Growing With Youth
*Grandir Avec la Jeunesse*

Montreal, Canada

June 12 – June 15, 2019/ *Juin 12 – Juin 15, 2019*

# WATER CONSERVATION IN THE HOUSEHOLD: THE IMPLICATIONS OF METRICS AND THE ASSOCIATION BETWEEN CHARACTERISTICS AND PRESENCE OF CONSERVATION

Araya, Felipe.[1, 2], Osman, Khalid.[1], Spearing, Lauryn.[1], and Faust, Kasey M.[1]
[1]University of Texas at Austin, United States
[2]felipe.araya@utexas.edu (corresponding author email)

**Abstract:**

Increased demand from population growth in areas experiencing water scarcity can place stress on water infrastructure systems in communities. The impacts of growth can be mitigated by a management approach that encourages conservation practices. By decreasing per capita demands, communities may mitigate the need to expand system capacity and address supply-side constraints. This study uses statistical inferencing to assess (1) the relationships between household characteristics (e.g., ownership status) and whether a household conserves water, as well as (2) how these associations may vary under different scenarios of defining household conservation. To assess the presence of actual water conservation, the study uses two metrics—125gpcpd (set by the local utility) and 90gpcpd (commonly cited in the U.S.). To define the duration of household conservation, the study applies three measures—a household conserving at least 50%, 75%, or 100% of the time. The two metrics and three definitions combine to create six different scenarios. This study was facilitated by a survey deployed in 2016 to the Austin, Texas metropolitan area. The survey was intended to understand water-use behavior and perceptions toward local water-infrastructure services. This data was subsequently matched to respondents' monthly water consumption from 2012 to 2016 by the local utility. The results of this study show that using different metrics influences the average duration of water conservation for each household characteristic. Understanding the influence of household characteristics on conservation may assist utilities as they develop programs that target specific categories of households (e.g., households with children through school programs).

## 1. INTRODUCTION

Between 2020 and 2070, the existing water supply in Texas is expected to decline by approximately 11% (Texas Water Development Board 2017). During this same period, the population in Texas is expected to increase by 70%, posing an imminent challenge for water providers and state policymakers alike (Texas Water Development Board 2017). Based on current assessments, in the absence of water demand management strategies, one-third of the state will be subject to limited water availability (Texas Water Development Board 2017). Recently, in Austin, city officials have implemented water-demand management strategies due partially to the severity of the 2011 drought (Austin Water 2015); for instance, the enforcement of water use restrictions like prohibiting the washing of cars with a water hose or set days for irrigation (Austin Water Utility 2017a). In addition to outdoor water restrictions, conservation campaigns were developed to target indoor water usage; for instance, encouraging residents to only wash full loads of laundry or turn off tap water while brushing teeth (Austin Water Utility 2017b).

Researchers have explored the effectiveness of such water-conservation programs (e.g., Geller et al. 1983; Michelsen et al. 1999; Olmstead and Stavins 2009). Geller et al. (1983) suggested that conservation programs are unable to reach their full potential due to obstacles such as minimal economic incentives or the absence of consumption-feedback mechanisms between users and water-conservation program authorities. More recent studies—such as Olmstead and Stavins (2009)—reiterated the notion that price-controlled conservation measures (e.g., penalties for water over usage) are more effective than non-price-controlled measures (e.g., education and outreach). However, as discussed by Olmstead and Stavins (2009), price-controlled conservation measures must include equity aspects in their design as high-income households are less sensitive to water price increases as compared to low-income households. Michelsen et al. (1999) focused specifically on non-price-controlled measures and found that they could be effective at reducing water usage. Notably, these studies emphasize the aggregate household results and do not provide insight into the interactions between individuals and their water-conservation efforts within the household. Thus, utilities may be equipped with insufficient information to develop effective conservation programs that target individual behaviors and perceptions.

