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WATER SCARCITY AND OUR GLOBAL FOOTPRINT

By

Jarad Kinyoun

AN UNDERGRADUATE THESIS

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With the Emphasis of: Natural Resources

Under the Supervision of Dr. Bruce Johnson and Dr. Leilani Arthurs

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ABSTRACT

WATER SCARCITY AND OUR GLOBAL FOOTPRINT

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University of Nebraska, 2012

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The study was conducted in Lincoln, Nebraska to test when individuals are educated on water scarcity issues and water saving techniques; they will make choices that lower consumption at the individual level.

The twenty households participated in this study on a volunteer basis. Each household was educated on current water issues, water saving techniques, and on their current ecological water footprint. These households were monitored over a four month period for actual reduction in water consumption and economic savings.

The water consumption patterns of the participants after being educated on water scarcity and water saving techniques correlated directly resulting in a decrease in water consumption and an increase in monetary savings. This indicates that individuals have the potential to make an impact on conserving water regionally and globally when motivated and educated.

Individual Water Scarcity Education

I. Introduction:

"When the well runs dry, we know the worth of water" (Benjamin Franklin).

Water is one of the most abundant resources on the plant, yet less than 1 percent of all water on the planet is freshwater available for our agricultural, industrial, and other consumptive uses. We are currently facing issues with climate change including increasing temperature, drought, earlier spring melts, severe weather events, and diminishing fresh water resources. Single households in the United States are some the largest consumers of freshwater, with the average person consuming around 2000 gallons per day ("Water footprint calculator," 2010). Of the daily 2,000 gallons, 70% of that water is consumed indoors ("Indoor water use," 2008). The opportunities for households to maximize their conservation of water can have a significant impact on freshwater resources.

With the average person consuming freshwater at a high rate in the United States as the model for the rest of the world. If those usage rates are coupled with a planet that just reached a population of 7 billion in October of 2011 and is expected to continue to grow exponentially. The planet will have a heavy burden on dividing up the use of our freshwater resources.

Environmental benefits from water conservation can be hard to quantify as actual costs and can be challenging to value correctly. The environmental benefits from decreased water use include reduced pollution from construction of capital facilities and increased water for other uses (Maddaus, Gleason & Darmody, 1996), lowered energy costs, financial savings, less wastewater, and the ability for positive feedback to create behavioral changes at larger levels.

II. Hypothesis:

When individuals are educated on water scarcity issues and water saving techniques; they will make choices that lower consumption at the individual level.

Current water policies in the United States do not take into account the value of water and are already causing rivers like the Colorado River to run dry before they even reach the sea. Across the country, water utility companies charge for the delivery of the water and charge their customers by volume of water used. Current water policies are inadequate for addressing the needs of nine billion people at current consumption levels (Zielinski, 2010). As our global population continues to grow, maintaining current rates of consumption of existing freshwater supplies will likely lead to freshwater shortages.

Conservation of water will become critical as freshwater becomes more scarce. Water conservation measures are actions, behavioral changes, devices, technologies, or improved designs or processes implemented to reduce water loss, waste, or use (Green & Maddaus, 2010). As the world's population continues to grow, people will continue to migrate to large urbanized cities. A cities ability to provide freshwater will be challenged as its population grows. To address these challenges, cities typically try to gain access to more fresh water by purchasing water rights, building dams, etc. However, there is another way to address the needs of the population: through conservation.

In the 1980s, Boston faced a water shortage and considered diverting water from the Connecticut River to meet the city's water needs, but decided to implement an aggressive conservation program. The peak water use for the city in 1980 was 125.5 billion gallons and as

of 2009 at 70.9 billion gallons, a 43% decrease in use, which is a 50 year low for the city (Postel, 2010). The city was able to reduce water consumption by fixing leaks in their water system infrastructure. Homes were made more efficient with better plumbing fixtures, and monitoring industry use.

Leaks in a home can contribute to not only a large waste in water but a lot of money that the consumer loses for water never used. In a study of 1,188 homes in 12 cities across the United States it was found that 67% of homes leaked an average of 10 gallons per day or less. But of those 67%, 5.5% of homes leaked an average 100 gallons or more per day, which accounted for 58% of all water leaked (Mayer & DeOreo, 1999). This illustrates how much water can be lost or saved by resolving issues on an individual level.

