Assessing the Factors Influencing Water Use in Austin, TX

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Abstract

Water plays an important role in domestic, agricultural and industrial domains and therefore its supply and quality are crucial to maintain. Water supply can be influenced by a number of factors with potential implications for its quality and availability. The goal of this project is to examine the spatial patterns of water use in Austin, TX and gauge the factors influencing its use. Key demographic variables are regressed on water use data in a bid to give insight on the factors affecting the spatial and temporal patterns of water use in the study area. Demographic variables utilized include median household income, size of household, average parcel size, and micro-climate data. This project is important as climate change will continue to modify our world, making sustainable resource use much more crucial to a nation. Understanding the factors of water use will provide functional knowledge to adjust policies and practices of people around the country. This project will help to determine what accounts for water use in Austin, TX. The results show that water use in Austin is influenced by (>70%) factors not included in this study. However, average parcel size, household size, and median household income are all shown to be statistically significant explanatory variables. Individuals and policy makers can use this information to adapt their future water use to more sustainable practices.

Introduction

The availability and quality of water is very important for human and ecosystem needs at various spatial and temporal scales. Water availability and quality are influenced by a number of anthropogenic and natural factors (Wilson 2015). Being able to understand the major factors that influence water use is important in providing relevant information for water resource planners in meeting water demand by individuals and municipalities. Population growth and its accompanied expansion of the buildup area, intensive irrigation agriculture, and extension of industries are the major factors that have resulted in increased demand for water over recent decades (UNESCO 2015). With climate change continuing to modify the Earth's environment, there is a potential that fulfilling future water demands for various anthropogenic activities might be more challenging. As a result, being able to accurately assess the supply of water as a resource is going to be incredibly important for future use. Therefore, it is pivotal to conduct analysis that can give insights into the factors that influences water demand and use in a bid to provide accurate information for planners. Previous studies have indicated that both income and household size significantly influences domestic water use (Balling, Gober and Jones 2008, Wilson 2015). The main goal of this study is to investigate the factors that account for domestic water use in the City of Austin, Texas between 2012 and 2015. Specific objectives include (1) to develop statistical models that can explain the dynamic of domestic water use in the study area, and (2) to analyze the spatiotemporal patterns of domestic water use. Using the variables of median household income, average household size, average parcel size, and micro-climate values, multiple linear regression models were developed in helping us to understand the dynamics of water use in the City of Austin, Texas.

Study Area

Austin, Texas is the 13th most populous city in the US, with a 2015 population estimate of 931,830 (US Census Bureau 2015). Austin is located in the east-central portion of Texas. The city has an area of 325.94 mi² (City of Austin 2017). The climate of Austin is humid subtropical, with warm winters, and hot summers (NOAA 2017). The elevation varies from 400 feet above sea level to over just over 1000 feet above sea level (NOAA 2017). Austin's unemployment rate in 2016 was 3.1%, with the largest employers being the government, professional and business services, and trade, transportation, and utilities (Bureau of Labor Statistics 2017).