One method of understanding the relationship between individuals and their water conservation efforts is through the understanding of end-user perceptions. The influence of public perceptions and socio-demographics on water consumption has been the subject of several studies (e.g., Rosenberg 2007; Randolph and Troy 2008; Fielding et al. 2012; Suero et al. 2012; Jorgensen et al. 2014). Russell and Fielding (2010) discussed the relationship between individual attributes (e.g., beliefs, habits, capabilities) and environmentally friendly attitudes, resulting in water conservation behavior. Studies have shown that a relationship exists between water-use behavior and household size (Rosenberg 2007; Randolph and Troy 2008), ownership of household (i.e., owned or rented; Randolph and Troy 2008), and the number of residents in the household (Fielding et al. 2012; Suero et al. 2012). Jorgensen et al. (2014) found that, across the literature, household size was a possible predictor of water consumption. A need exists, they demonstrated, for further studies on how water conservation is influenced by household size (e.g., whether a larger household leads to more consumption).

Water conservation is colloquially understood as “using less than was previously being used.” Nonetheless, utilities often establish metrics to define conservation behaviors among residents. Such metrics define the maximum amount of water a household should consume to be classified as conserving. In the literature, several examples of such metrics have been reported (e.g., 10gpcpd reduction, Anton 1995; 54gpcpd, Cahill and Lund 2012; 40gpcpd, Dziedzic et al. 2015). These metrics determine whether households are classified as conserving or not. Notably, when it comes to defining conservation metrics, researchers have found it relevant to consider different locations and property types. Cahill and Lund (2012) found, for example, that using the Californian conservation ceiling (105gpcpd) would result in classifying all Australians as conserving, given the average usage is 50gpcpd lower in Australia. Dziedzic (2015) suggested that different property types (e.g., single-family, multi-family, residential, commercial) should have different ceilings for water conservation. Considering this, the assessment of all property types using a single, nationwide metric may lead to inaccurate evaluations of conservation programs (e.g., finding that a program is ineffective due to property type). However, limited research has been done on the impact of using different metrics to assess household conservation on the same population.

This study seeks to address a gap in the literature regarding the joint influence of household characteristics and metrics used to assess conservation on actual water-consumption behavior. Survey analyses and statistical inferencing are used to explore the following: (1) the presence of relationships between household characteristics (e.g., number of occupants, ownership status) and whether a household conserves water; and (2) how these associations may vary considering different scenarios of defining household conservation. Two conservation metrics—125 gpcpd and 90 gpcpd—are used to assess variations in the presence of and statistical significance of relationships between household characteristics and residential water conservation. To define the duration of household conservation, the authors applied three different time frames—households conserving at least 50%, 75%, or 100% of the time. Ultimately, six different scenarios are available for analysis. The results from this study help to accomplish three things: 1) contribute to the existing literature on the relationship between household characteristics and non-price-controlled water conservation efforts; 2) support the notion that water conservation metrics should vary

based on household characteristics; and 3) inform utilities developing water-demand management programs.

## 2. METHODS

Enabling this study is a survey capturing public attitudes toward water conservation in Austin, Texas. To evaluate household water conservation behavior, the authors matched these survey responses with five years of utility-provided monthly household water consumption. Water conservation was assessed using two metrics—125 gpcpd and 90 gpcpd. By pairing household characteristics with monthly water consumption, statistical inferencing was able to explore two elements—the presence of a statistical association between water conservation and household characteristics, and how these associations may vary considering different defining scenarios of household conservation.

### 2.1 Survey Development and Deployment

An online survey was deployed in August 2016 in the Austin, Texas, metropolitan area. The survey sought to capture perceptions of individual and household water use and the community's water infrastructure. Before its deployment, the survey underwent content and expert validation. Additionally, the Institutional Review Board (IRB) from The University of Texas at Austin reviewed the survey. Respondents took the survey voluntarily; all respondents were 18 or older and consented to have their survey responses matched with their water-consumption records. The final sample consisted of 407 valid responses spanning 29 zip codes. As such, the sample provided a confidence level of 95% with a margin of error of 5% that the data was representative of Austin residents. Table 1 shows descriptive statistics of sociodemographic attributes from survey respondents and the 2015 Census for Austin.