There are other issues that arise in meeting the needs of water consumers. For example, the cost of water isn't the true value of water. Water utilities charge consumers for the delivery of the water they use. "Although reduced residential water use and "water conservation" are generally portrayed as positive in water-poor regions challenged by restricted water supplies, the observed gradual attrition in residential consumption may force utilities to raise rates to cover basic operating costs and maintain sufficient revenues for expanding service and replacing old water mains and equipment" (Rockaway, Coomes, Rivard & Kornstein, 2011). As conversation continues and climate change continues to affect the globe, water prices should continue to rise and reach their true cost which includes the cost of not only delivering the water, but as well the cost of gaining the rights to the water, the environmental impact of diverting the water from other areas, ensuring water quality, etc. The true cost of water could end up being a price that is not affordable for everyone, which could lead to regulation ensuring that water remains affordable for all demographics.

Tucson, AZ, already in a state of drought, is becoming a leader in innovating ways to save water at the household level. Water that people use domestically for washing dishes, bathing, showers, etc… and does not include human waste is considered to be grey water. Depending on the climate and the size of one's yard, gray water reuse can lower a household's total consumption by as much as 40% (Feldman, 2011).

III. Materials and Methods:

I chose twenty households in the city of Lincoln, Nebraska and educated each individual household on current water issues, water saving techniques, and on their current ecological water footprint. These households were monitored over a four month period for actual reduction in water consumption and economic savings. From the twenty households, prior water usage was collected from previous two years when available. Lincoln Water System stores each household's water bill online and access to these records were obtainable for participants in this study who lived in the same residence for the past two years.

The twenty households participated in this study on a volunteer basis. Advertisements for volunteer participants were placed on social networking sites and various bulletin boards across the University of Nebraska - Lincoln campuses.

Each of the participants was presented with a pre-survey that consisted of six questions. The households accessed the Water footprint calculator through National Geographic and received an individual ecological footprint. Each household calculated an average ecological water footprint based on the average of all residents in the household and their daily habits of water consumption. Then each resident was educated on current water issues, water saving

techniques, read two short articles, one from the Times magazine entitled “Why the World May Be Running Out of Clean Water” and the other from the Smithsonian entitled “The Colorado River Runs Dry” were presented with an insight into global water issues.

At the first meeting I examined the household with residents for visible water leaks. We tested toilet(s) for leaks by placing food dye into the toilet tanks and checked the toilet after 15 minutes to see if the dye is visible in the toilet bowl. I then advised the resident(s) how to get a free toilet bank from the Lincoln Water System. The toilet bank is used to offset the average flush of 5-7 gallons water down to only 3 gallons of water per flush.

Each month I met with the participating households to discuss how the previous month went and addressed any issues that arouse. I also collected data from the water meter in each household, including the current water meter reading to determine monthly use in conjunction with the water bill. During each monthly meeting, I examined a current water bill, if available, to document water use for that month and compared it to the previous month, and then compared it to the same month a year ago. The Lincoln Water System only collects water usage data for households every two months, so it was necessary to properly document the water meter on each household.

After the four month period passed, I had each household calculate their ecological water footprint again and note any changes in footprint from start to end, along with completing a post-survey that was made up of the original six questions from the pre-survey. Data collected after the four month period was used to assemble a graphical representation of water usage prior to water conservation education and usage trends after education during the four month period. The

data was analyzed for a correlation between water scarcity and conservation education, as well as actual water usage.

IV. Timeline

The proposed timeline collected data over a four month period between January and April 2012.

V. Budget

No funding was required for this research project. Any materials needed were either obtained at the homeowners cost or in the case of the toilet bank, free from Lincoln Water System.

VI. Results

The study began with twenty households and through attrition, the study ended with fourteen volunteers. Participants were presented with a pre-survey that consisted of the following six questions:

Q1: How much do you value water?

Q2: Do you know how much water your household uses each month?

