “Coke-a-Cola and Intel have recently been two big companies to change their water policies to help the environment.”^{xxii} The people at these companies have recognized their impacts on the environment through their water use and have changed their policies based on water ethics. Intel has started a major water recycling program that is reducing their water intake by “5.2 million gallons of water each day.”^{xxiii} They are able to conserve water by using the water from their local aquifers and then “recovers, treats and returns a portion of Intel’s rinse waters to the aquifer.”^{xxiv} This process of using the water, cleaning it, and then returning it to the water source has been highly efficient for reducing Intel’s water footprint. The change in their ethics has allowed the company to reuse “75 percent of its water”^{xxv} which has helped sustain the local aquifer. Coke-a-Cola has also helped sustain their local water sources by changing their water ethics and implementing new water policies.

Water ethics have also had a huge impact on how Coke companies in America have been using their water. Coke has begun to change how much water is being used in the manufacturing process. By doing this, Coke has reduced their water usage from “2.7 liters of water to make 1 liter of product...to 1.96 liters of water to make 1 liter of product.”^{xxvi} This might seem like a small decrease in water consumption, but Coke made “155 billion liters of product”^{xxvii} in 2016. The change in Coke’s water ethics has heavily reduced the amount of water intake across America. Coke has also recognized how much water was used on

agricultural ingredients and has started implementing changes to reduce water used on their ingredients. These cities and companies have all helped reduce the water that is consumed by using water ethics to help change policies on how water is used. The amount of water that is consumed can also be lowered by the recent advancements in technology that are making systems use less water and still operate efficiently.

Technology

Water consumed in domestic and urban use accounts for “more than 300 gallons of water per



day for one household.”^{xxviii} So why are Americans using over 300 gallons of water and what are they using the water on? According to the chart and data provided by the EPA, water use for the average American is mostly accounted for chores and health.^{xxix} While indoor use accounts for “seventy percent of domestic water use... outdoor water use accounts for 30 percent of household use.”^{xxx}

Both indoor and outdoor water use can be reduced. In order to reduce indoor water waste, technology will need to be used to fix the majority of inside water consumed now that most companies are starting to sell green technologies. Unfortunately, technology cannot help reduce outside water because the majority of outside water is used to irrigate landscape.

Now that people know how water is being used in American households, how can people help reduce their water intake? According to the United States Geological Survey, “about 42 million gallons of water are used per day”^{xxxix} to supply the public with water with another “3 to 4 million gallons per day”^{xxxix} are used by well-water. The indoor water use can be heavily reduced by technologies that are designed to reduce the amount of water consumed, and still fulfill their task efficiently. Toilets use the most amount of water in American households, but how can Americans reduce their water amounts from something that they have to use every day? Companies have started to produce new toilets that are more water efficient. Older toilets can use “.5-1.6 gallons per flush,”^{xxxix} while the newer toilets are reducing the amount of water from flushing to “less than one gallon per flush.”^{xxxix} These newer toilets will help reduce water consumption significantly by using less water while flushing and refilling.

Showers are another big water consumer in households that are unavoidable. New showerheads are being installed to help reduce the amount of water unlike older models by “fifty percent by using low-flow showerheads.”^{xxxix} Faucets, like shower heads, have had companies to reduce their water flow by “forty percent and have restricted the water flow to 0.5-1.5 gallons per minute.”^{xxxix} Dishwashers and washing machines for clothing are starting to be produced with energy efficient or green labels. These labeled machines “use 18% less water ...than conventional machines.”^{xxxix} The water that is used in these machines can also be modified to help reduce the amount of water that is being used in households.

Water in households can sometimes be referred to as hard water. According to the United States Geological Survey, “hard water is high in dissolved minerals, both calcium and magnesium.”^{xxxix} Hard water increases water use because “when using hard water, more soap

or detergent is needed to get things clean.”^{xxxix} This is an issue even if Americans are using green labeled machines because hard water makes the machines run less efficiently. Due to machines using more water, companies have begun using water softeners. According to Travis Thayer, a 16-year global engineer for A. O. Smith Corporation, “hard water can be reduced with the use of water softeners.”^{xl} Water softeners help reduce the amount of minerals that are dissolved in the water. Due to the decrease of these minerals, clothes or dishes can be cleaned with less water. Using green technologies and water softener systems can help reduce the amount of water indoor in America. Americans can even reuse some of their indoor water to help reduce water used outdoors. The water used in showers or sinks can be reused to help decrease the water amount outside of the house.