Table 1: Sample demographics compared with Census Data for Case City (US Census Bureau, 2015)

| Independent Parameter | Sample Avg. | Census Avg. |
|---|---|---|
| Male | 0.62 | 0.51 |
| Age 18-50 | 0.65 | 0.62 |
| Employed | 0.61 | 0.73 |
| Home Ownership | 0.26 | 0.45 |
| Household income under $34,999 | 0.12 | 0.17 |
| Bachelor's Degree Obtained | 0.53 | 0.48 |
| Number of cars in the household (cars) | 1.93 | 2.00 |

### 2.2 Actual Water-Consumption Data

To evaluate the water-conservation behavior of residential users and its relationship with household characteristics, the local utility matched each survey response with the previous five years of monthly water-consumption records (January 2012-December 2016). The local utility company classified survey respondents into ten groups (e.g., multi-family shared meter, duplex, or single-family-owned meter). Of interest to this study were single-family owned households ($n = 217$). The reason for this selection was to ensure that each survey response corresponded to only one household consumption record. In the case of households classified as multi-family shared meter, it becomes more difficult to match the survey responses with the corresponding household-consumption record, as the consumption record is associated with multiple households.

To determine if a household conserved water or not, the authors used two different metrics, one defined by the local utilities and the other cited as a national average. Different values measuring whether conservation occurred in the household explored the consequences of classifying or misclassifying household

conservation. The first metric used was 125gpcpd/ 472.5lpcpd, defined by the local utility. The second metric used was 90gpcpd/ 340.2lpcpd, commonly cited in the US (Maupin et al., 2014; Sankarasubramanian et al., 2017; Worland et al., 2018). Household consumption was assessed by the month to ascertain the presence of conservation over five years (i.e., 60 months; see Eqns. 1 and 2). In this study, the authors classified a household as conserving according to three definitions—if they conserved at least 30 out of 60 months (50% of the time), at least 45 out of 60 months (75% of the time), or all 60 months (100% of the time).

$$[1]\ \text{Conserving}_{\text{householdCity}} = \begin{cases} 1, & if\ \text{monthly consumption} < 472.5\ \frac{\text{liters}}{\text{capita}*\text{day}} * \text{household size (number of occupants)} * \text{days in the month}, \\ 0, & otherwise \end{cases}$$

$$[2]\ \text{Conserving}_{\text{householdUSA}} = \begin{cases} 1, & if\ \text{monthly consumption} < 340.2\ \frac{\text{liters}}{\text{capita}*\text{day}} * \text{household size (number of occupants)} * \text{days in the month}, \\ 0, & otherwise \end{cases}$$

### 2.3 Tests of Independence

Chi-square tests of independence and Fisher' exact tests were performed to assess the presence of associations between household conservation and household characteristics. The household characteristics of interest in this study are household ownership status, household occupancy—i.e., having three or more people living in the household, if at least one child is under the age of 18 in the household, and if at least one child is under the age of five in the household. These four characteristics were chosen because they represent attributes at the household level and as such, are at the same level of analysis as the information from the actual consumption records that the data is matched with. Additionally, to investigate the influence of the geographic location of the household on conservation, the authors explored the association between household conservation and the respondents' zip codes. Contingency tables were created for each test. In most of the tests, the Chi-square test was successfully applied, but in two cases the expected frequency of the test was lower than five, thus limiting the reliability of the results (Washington et al., 2010). To overcome such a limitation in these two cases, the authors implemented, following Washington et al. (2010), the Fisher's exact test. Additionally, two tests were unable to be performed due to one of the categories having a frequency of zero. The corresponding p-values from the tests are reported in Table 2.

### 2.4 Limitations

As with any study, limitations exist in this one. One limitation is that at the time of this study there was no clear definition of how long a metric should be applied to assess residential conservation. For instance, does a household conserve if they consume a certain amount of water for one billing period or three consecutive billing periods? The authors defined conservation as consuming less than a specific metric for at least 30 out of 60 months, 45 out of 60 months, or during all 60 months. A second limitation of this study is that tests of independence (i.e., Chi-square or Fisher's exact) indicate only whether the studied characteristics are related or not, and provide no further information of the type of relationship, if one exists.