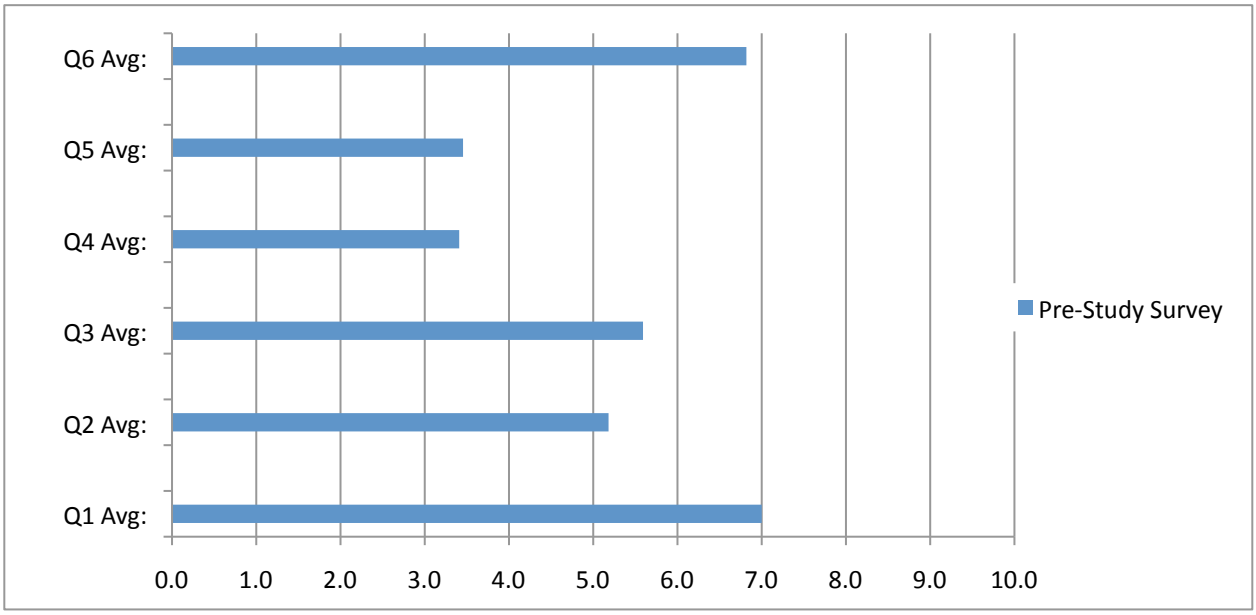
Q3: How comfortable are you with water saving techniques?

Q4: Do you follow regional water issues?

Q5: How much do you know about global water scarcity?

Q6: Do you feel that there will be a global water shortage problem in the future?

The answers were collected on a scale of 1-10; with 1 being low/none and 10 being high/yes. Below are the averages for the response to each question.



The average number of toilets present was 2.3; the minimum was 1 and maximum was 3. Twelve households had all high efficiency fixtures, the average high efficiency toilets per household was 1.9. Four households had toilets that leaked. The average leaks per household totaled 4 and the total number of leaks fixed was 0.

Households	Number of Toilets:	Number of High Efficiency Toilets:	Number of Leaking Toilets:	Leaks Fixed:
Household 1	1	1	0	N/A
Household 2	1	1	0	N/A
Household 3	3	3	0	N/A
Household 4	2	2	1	0
Household 5	3	0	0	N/A
Household 6	3	3	2	0
Household 7	2	2	0	N/A
Household 8	1	1	0	N/A
Household 9	2	2	0	N/A
Household 10	2	2	1	0
Household 11	3	3	1	0
Household 12	3	0	0	N/A
Household 13	3	3	0	N/A

Household 14	3	3	0	N/A
Averages:	2.3	1.9	0.4	0

The average American uses 2000 gallons of water per day. "Nearly 95% of your water footprint is hidden in the food you eat, energy you use, products you buy, and services you rely on." (National Geographic Water Footprint Calculator, 2010) The following are results using the National Geographic Water Footprint Calculator. The initial average household water footprint was 3114.1; the minimum was 2866 and the maximum was 3367.5. The final average household water footprint was 3120.4; the minimum was 2866 and the maximum was 3595.5.

Households	**Initial Average Water Footprint**	**Final Average Water Footprint**
Household 1	2866.0	2866.0
Household 2	2939.0	2939.0
Household 3	3367.5	3595.5
Household 4	2955.0	2935.0
Household 5	3425.5	3425.5
Household 6	3141.5	3122.0
Household 7	3165.0	3271.0
Household 8	3091.0	3091.0
Household 9	2931.0	2954.0
Household 10	2937.5	2937.5
Household 11	3318.0	3098.0
Household 12	2949.5	2941.0
Household 13	3359.0	3359.0
Household 14	3151.5	3151.5
Averages	**3114.1**	**3120.4**

Average water usage for the households prior to the study was 5.3 units of water per month. Data for prior water usage was collected from Lincoln water systems, which only provided data for the last 18 months. During the study average water usage was 5.2 units of

water per month. The average percent change in water usage per household was -3.2%. The average monetary savings per household was an increase of $0.01.

