Water You Doing to Conserve, California?

Team member names: Dhyuti Ramadas, Jenna Sparks, Nicholas Xu, Ke Zhang

Date: 12/04/2022

Overview:

California has experienced two statewide droughts in the last twenty years[1]. Water usage mitigation is critical for sustainable living conditions in California. In this project, we propose to identify a key water conservation measure based on current inefficiencies in water usage in urban areas. We will then measure the water usage of urban communities before and after that water conservation measure is implemented. We will be surveying a statistically significant number of urban communities to determine the effectiveness of this water conservation method. Based on a comparison of water usage before and after this implementation, we will recommend state policies for water conservation to California state government officials.

Research Question:

Main Question: How can California reduce water consumption during periods of drought?

Sub Question 1: What are inefficiencies in current water usage in urban areas?

Sub Question 2: How can urban water use be reduced?

California divides water use between three main sectors[2]. Usage is approximately 50% environmental, 40% agricultural, and 10% urban. Environmental water is mainly used for rivers, streams, and wetlands along the north coast, and is largely separate from agricultural and urban areas. Agricultural water refers to water used on California's farmlands. Urban water refers to water used in households, businesses, institutions, and industrial processes[3]. This study will focus on urban water consumption.

---

[1] https://water.ca.gov/water-basics/drought
[2] https://www.ppic.org/publication/water-use-in-california/
[3] https://water.ca.gov/programs/water-use-and-efficiency/urban-water-use-efficiency

Study Design:

1. A statistically significant amount of urban areas will be randomly selected within California. Urban areas will defined as land having at least 50,000 inhabitants in a continuous space (>1500 inhabitants per km^2)[4]
2. Survey community members in urban areas to understand current water consumption and identify one main water conservation measure. For example, if a majority of participants water lawns frequently, planting drought-resistant plants could be one such measure.
3. We conclude the survey when we've received a statistically significant number of responses. We will resend surveys if we do not receive a sufficient number of responses the first time. More detail on this sample size can be found in the Data section.
4. Participants will be sampled using stratified random sampling based on the sector: household, commercial, industrial, and institutional.
5. Once the water conservation measure is determined, it will be explicitly explained to the participants of the study in the experiment group.
6. Within each sector, participants will be further divided based on size. This will allow equal representation of small and large families, businesses, institutions
7. Participants will be divided equally to two groups: control group which does not implement the water conservation measure, group which implements the new water conservation measure.
8. Water consumption will be measured over a period of six months. This duration was chosen because it is long enough to allow us to notice a change in water consumption, but short enough to minimize fatigue with participants.

Data:

- We will begin by surveying the stratified sampling groups: household, commercial, industrial, and institutional. The conservation method implemented will be determined based on the survey results.
- A single point of contact will be made for each of the groups (eg. household = a current occupant, commercial = office manager in charge of energy usage, etc.)
- We will survey a statistically significant number of participants for each group based on the Taro Yamane method (more detail in Statistical Methods) in urban communities, asking the community members about their current water usage.

[4]https://blogs.worldbank.org/sustainablecities/how-do-we-define-cities-towns-and-rural-areas#:~:text=Cities%2C%20which%20have%20a%20population,inhabitants%20per%20km2%3B%20and

- In the survey, we will ask questions about the duration of water usage during common activities that may include watering the lawn, landscaping, showering, etc.
    - For each water-using activity the surveyee will be asked to specify if the activity is necessary or extraneous
- After the survey, we will identify the respondents that are interested in participating and select a statistically significant population for this study.
- Respondents will be randomly divided into a control group and an experimental group.
- We can then ask the experimental group building's owners to implement one water conservation method for six months.
- We will compare the experimental group's monthly water usage to the control group's monthly water usage and then overall water usage. We will measure water usage using each building's water meter.

Sample:

Sample for Survey:

- The sample size will be multiple cities with similar demographics (a statistically significant sample size will be determined). Specifically, the survey will be given to single-family dwellings (household), single-business buildings (commercial), single factory warehouses (industrial), and single-institution buildings (institutional). These categorizations will target buildings where occupants have the ability to control water consumption for the entire premises. Please see statistical methods for more information about how sample size is determined.