## 3. RESULTS

### 3.1 Independence Tests

The results of the tests of independence are shown in Tables 2-4. The tables were separated based on the three definitions of conservation, specifically, conserving (1) at least 30 months, (2) at least 45 months, and (3) all 60 months. The scenario in which households are considered conserving at least 45 months showed the largest number of associations between household characteristics and household conservation. Conversely, the case in which households conserve at least 30 months showed the lowest number of

associations. Focusing on the household characteristics, having at least one child in the household under 18 years was the only characteristic associated with conservation for all six scenarios. In contrast, having at least one child in the household under five years was the only characteristic that was not associated with conservation for all scenarios.

Table 2: Results for associations between household conservation and household characteristics

| Description of the conservation scenario | Household Characteristics | Metric to determine presence of household conservation: 90gpcpd/340.2lpcpd | Metric to determine presence of household conservation: 125gpcpd/472.5lpcpd |
|---|---|---|---|
| ***Household conserves at least 30 of 60 months, or 50% of the time*** | Three or more people living in the household | **0.011** ** | 0.107 |
| | At least one child under 18 years living in the household | **4.34x10E-5*** ** | **0.009*** ** |
| | At least one child under 5 years living in the household | 0.1 | 0.614 |
| | The household is rented by the residents | 0.334 | 0.015** |
| | Residing in zip code 78753[1] | **0.041** ** | **0.047** ** |
| | Residing in zip code 78731[1] | **0.083*** | 0.157 |
| ***Household conserves at least 45 of 60 months, or 75% of the time*** | Three or more people living in the household | **0.002*** ** | **0.014** ** |
| | At least one child under 18 years living in the household | **0.001*** ** | **0.002*** ** |
| | At least one child under 5 years living in the household | 0.32 | 0.405 |
| | The household is rented by the residents | **0.047** ** | **0.015** ** |
| | Residing in zip code 78753[1] | 0.137 | 0.008*** |
| | Residing in zip code 78731[1] | **0.0105** ** | 0.277 |
| ***Household conserves all 60 months, or 100% of the time*** | Three or more people living in the household | **2.44x10E-5*** ** | **1.08x10E-5*** ** |
| | At least one child under 18 years living in the household | **7x10E-5*** ** | **1.1x10E-4*** ** |
| | At least one child under 5 years living in the household | 0.226 | 0.366 |
| | The household is rented by the residents | 0.384 | 0.870 |
| | Residing in zip code 78753[1] | 0.459 | 0.2114 |
| | Residing in zip code 78731[1] | N/A | N/A |

**p<0.1, **p<0.05. ***p<0.01*

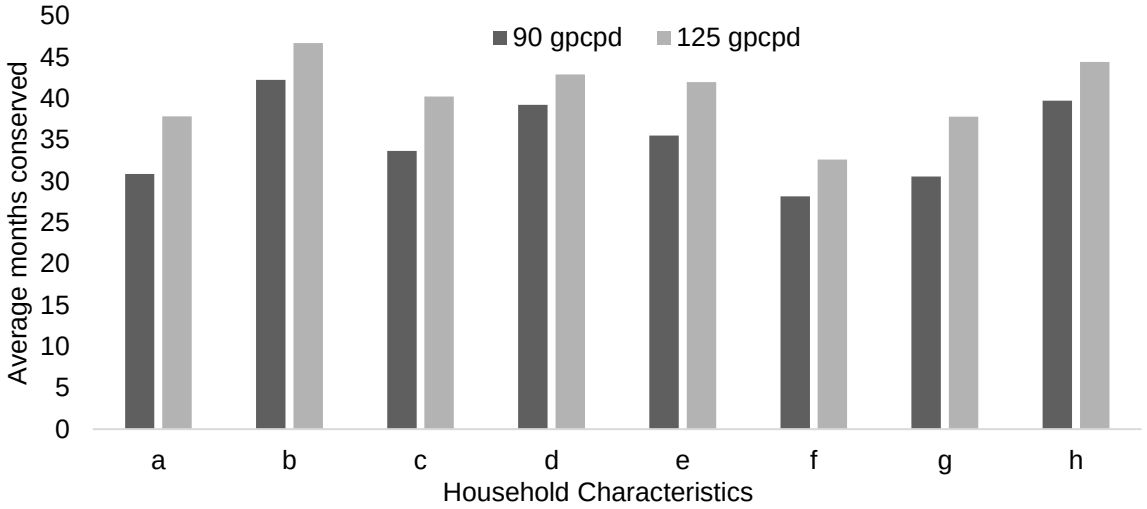
*N/A: the test could not be performed due to one of the categories had a frequency of zero*