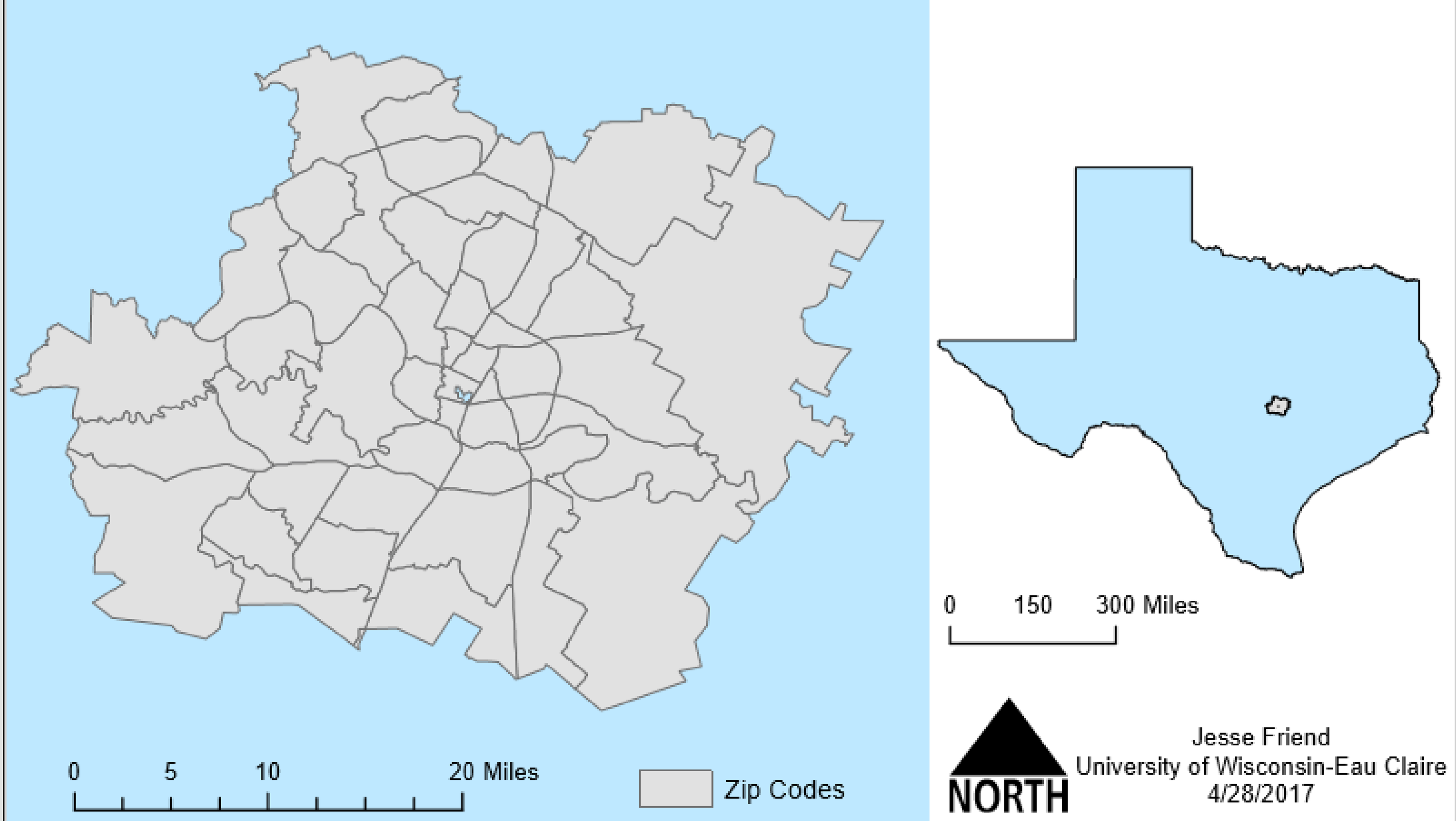

Figure 1: A map of Texas showing The City of Austin.

Methods

The following datasets were used:
- -City of Austin Water Consumption (DATA.GOV 2016)
- -Median Household Income (US Census Bureau 2011-2015)
- -Average Household Size (US Census Bureau 2011-2015)
- -Residential Parcel Data (City of Austin GIS Data Download)
- -Micro-climate Data (PRISM Climate Group 2016)
- -Austin Zip Codes & Texas Shapefiles (US Census Bureau)

Median household income and parcel sizes were aggregated and averaged at the zip code spatial scale.

Regression Analysis

Multiple linear regression analysis were developed to help comprehend the factors that influences water use in the City of Austin, Texas. In a regression model, the dependent variable Y is a function of explanatory variables X_1, X_2, …X_n. In the models developed for this study, water use (dependent variable) was regressed on median household income, household size, size of residential parcels, and temperature. Equation 1 exhibits the multiple linear regression models developed in this study.

$$W_{use} = \beta o + \beta 1_{INC} + \beta 2_{H} + \beta 3_{P} + \beta 4_{T} + \varepsilon \qquad (1)$$

Where W_{use} = water use, β are model parameters, INC = median household income, H = household size, P = parcel size, T = six months average temperature, ε = residuals.

The regression models were all tested for statistical significance at the 95% confidence level ($p < 0.05$).