Sample for Measure Implementation:

- We will have a target sample size of a statistically significant number of participants for each category from the survey. Participation in the survey and subsequent experiment will be voluntary.

Variables and/or Intervention:

- As mentioned in the Study Design, the participants will be categorized into household, commercial, industrial, and institutional. Each sector will be further divided into classes based on their sizes. This will ensure each class is heterogeneous compared to others, and homogenous among themselves. Then when measuring the effectiveness of the water conservation measure, there will be minimal statistical noise due to variations in sociodemographic factors. This will create clearer generalizability.

- After reviewing the number of participants in each class, we might aggregate classes into sectors if the data are too thin (not statistically significant). And if data is excessive, we will still aggregate the classes and see if we can reach similar conclusions at various levels.
- We will measure their water consumption over six months. We will calculate the change in water consumption from before the water conservation measure implementation and after the experimental water conservation measure has been implemented for six months. The control group will receive no water conservation measure instructions. It's important to have a control group to capture any outside factors that are influencing water consumption possibly.
- During the study, we will conduct active inspections by visiting random participants to verify the water conservation measure is properly implemented.

Statistical Methods:

- We will determine a statistically significant sample size using the Taro Yamane method[5]. It calculates the sample size using the size of the population and the margin of error. It allows us to make inferences and conclusions from the survey to be applied to the whole population.
- To determine whether the water conservation measure is effective, we will conduct a two-sample t-test, a hypothesis test for the difference between two means (before water consumption rate versus post-experiment water consumption rate).
- The null hypothesis will be the mean changes for the water conservation measure group and the control group are the same. The alternate hypothesis will be the mean change for the water conservation measure group is lower than the control group. We will choose a significance level of 0.05 as it is most commonly used for statistical analysis.
- We must meet several assumptions to conduct a valid t-test. The samples have to be independent, approximately normally distributed, and obtained from a random sampling method. All of these will be met as part of our research design.
- Depending on whether the variance of the samples is equal, which we can easily check so after gathering the data from the two groups, we will either perform a Student's t-test or Welch's t-test[6]. They are very similar except with slightly different test statistics and degrees of freedom.

[5]https://projectclue1.medium.com/taro-yamane-formular-in-calculating-sample-size-for-research-92b93a39696c

[6] https://www.rips-irsp.com/articles/10.5334/irsp.82/

- If the null hypothesis is rejected, then it suggests the water conservation measure group has a larger decrease in water consumption than the control group, indicating it is more effective.

Potential Risks:

Data Privacy:

- The survey recipients might have concerns about providing detailed information about their water usage. There will be a way to opt out of any future contact. For those who responded, the data will be anonymized and be compliant with CCPA (California Consumer Privacy Act).

Response Bias:

- The preliminary survey might not have 100% fill rate, which might introduce response bias where all respondents might adopt a certain lifestyle in common (i.e. work from home), hence leading to biased water consumption results.
- To overcome this, we will design the survey to be short and simple, easy for everyone to respond. We also will use incentives to make sure we reach desired numbers of respondents for each stratum.

Ethical Considerations:

- Since surveys and experiments are voluntary and the intention of the study is to improve the environment and the wellbeing of the California resident, this research should have minimal ethical risks.
- However, we will still have a third-party ethical review board to provide review and provide feedback to the study design and make adjustments accordingly.

Effective Implementation of Water Conservation Measure:

- We might not be able to measure the effective implementation of the water conservation measures; for example, the residents are away from home when we visit; or the resident refuses to provide updates.
- We will give 48 hour notice for the visit and have an agreement signed by participants before enrollment.