*[1]Other zip codes were tested but were not found significant*

### 3.2 Average Months Conserved by Household Characteristics

The average number of months a household conserved using the metric of 90 gpcpd is 34.5 months with a standard deviation of 18.5 months. Using the metric 125 gpcpd, the average number of months a household conserved is 40.6 months with a standard deviation of 17.4 months. Figure 1 shows the average number of months households conserved water based on the different household characteristics used in this study. Notably, the impact of using two conservation metrics differs among the four household characteristics—

e.g., compare c and d in Figure 1. Differences among household characteristics range between 8.6% and 19.2%, with an average of 15%.




(a) No children under the age of 18
(b) At least one child under the age of 18
(c) No children under the age of 5
(d) At least one child under the age of 5
(e) The household is owned
(f) The household is rented
(g) Up to two persons living in the household
(h) Three or more persons living in the household

Figure 1: Average total number of months a household conserves over a 60 months period, categorized by household characteristics for each metric

### 3.3 Average Months Conserved by Year

Figure 2 shows the sample's (*n = 217*) average number of months a household conserved per year from 2012 to 2016. Interestingly, with every year that passed, the average number of months conserving increased, for both metrics, by approximately one month.

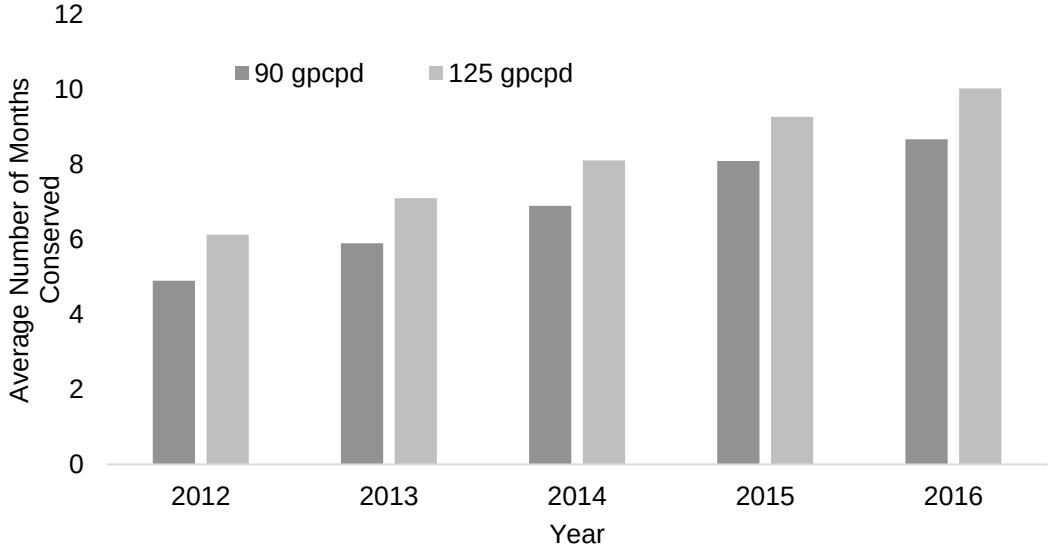



Figure 2: Average months conserved per year from 2012 to 2016

## 4. DISCUSSION

### 4.1 Household Characteristics

Notably, only one household characteristic was consistently associated with household conservation for all metrics and conservation periods (in months). That characteristic was having at least one child under 18 years old living in the household (Table 2). Another characteristic associated with household conservation, in five out of the six scenarios, was having three or more people living in the household (see Table 2). These two characteristics highlight the importance of taking household composition into account when discussing conservation. The results suggest that as the number of people living in the household increases, so does the likelihood of water conservation occurring in that household (Figure 1). Although this may seem counterintuitive, many household activities requiring water are typically performed periodically, somewhat independent of the number of residents in the household. For instance, washing the dishes or water for cooking are typically performed regardless of the number of household residents. Although a larger household may use more water in total for these activities from cooking larger quantities or running the dishwasher more frequently, the per capita impact of the activities decreases. This idea supports Wa'el et al.'s (2016) finding that everyday activities are more efficient in households with more residents. Based on these findings, future work should assess the impact of everyday water use activities on household conservation. As such, local utilities may develop conservation programs to educate and incentivize residents to use water-efficient appliances best suited for everyday activities, such as dishwashers.

Found to be associated with household conservation in three out of the six scenarios was the ownership status of households—i.e., whether the household was rented or not. Homeownership status has been found in the literature to be an indicator of positive relationships with water utilities due to longstanding interactions (Giuliani, 2003), as well as place attachment from long-term residents (Lewicka, 2011). In other words, the ownership status may represent a proxy variable for the length of time the utility and residents have been interacting. As such, the longer the interaction, the more likely it is that residents conserve water. Unsurprisingly, renting the household was associated with conserving 50% and 75% of the time but not with 100% of the time. These results may reflect that residents that rent their homes have less stake in the home, which may lead to actions that are less deliberate, such as water-conservation steps (Devine-Wright 2007). Additionally, when renting, residents may have a lack of control regarding—or lack of motivation to make—changes to household appliances, which may negatively impact conservation (Krishnamurti et al., 2012).