Water usage on the outside of the household is primarily used for the upkeep of lawns. The “national average is about thirty percent of water use per home and rapidly increases in drier parts of the country.”^{xli} The use of this much water seems extremely wasteful in the grand scale of things since lawns are not a necessity to live, unlike agriculture or products made by companies. The way faucets and showers can help reduce this is by reusing the grey water produced while taking a shower or washing dishes. Grey water is “the relatively clean waste water from baths, sinks, washing machines, and other kitchen appliances.”^{xlii} The use of grey water can help reduce water consumption because it will allow Americans to reuse water that would be going to waste. Reusing grey water will allow people to maintain their lawns and allow their water consumption to be reduced since “grey water systems allow for sixty percent of water to be reused.”^{xliii}

Another way to help water lawns and keeping lawns looking fresh longer, is by collecting rainwater. Collecting rainwater can also help water lawns without using more water. Capturing rainwater in “barrels or collect rainwater from your roof by connecting your downspout directly into a barrel”^{xliv} can help use water that would have otherwise been evaporated. Water usage outdoors can also be reduced by modifying our lawns. David Groenfeldt states in his book how “people in Las Vegas, Nevada have started to reduce lawn water consumption by replacing most of their grass with gravel.”^{xlv} The use of gravel for lawns will reduce the amount of water with the drawback of not looking as good as a lawn. If people would be willing to replace the majority of their lawns with gravel, the little grass that is left could be watered with grey and rain water. Reusing rainwater can also be useful if homes have gardens or if they are farmers, rainwater could be a cheaper way to water their crops. Using water for agriculture is a necessity for life and unavoidable because it helps vegetation grow. Humans, not just Americans, need food to survive. So, using water on agriculture is not a bad use of water, but are Americans using the water for crops efficiently? The efficient use of water for crops would involve reducing wasted water on during irrigation.

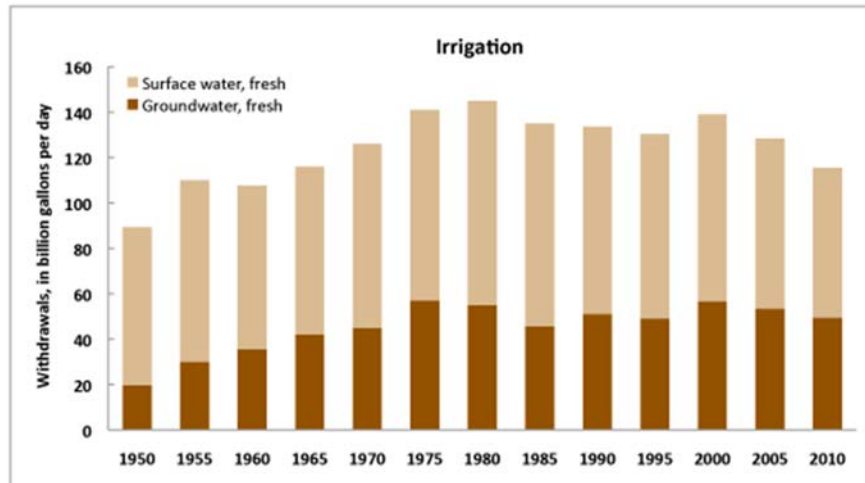
Efficient water use for crops is important because “total irrigation withdrawals were 115,000 million gallons per day, which accounted for 38 percent of total freshwater withdrawals”^{xlvi} according to the United States Geological Survey. If agriculture is accounting for over a third of American’s water use, they need to ask, “Why are we wasting too much water on crops?” Crops in America are watered with the closest natural source of water. These natural sources are usually surrounded by “many farmers that are all using the same source for their water.”^{xlvii} The high use of water on the same body of water is quickly draining the water.

Another issue for farmers, especially in the hot, arid Midwest, is the rapid rate at which water is evaporated. Due to the water evaporating and the farmers constantly using the same water sources, this is causing the rivers, lakes, and aquifers to drain a lot faster than rain can refill them. This water needs to be conserved so farmers can continue to use the local resources in the future. The future health of these rivers can be sustained if farmers would use rainwater and technology to help reduce their water intake for their crops.

Rainwater is used around the world in agriculture. Even in some arid, hot countries rainwater is the primary way that their crops are watered. Some research has been conducted to see how plants are affected by only rainwater. In Carr, G., S. Nortcliff, and R. B. Potter's article about Jordan water sustainability, they discovered that the reused rainwater was contaminating the soil in Jordan. The use of rainwater on crops can be potentially dangerous to soil and plant health if the rainwater is not filtered to get the toxins out. In Carr, G., S. Nortcliff, and R. B. Potter's article they found that even if the water was slightly contained, the natural elements still made the plants grow better. The rainwater contained "significant quantities of plant beneficial ions (nutrients) such as nitrogen, phosphorus and potassium."^{xlviii} Rainwater has beneficial chemicals that help soil fertility and plant health. Using rainwater for agriculture is not affecting environmental health and is using water efficiently. Water efficiency can also be improved by using technology to help reduce the water amount used on farms.