Participants	Avg Use During Study	Avg Use Prior	Percent Change	Money saved
Household 1	4.5	4.8	-6.2	$ 0.40
Household 2	4.7	4.5	4.7	$ (0.29)
Household 3	5.1	5.1	-0.1	$ 0.01
Household 4	3.2	4.1	-23.2	$ 1.28
Household 5	10.9	8.3	31.7	$ (3.51)
Household 6	5.1	5.5	-7.3	$ 0.54
Household 7	1.5	2.5	-38.1	$ 1.28
Household 8	3.2	4.3	-25.0	$ 1.43
Household 9	7.1	7.6	-6.5	$ 0.66
Household 10	5.0	3.9	27.1	$ (1.43)
Household 11	8.7	7.1	22.2	$ (2.13)
Household 12	5.6	6.4	-12.8	$ 1.10
Household 13	3.6	N/A	N/A	N/A
Household 14	4.7	5.1	-8.7	$ 0.60
Average:	5.2	5.3	-3.2	$ (0.01)

*data is represented as a unit, 1 unit = 100 cubic feet or 748 gallons water

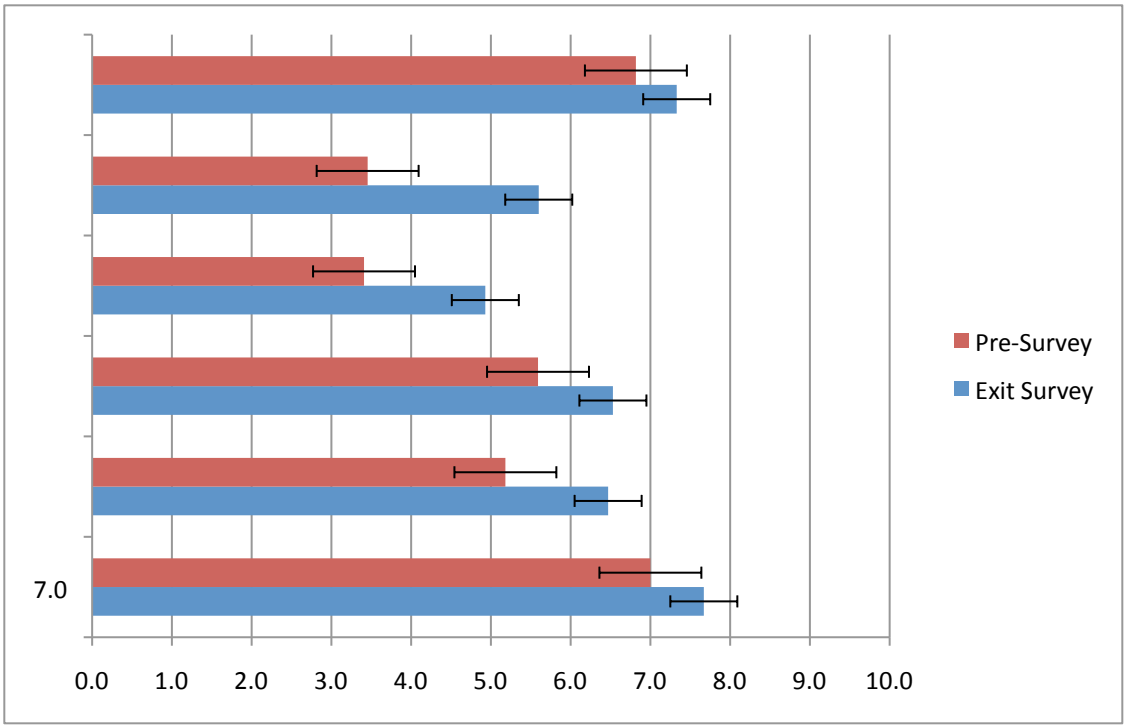
**approximate cost per unit of water $1.344