In regard to the influence of geographic location on household conservation, it was found that residing in 2 out of the 29 zip codes were associated with household conservation in four of the six scenarios (Table 2). The lack of consistency in the presence of an association between zip code of residence and household conservation suggests the presence of heterogeneity in conservation geographically. This finding highlights that localized factors, such as neighborhood culture, may impact household water conservation.

### 4.2 Influence of using two Metrics

Using different metrics to assess residential conservation had limited influence on whether a household characteristic was associated with conservation or not. Of the 36 associations explored, only five differed between the two metrics (Table 2). For instance, in the 30-month and 45-month scenarios, residing in the zip code 78731 was found to be associated with conservation using 90gpcpd but not using 125gpcpd (Table 2). The respondents residing in the area designated by the zip code 78731 had a median income that exceeded the city-wide and national levels (United States Census Bureau, n.d.). Such an association may indicate that households with varying income levels may have differing conservation behaviors.

As expected, using different metrics influenced the average duration of conservation for each household characteristic differently (see Figure 1). For example, households classified as having less than two persons show an approximate 7-month difference in conservation between the two metrics (i.e., 31 months for

90gpcpd vs. 38 months for 125gpcpd). This finding supports the need for disaggregated assessments of household conservation (e.g., accounting for different household characteristics when developing a metric). Further, the relationship discovered between conservation and household characteristics is not limited to the definition of household conservation used in this study—i.e., using three different periods 30, 45, and 60 months.

In addition to the influence of—or lack thereof—using multiple metrics, this study explored the average number of months that a household conserves water. Over the 60-month period, there was an increase in the average number of months conserved per year. Notably, this trend is irrespective of the metric used to assess conservation (see Figure 2). This trend of increased conservation over time may reflect the efforts made by the utilities to encourage water conservation among residents during the period of this study (2012-2016). During these five years, the City of Austin faced severe drought conditions (State Impact 2015), and as such, water utilities implemented a variety of programs to encourage conservation among residents (Austin Water Utility 2017a; Austin Water Utility 2017b). It is important to note that while utilities' efforts most likely influenced water conservation, other external factors may also have impacted conservation, such as a cultural shift to sustainability in Austin, Texas (Neely 2018).

### 4.3 Implications and Recommendations

Water utilities can use the results of this study to better understand how household characteristics and location influence water conservation. Equipped with a better understanding, the utilities could make strategic planning decisions to improve water conservation. The observed heterogeneity among household characteristics and locations implies that programs and policies should be implemented on a smaller scale. Utilities could, for instance, implement educational programs by neighborhood to capture geographic differences (e.g., poverty level, culture) in conservation, or they could direct efforts at children through schools. The Dowser Dan School Assembly Program, for example, aims to educate elementary school students about water conservation (Austin Water Utility 2019).