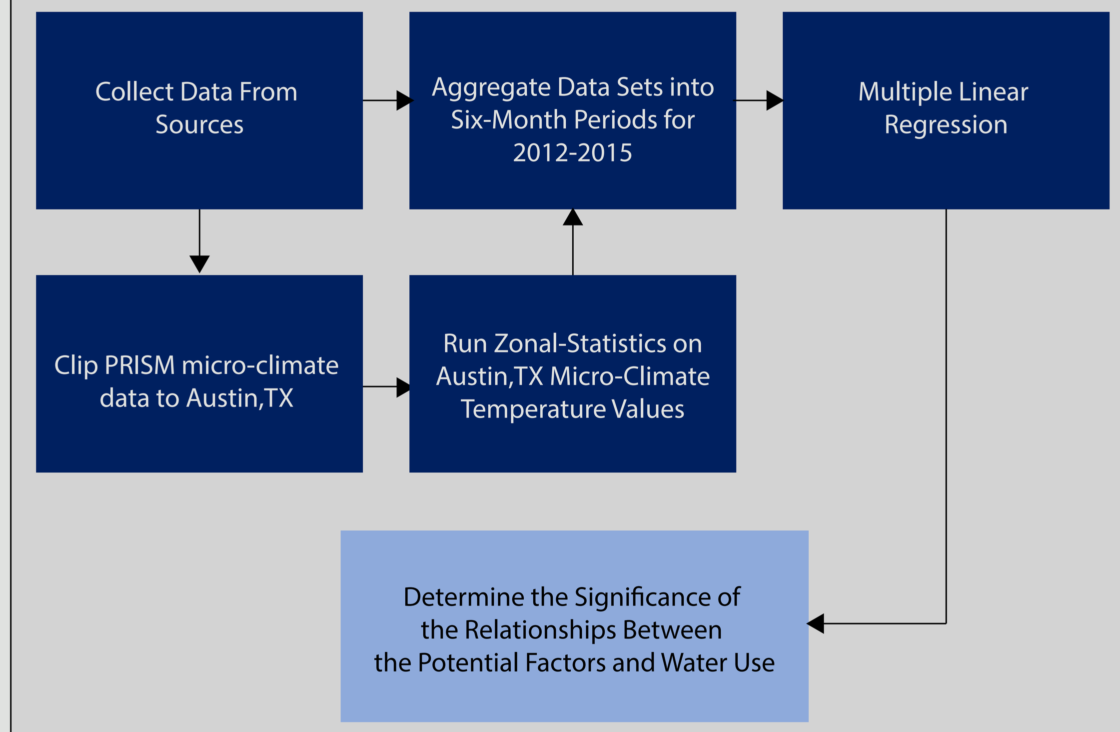

Figure 2: A schematic workflow of the methods.

Results: Statistics

Table 1: Summary of the multiple linear regression results.

Year	2012	2013	2014	2015
Explanatory Variables				
Median Household Income	-NS	-S	-S	-S
Household Size	-S*	-S*	-S*	-S*
Temperature	-NS	+NS	+NS	+NS
Average Residential Parcel ft²	-S**	-S**	-S*	-S*
	R^2 =.242 P<0.05	R^2 =.275 P<0.05	R^2 =.281 P<0.05	R^2 =.280 P<0.05