Commitment from the Stakeholders:

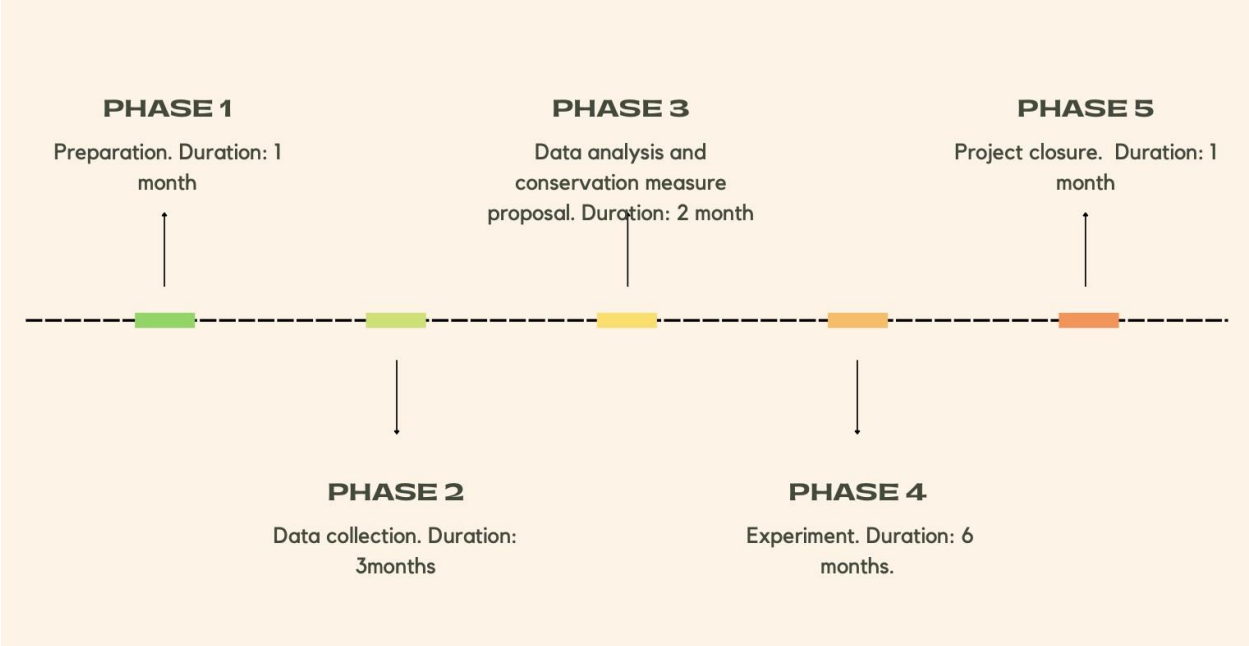
- We may not reach an effective water conservation measure if the stakeholders decide to exit due to arising unforeseeable circumstances such as financial emergency, natural disasters, etc.

- We will have a contract with the party of interest; however, there's still risk of commitments and it is out of scope of this project.

Costs:

- It might be costly to assemble a workforce to organize, execute and monitor experiment progress in the local community.
- However, this is beyond the scope of the design.To influence a community collective water usage behavior would inevitably require extensive resources.

Deliverables:



Phase 1 - Preparation. Duration: 1 month.

- Review demographic data available and select an area of interest for subsequent survey
- Perform power analysis on selected samples and select appropriate sample size.
- Contact local postal office to learn and implement survey distribution method

Phase 2 - Data collection. Duration: 3 months.

- Distribute surveys through postal services
- Processes returned surveys
- Assemble survey results into digital formats for further analysis

Phase 3 - Data analysis and conservation measure proposal. Duration: 2 month

- Propose a new measure for urban water conservation.
- Prepare relevant information materials such as flyers or video to teach participants to effectively apply the conservation measure.

Phase 4 - Experiment. Duration: 6 months.

- This is the core of the study. The new measure will be implemented at the test group and their water usage will be analyzed to discover the effectiveness of the measure.

Phase 5- Project closure. Duration: 1 month.

- Determines the effective measures for water conservation.
- Write up the final report with insights and recommendations for continuous water conservation plannings.