Results showed an association with water conservation and households having at least one child under 18. This association may be credited to or influenced by conservation programs implemented by the City of Austin at the school level. During the planning and implementation of water-conservation programs, utilities should avoid one-size-fits-all water-conservation policies. Moreover, utility operators must recognize that the way in which they measure conservation impacts the information they gather. By defining conservation duration in three ways and using two metrics, this study showed that the way in which conservation is defined impacts the reporting of overall conservation trends. In turn, cities should acknowledge that metrics should be dynamic and vary based on household characteristics and time of the year.

## 5. SUMMARY AND CONCLUSIONS

This study assessed the presence of associations between household and geographic characteristics and household water conservation. It defined the duration of household conservation in three ways (at least 50%, 75% or 100% of the study period) and, to classify households as conserving used two metrics—90gpcpd and 125gpcpd. The presence of such relationships emphasizes the influence of household occupancy, location, and composition on water conservation. The statistical tests of independence performed in this study showed that there were several household characteristics related to residential water conservation. It was found that in the six scenarios household conservation was consistently associated with the presence of at least one child under 18 and having three or more residents in the household. These results may reflect the contribution of everyday water-use activities at the household level such as washing the dishes; these activities may be more efficient in households with a higher number of residents (Wa'el et al., 2016). Furthermore, these results support the potential benefits of educating children about water conservation and encouraging conservation habits. It is important to note, however, that the survey population was a highly educated one (Table 1). Thus, results may be capturing households in which adults who received conservation education at universities are teaching their children. Additionally, it was found that the shortest duration of household conservation came from renters. This finding may be

explained by short-term relationships the occupants held with the utility or their having limited time or motivation to develop conservation behaviors.

This study contributes to the literature by improving the understanding of the relationships between household characteristics and household conservation, specifically by using different scenarios of defining household conservation—i.e., metrics and time frames. The practical contribution of this study is to equip utilities with better information to improve the development of water-conservation programs and to assess conservation periodically by implementing dynamic metrics. Future research should explore the associations found in this study to assess the influence of everyday water consumption activities on household conservation and to investigate using alternative definitions of conservation metrics based on seasonality effects.

**Acknowledgments**

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No.DGE-1610403, and by Conicyt under the program Becas Chile grant number 72170369.

## 6. REFERENCES

Anton, W.F., 1995. Implementing ASCE Water-Conservation Policy. *Journal of Water Resources Planning And Management*, **121**(1): 80-89.

Austin Water Utility, 2019. Dowser Dan School Assembly Program. Retrieved From: Http://Www.Austintexas.Gov/Department/dowser-dan-school-assembly-program.

Austin Water Utility, 2017a. State 2 Watering Restrictions. Retrieved From: Http://Www.Austintexas.Gov/Department/Stage-2-Watering-Restrictions

Austin Water Utility, 2017b. Simple Ways To Save Water. Retrieved From: Http://Www.Austintexas.Gov/Department/Simple-Ways-Save-Water.

Austin Water. 2015. Understanding the drought. Retrieved From: https://www.austintexas.gov/sites/default/files/files/Water/Drought/Understanding_the_Drought_Feb2015.pdf

Cahill, R. And Lund, J., 2012. Residential Water Conservation In Australia And California. *Journal Of Water Resources Planning And Management*, **139**(1): 117-121.

Devine-Wright, P. (2007). “Reflections on place attachment and favourite places”. IAPS Bulletin, 31, 6-8.

Dziedzic, R., Margerm, K., Evenson, J. And Karney, B.W., 2014. Building An Integrated Water–Land Use Database For Defining Benchmarks, Conservation Targets, And User Clusters. *Journal Of Water Resources Planning And Management*, **141**(4): 04014065.

Fielding, K.S., Russell, S., Spinks, A. And Mankad, A., 2012. Determinants Of Household Water Conservation: The Role Of Demographic, Infrastructure, Behavior, And Psychosocial Variables. *Water Resources Research*, **48**(10).