Results: Yearly Residuals

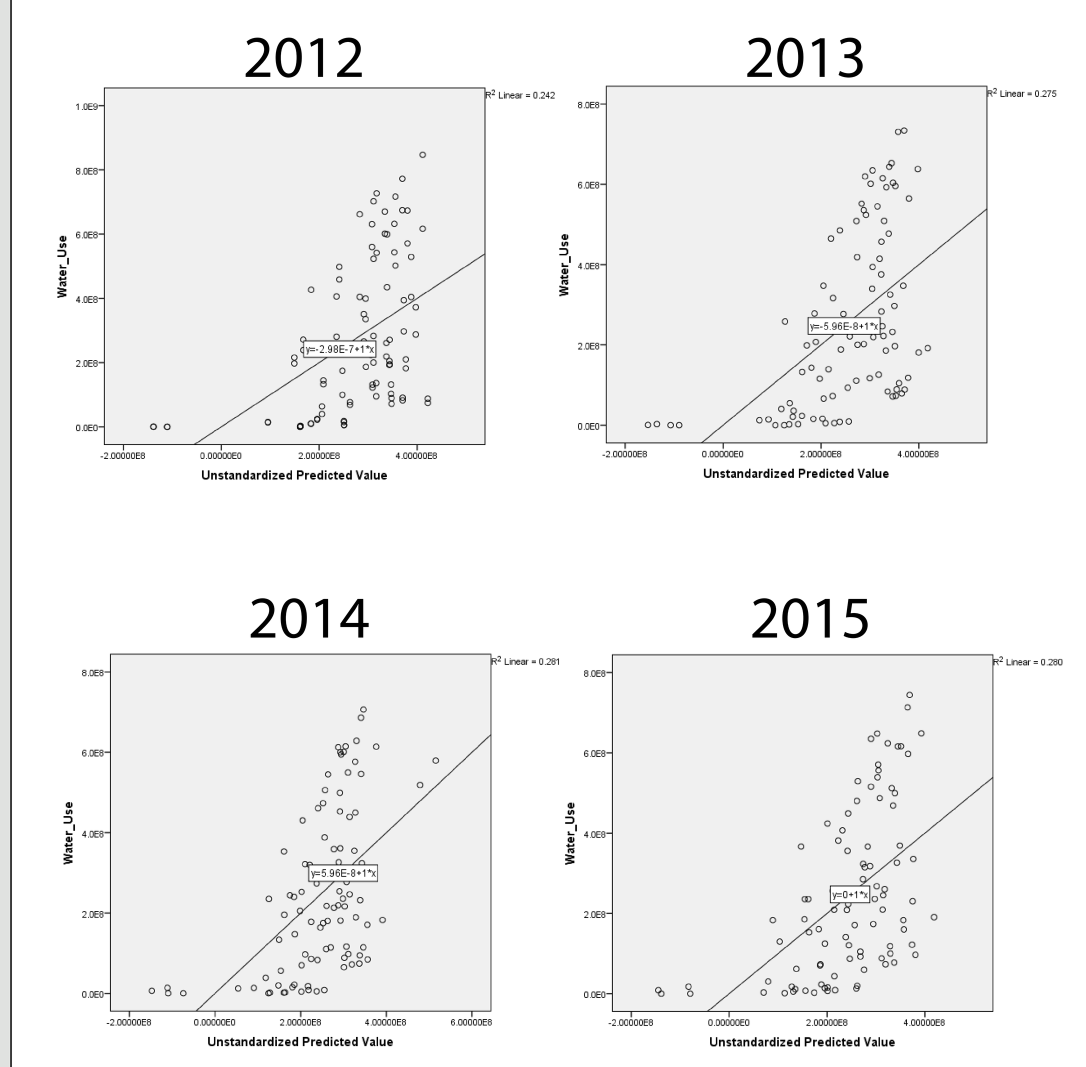

Figure 3: Scatterplots of regression models.

Maps

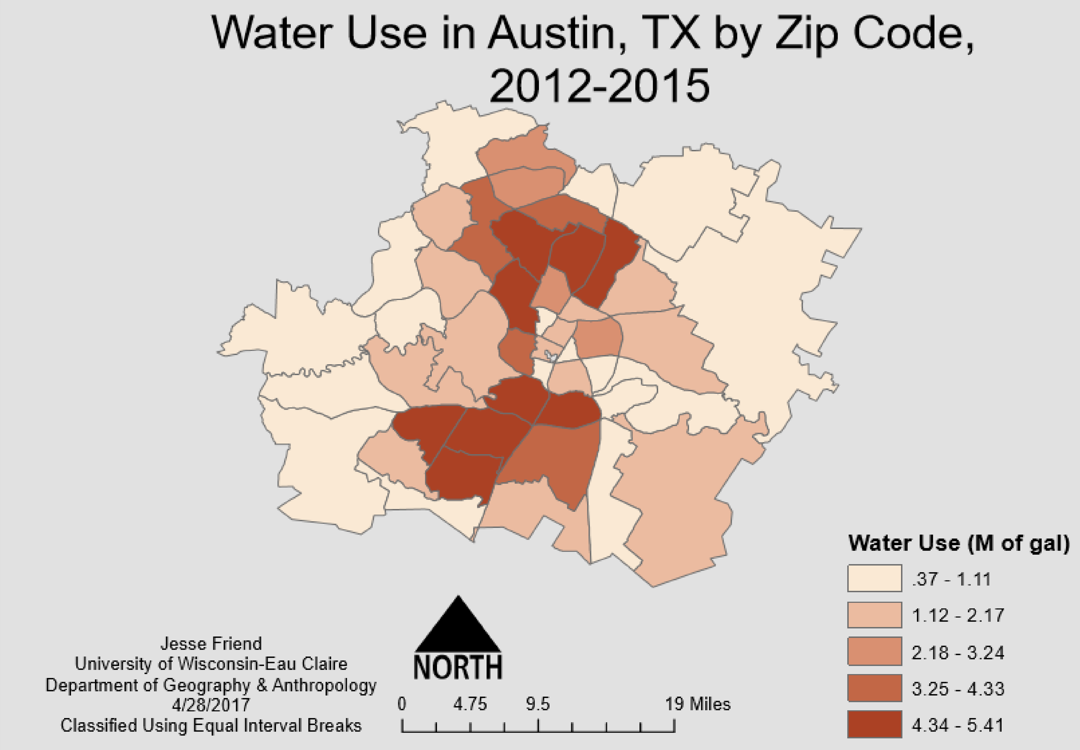

Figure 4: Map of water use per zip code in Austin, TX.