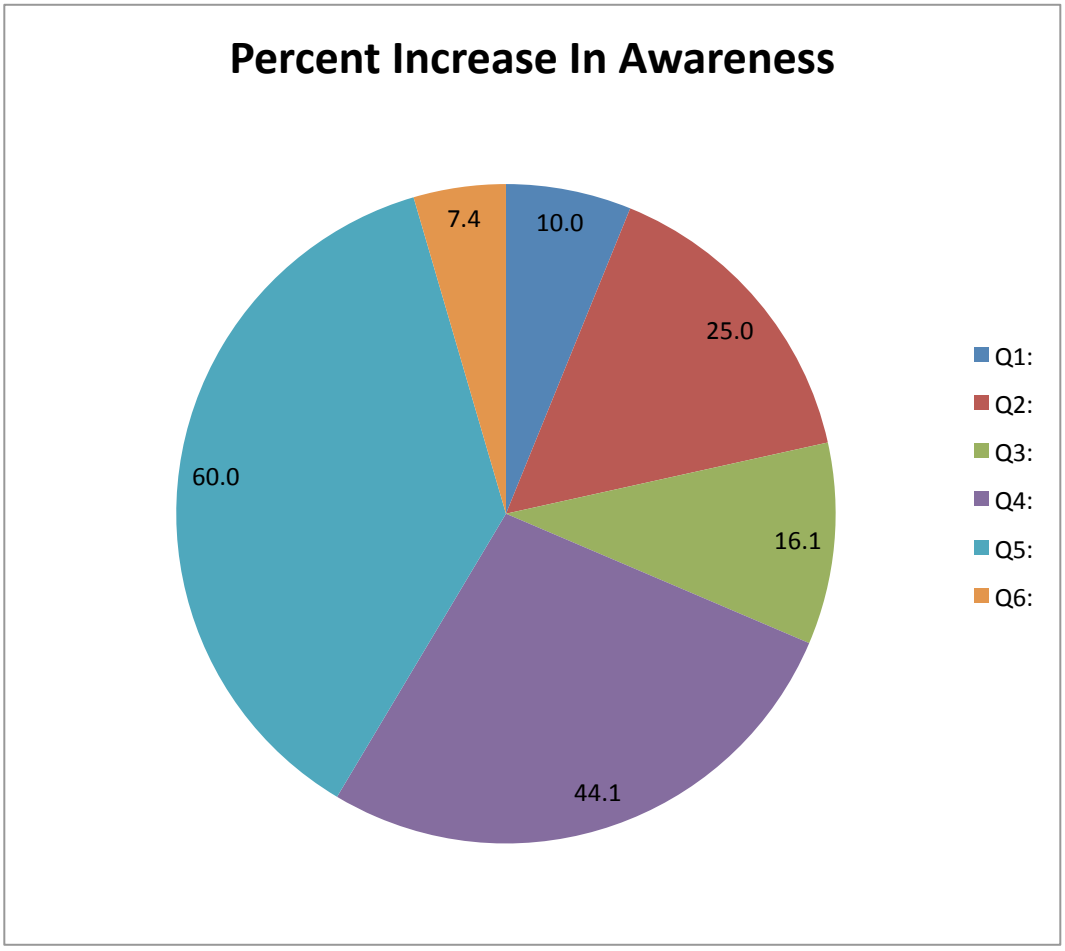
Results of the exit survey indicated an increased overall awareness of water issues. An increase in results averages between 6 questions by 27.1%; with minimum awareness increase of 7.4% and a maximum increase of 60%.

Survey Questions:	**Average Response for scale 1-10**	**Percent Increase In Awareness**
Q1:	7.7	10.0
Q2:	6.5	25.0
Q3:	6.5	16.1
Q4:	4.9	44.1
Q5:	5.6	60.0
Q6:	7.3	7.4
Average		27.1

VII. Analysis

The results from the survey indicate that there was an increase in individuals overall awareness to water issues. Awareness that global water scarcity is an issue saw the biggest increase (Q6). The readings provided to the participants along with discussions about water issues factored into the increase in awareness on the subject. Question four also indicated a large increase in awareness from the beginning of the study until its completion. Participants were made aware of regional water issues and how their individual habitats can affect water levels on a regional scale when compounded. The education of the participants had a direct effect on water scarcity awareness based on the survey results. The graphs illustrate the increases in awareness for the six questions.


7.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Pre-Survey
Exit Survey


Percent Increase In Awareness
10.0
25.0
16.1
44.1
60.0
7.4
Q1:
Q2:
Q3:
Q4:
Q5:
Q6:

Out of the fourteen homes that participated in the study only two homes did not have high efficiency toilets. Four homes had leaks in their toilets and zero elected to correct leaks during the study. None of the homes elected to utilize the Lincoln Water Systems free toilet bank. Only two homes would have needed the toilet bank because their toilets were not high efficient models. However neither home with the low efficiency toilets had a leak.