Geller, E.S., Erickson, J.B. And Buttram, B.A., 1983. Attempts To Promote Residential Water Conservation With Educational, Behavioral And Engineering Strategies. *Population And Environment*, **6**(2): 96-112.

Giuliani, M.V., 2003. Theory of attachment and place attachment. na.

Jorgensen, B.S., Martin, J.F., Pearce, M.W. And Willis, E.M., 2014. Predicting Household Water Consumption With Individual-Level Variables. *Environment And Behavior*, **46**(7): 872-897.

Krishnamurti, T., Schwartz, D., Davis, A., Fischhoff, B., de Bruin, W. B., Lave, L., and Wang, J. (2012). Preparing for smart grid technologies: A behavioral decision research approach to understanding consumer expectations about smart meters. *Energy Policy*, **41**: 790-797.

Lewicka, M., 2011. Place attachment: How far have we come in the last 40 years?. Journal of environmental psychology, 31(3), pp.207-230.

Maupin, M. A., Kenny, J. F., Hutson, S. S., Lovelace, J. K., Barber, N. L., & Linsey, K. S. 2014. Estimated use of water in the United States in 2010, *US Geological Survey*, **1405**.

Michelsen, A.M., Mcguckin, J.T. And Stumpf, D., 1999. NONPRICE WATER CONSERVATION PROGRAMS AS A DEMAND MANAGEMENT TOOL 1. *JAWRA Journal Of The American Water Resources Association*, **35**(3): 593-602.

Neely, C., 2018. Austin Rethinking Its Water System Amid Climate, Growth Challenges. Community Impact Newspaper. Retrieved From: Https://Communityimpact.Com/Austin/Central-Austin/Environment/2018/06/28/Austin-Rethinking-Its-Water-System-Amid-Climate-Growth-Changes/

Olmstead, S.M. And Stavins, R.N., 2009. Comparing Price And Nonprice Approaches To Urban Water Conservation. *Water Resources Research*, **45**(4).

Randolph, B. And Troy, P., 2008. Attitudes To Conservation And Water Consumption. *Environmental Science & Policy*, **11**(5): 441-455.

Rosenberg, D.E., 2007. Probabilistic Estimation Of Water Conservation Effectiveness. *Journal Of Water Resources Planning And Management*, **133**(1): 39-49.

Russell, S., & Fielding, K. (2010). Water demand management research: A psychological perspective. Water resources research, **46**(5).

Sankarasubramanian, A., Sabo, J.L., Larson, K.L., Seo, S.B., Sinha, T., Bhowmik, R., Vidal, A.R., Kunkel, K., Mahinthakumar, G., Berglund, E.Z. and Kominoski, J., 2017. Synthesis of public water supply use in the United States: Spatio-temporal patterns and socio-economic controls. *Earth's Future*, **5**(7): 771-788.

State Impact., 2015. The Texas Drought's Over, But The Texas Slow-Motion Water Crisis Is Not. (Accessed January 11, 2019)

Straus, J., Chang, H. And Hong, C.Y., 2016. An Exploratory Path Analysis Of Attitudes, Behaviors And Summer Water Consumption In The Portland Metropolitan Area. *Sustainable Cities And Society*, **23**: 68-77.

United States Census Bureau. "American Fact Finder: Median Household Income." *2013-2017 American Community Survey.* (Accessed February 26, 2019)

Texas Water Development Board, 2017. 2017 State Water Plan. Retrieved From: https://Www.Twdb.Texas.Gov/Waterplanning/Swp/2017/

Wa'el A, Hussien, Fayyaz A. Memon, and Dragan A. Savic. 2016. Assessing and modelling the influence of household characteristics on per capita water consumption. *Water Resources Management,* **30**(9): 2931-2955.

Washington, Simon P., Matthew G. Karlaftis, and Fred Mannering. Statistical and econometric methods for transportation data analysis. Chapman and Hall/CRC, 2010.

Worland, S.C., Steinschneider, S. and Hornberger, G.M., 2018. Drivers of Variability in Public-Supply Water Use Across the Contiguous United States. *Water Resources Research*, **54**(3): 868-1889.