Technology can help optimize how much water is used on crops. Crops all have different amounts or levels of water intake that they need to have in order to grow. Technology can help reduce water consumption on farms by not using too much water on certain crops. The "irrigation withdrawals in the United States are shown in the chart from the USGS."^{xlix} This

shows that the amount of water used has slowly declined since the 2000s. The primary reason



for the slow decrease in water intake is the advancement of technology. Technology is still being improved today and some newer technologies can help

further decrease water amount. David Groenfeldt mentions in his book how “drip irrigation is affecting agriculture.”ⁱ Drip irrigation “is the precise application of water and nutrients directly to the plant root zone.”ⁱⁱ Drip irrigation could help save water on farms by allowing farmers to set different drips for different crops. This would help optimize water use per crop and make water more sustainable for local water resources. The water resources in Jordan were scarce due to high temperatures leading to rapid evaporation. Evaporation could be minimized through drip irrigation systems being underground and only having the water exposed to the landscape when hitting the plant. If the plants health is monitored when less water is supplied, farmers should be able to figure out how to water their crops efficiently without losing crops. Crops can also die due to toxic chemicals that are in the water. These toxic chemicals can be removed with new water filtering systems.

Water filtering systems are vital in helping remove harmful toxins in water, but not all of the water can be cleaned. Older watering filter systems can take “two gallons of unclean water to produce one gallon of clean water.”ⁱⁱⁱ The one gallon of water is still unable to be used

because it is still contaminated. Newer filtration systems have recently been released and are more efficient. The new water purification systems can “filter the water faster and are able to produce cleaner water than earlier systems.”^{liii} These advancements in technology will help reduce the unclean, wastewater, and increase the amount of clean water that can be produced through filtration systems. The new filtration systems can even be more efficient in producing water for agriculture rather than producing drinking water. Water used in agriculture does not have to be as clean as drinking water. This will further increase the efficiency of the new filtration systems since it will not take as long for the water to reach a good enough level to be used. Since the water is being filtered faster, the farmers will be able to produce more crops with reused rainwater. The concern of water efficiency affecting production is also a concern for businesses across America.

Business water intake accounts for “15,900 million gallons per day.”^{liv} With the new water footprint concept, many companies have started to look closer at how they are using water. This has caused some companies to implement changes in their manufacturing process. Companies have started to hire engineers to come in to their business and improve water efficiency as well as to implement new technologies or help maximize the efficiency of the manufacturing process. Companies are becoming more water efficient because of new technologies. These new and improved technologies are helping them use less water in the production process. Some companies have started to produce models that will help accurately predict their water intake. The companies can use these models to help predict how different policies will affect their water footprint.

Companies can start using diagrams to help reduce how much water is consumed. Water intake can be monitored through the diagrams and can show what the companies are using water on. New models like the “Water Evaluation and Planning (WEAP)”^{iv} diagram is being used by some companies to view how water is being consumed. This diagram is a “planning and scenario-building model that helps facilitate long-range water supply planning.”^{lvi} This model helps companies to see how new policies or technologies would affect the amount of water that is consumed. Water footprints could then be analyzed to see where businesses could use less water. Companies can use this prediction model to see if the proposed solutions would be effective in reducing the companies water footprint. These models will “improve the way water managers meet human and river health needs.”^{lvii} Using the model to account for the businesses needs and the environments needs will help businesses see how water efficiency will impact the company. Businesses could also use the models to see if the water efficient proposals would reduce production or lose the company money. Utilizing these models can give businesses a safe option for consuming less water in the most cost-effective way. Maximizing efficiency is often a concern for businesses which leads them to hire engineers to help optimize efficiency.

Engineers are often hired to help reduce water consumption and maintain optimal efficiency. Water used by companies has been reduced with some new ideas from the hired engineers. Travis Thayer, a 16-year global engineer, has helped countries across the world use less water. Thayer has helped increase water efficiency by “reducing the water pressure of the companies.”^{lviii} The reduced water pressure allows the companies to still use water for the entire day, but since the pressure is decreased, the company uses less water. Reducing the

pressure affects the water's flow rate into the company. Flow rate is the "quantity of a gas or liquid moving through a pipe or channel within a given or standard period."^{lix} Reducing the flow rate helps companies use less water without having to implement new policies or invest in new technologies. By reducing the water pressure, companies were able to save "millions of gallons of water per day,"^{lix} according to Thayer. Companies that have reduced water pressure can help decrease the water footprint of businesses in America. Businesses that implement this will also save water without having to apply new systems to help conserve water. Conserving water can happen in businesses, farmers, and common citizens if ethics and new technologies are applied to water decisions.

America uses the most water annually and can reduce water consumption in key areas to help sustain water sources. Businesses, farmers, and urban/domestic groups need to reduce the water that is consumed to help sustain natural water resources. Water sources are being overused and cannot sustain if water consumption stays the same in America. If water ethics is applied to water decisions, can the use of new policies or technology reduce water consumption enough to help water sources return to natural water levels and flow? Some American cities and corporations have seen the benefits of a healthy river or lake and have changed water policies based on water ethics. American households can also change to reduce water consumption by using new technology that uses less water or by recycling water. Recycling water and implementing new technologies can also reduce how water is being consumed in agriculture. Businesses are using engineers, technology, and recycling water to help local water sources to sustain. Local water sources cannot sustain if water consumption continues to rise in America. If more companies and citizens continue to implement water

ethics into water decisions, American rivers, lakes, and aquifers will begin to return to natural flows and levels.

End Notes

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