The average water footprint from the initial to final water footprint either remained the same or increased in 10 out of 14 households. In the other 4 households the water footprint decreased slightly. This can be attributed to either the participants overestimating their actual water saving techniques prior to the water scarcity education, since almost every household saw a decrease in water consumption. It can be attributed to participants' psychological feeling that they were sufficient at water conservation prior to the study and that they made little to no changes in their daily habits. It could be even a combination of both overestimation and the participant's view of their water conservation habits.

Water usage prior to the study was 5.3 units of water per month and during the study from January – April of 2012 water usage was 5.2 units of water per month. Nine of the households saw a decrease in water consumption over the study. One of the remaining five homes had just moved into a new home in December and had no prior data to compare water usage history to. The other four households either had an unexpected change; one household installed a new water heater in January which resulted in an increase of 4.7% when compared to the previous years, three households had a change in family member residing with them, all three households saw an increase over 20% to their water consumption over the previous year. The average decrease in water consumption was 3.2%; with the biggest decrease being 38.1%. If the three homes with changes to family members residing in the home would have remained the

same as initial contact water consumption would have been expected to decrease based on the results of the other households.

Monetary savings were minimal for the four month period. However as a group the savings were thrown off by the three households that had a change in family members consuming water (household 2's increase was minimal compared to other three). Household 3 exhibited little changes in their daily habits which are reflected in their water use and water footprint. The rest of the households could expect to continue to see savings that would add up over their life time with consistent water conservation habits.

Participants	Avg Use During Study	Avg Use Prior	Percent Change	Money saved
Household 1	4.5	4.8	-6.2	$ 0.40
Household 2	4.7	4.5	4.7	$ (0.29)
Household 3	5.1	5.1	-0.1	$ 0.01
Household 4	3.2	4.1	-23.2	$ 1.28
Household 5	10.9	8.3	31.7	$ (3.51)
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Household 12	5.6	6.4	-12.8	$ 1.10
Household 13	3.6	N/A	N/A	N/A
Household 14	4.7	5.1	-8.7	$ 0.60

Average:	5.2	5.3	-3.2	$ (0.01)

*data is represented as a unit, 1 unit = 100 cubic feet or 748 gallons water

**approximate cost per unit of water $1.344

VIII. Conclusion

The data collected supports my hypothesis. The water consumption patterns of the participants after being educated on water scarcity and water saving techniques correlated directly resulting in a decrease in water consumption and an increase in monetary savings. This indicates that individuals have the potential to make an impact on conserving water regionally and globally when motivated and educated.

The number of participants that indicated their water footprints had no effect on their daily habits of water conservation still yielded a decrease in water usage from the previous year, also resulting in an increase in their water scarcity awareness and water saving techniques. I feel that the education played an underlying reason in why the water consumption reduced. However, in just the few months of this short study the participants' awareness was raised, whether consciously or subconsciously, changes made by the participants directly correlated in the change in water consumption patterns.

After conducting this research I believe that a more thorough and extensive study would yield better results of my hypothesis. I feel that a more accurate observation could be completed if the study was over an extended period of time, i.e. 5-10 years. I believe that by observing these households for a longer period of time and continuing the education of the participants would yield a significant decrease in water usage and significant increase in water conservation,

monetary savings, and habitual change overall. A larger pool of households would be ideal for an extended study, with an ideal number of around 500. The attrition and awareness for the importance of this study was also disheartening. I started out with only twenty households and within a month six dropped out. Awareness needs to be marketed to the population about the severity and gravity of water conservation.

However small the results, I believe that this study exemplifies what a little bit of information can do to raise the awareness of an issue. Awareness results in change, change requires knowledge, and acting on our knowledge can save our futures. Change can happen either consciously or subconsciously as individuals are made aware of an issue they are able to yield results no matter how small.

Markets that are affected by fresh water shortages could make an impact on their resident's uses with a marketing campaign that implanted small facts of information educating their residents on water scarcity. My study has shown the correlation between education and a decrease in water consumption. Efforts that include educating the public, along with upgrading infrastructures could prove to be extremely efficient in helping reduce a community's usage of fresh water.

Any attempts to save water by a community will come down to a community's understanding of the issue and their ability to correlate water usage and the impact it is having on not only their community, but the rest of the world. Leonardo Da Vinci said "All our knowledge is the offspring of our perceptions," which rings too true when it comes to conservation efforts. Without education and awareness, change cannot happen.

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