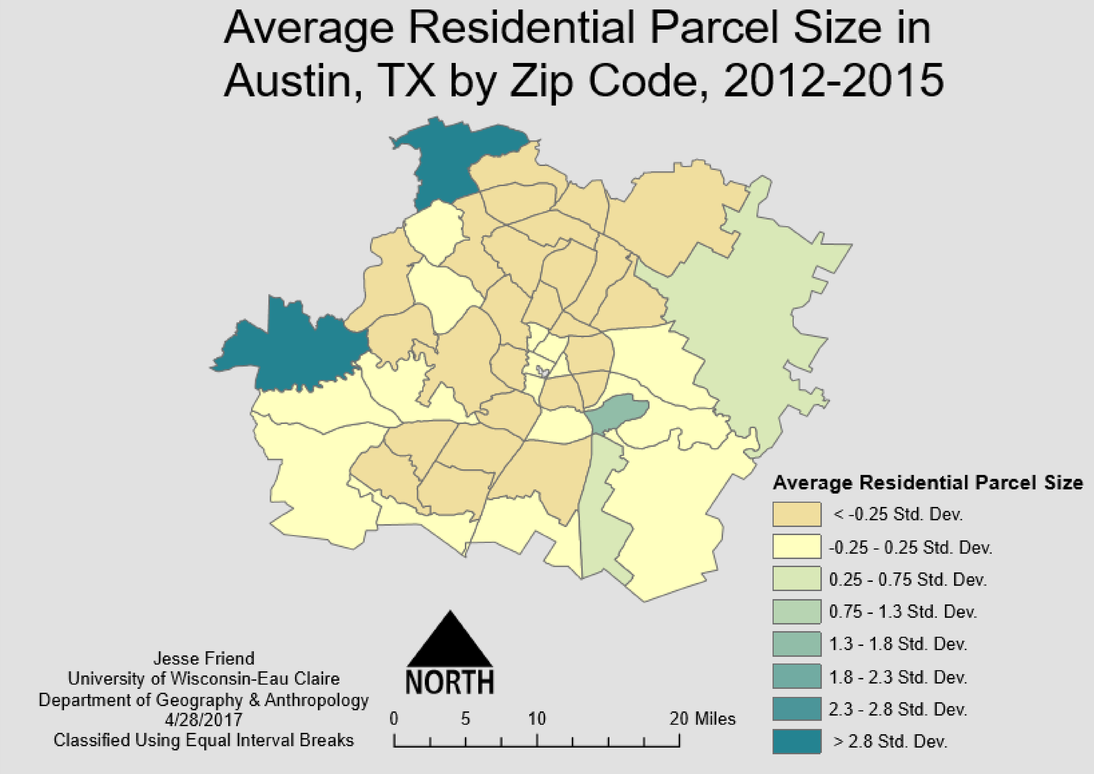

Figure 5: Map of average parcel size per zip code in Austin, TX.

Discussion

The regression analysis shows that water use in Austin Texas is mostly influenced (> 70%) by other factors beyond those analyzed in this study. The coefficient of determination (R^2) for all the models were less than 0.3 (Table 1). Notwithstanding, the explanatory variables revealed some interesting findings.

Average parcel size was found to be a statistically significant variable that influences water use in every year of the study. The latter demonstrated a negative relationship with water use. This suggest that larger parcels generally can mean less people per unit area within each zip code; this normally translates to less water use.

Average household size is a statistically significant variable that displayed a negative relationship with water use in every year of the study. Larger household sizes are normally found in inner cities where income and lot sizes are smaller. Smaller lot sizes vis-à-vis larger population and relatively lower income translate to smaller demand per capita of water for irrigating lawns. In addition, some apartment complexes are not fitted with laundry machines. People tend to use commercial laundromats which are mostly endowed with water efficient washers thus reducing water use for those inhabitants in larger households.

Median household income is statistically significant 3 out of the four years of this study. Higher income can translate to larger land ownership and less inhabitants per unit area resulting in smaller amount of water use per capita.

The regression models shows that temperature did not exhibit a statistically significant role in water use. However, it suggested that water use tend to increase as temperature increases.

Additional factors that might have conditioned water use in Austin include the percentage of water efficient appliances in households and laundromats, swimming pool availability and management culture, presence of tree cover which can result in reduced frequency of watering lawns, and the sizes of lawns in relation to parcel sizes. A potential limitation of the study is the spatial scale of the temperature data which was relatively coarse. A finer scale temperature data might have resulted in explaining more of the variance of the model.

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