Linking climate, water demand, urban form and social norms in Hawai'I

Daniele Spirandelli [1,4], Michael Roberts[2,3,4], Kimberly Burnett[3], Christopher Wada[3]

[1]*Department of Urban and Regional Planning, University of Hawaii, Honolulu, Hawaii, USA*
danieles@hawaii.edu

[2]*Department of Economics, University of Hawaii, Honolulu, Hawaii, USA*
michael.roberts@hawaii.edu

[3]*University of Hawaii Economic Research Organization, University of Hawaii, Honolulu, Hawaii, USA*
kburnett@hawaii.edu, cawada@hawaii.edu

[4]*Sea Grant College Program, University of Hawai`i, Honolulu, Hawai`i, USA*

Keywords: residential water use, conservation, demand management, Oahu, climate change

Climate, urbanization and ecosystem change present major challenges for the future of water resources. A major focus of water resource and climate change research has concentrated on how climate change might affect the supply of water [1–3]. However, just as important, is how climate change could affect water demand through biophysical and social mechanisms [4]. Changes in temperature, humidity and/or rainfall can significantly influence evaporation, evapotranspiration and soil moisture, and thus demand for irrigation water in residential landscapes. Climate can exacerbate the microclimate effect (also known as the urban heat island) of urbanization. Residential use of air conditioning can spike as temperatures warm, which can drive indirect demand for water use. The shape, use and structure of the built and natural environment can also affect water management. For example, previous research has shown that water use is dependent on population density, parcel size, land cover, built infrastructure, and landscaping practices [5–7]. A separate line of research has also shown that water use is likely influenced by social and economic structures, including social norms. For example, attitudes and norms toward future resources have been shown to be significant predictors of water conservation and intention to use less water [8].

The objective of this research is to better understand the role that social norms play in water use and conservation behaviors. A better understanding of water conservation behaviors can provide decision makers and policy-makers valuable information about water demand management strategies. In this study we investigate the extent to which household characteristics and attitudes are associated with water conserving actions among a cross-section of residential households living in both wet and dry climates on the island of Oahu, Hawai`i. The island of Oahu is an ideal location for such a line of research. The island is the most urbanized of the Hawaiian islands with nearly one million in population. There is a wide cross-section of residential households from single-family to high-density condominium towers, and a range of microclimates from wet to very arid.

Using a household survey that we merge with billing data from the Honolulu Board of Water Supply, we consider how socio-economic, attitudinal, behavioral, built environment and climate factors are associated with water consumption patterns across Oahu. We combine survey data with parcel-level attributes on the built environment. We address several research questions, including: (1) Do more informed and water-conscientious households actually use less water? (2) Are households in more arid environments more concerned about conserving water than households in wetter climates? (3) Do households that have taken water-conserving actions, like installing low-flow toilets or drip irrigation, actually use less water? If so, how much? (4) How important are household demographics relative to built environment characteristics? (5) Is there variability in water conservation attitudes both within and between households living in high vs low density neighborhoods?

An online survey was administered to 406 residential households across Oahu. The survey asked households about water use practices both inside the home and outside the home, and differentiated these practices by housing type (single-family vs. multi-family units) and tenure type (ownership vs. rental). The survey asked questions about efforts to conserve water (e.g. installing low-flow toilets and drought tolerant landscaping), awareness of conservation programs and policies, and attitudes about more sustainable consumption practices that could be undertaken to encourage households to reduce water consumption. Monthly water consumption patterns will be estimated from historical billing data obtained from the Honolulu Board of Water

Supply. Micro-scale weather patterns are approximated using weather station data in conjunction with the Climate Atlas of Hawai`i (http://climate.geography.hawaii.edu). Parcel level data is obtained from the Hawai`i State GIS database.

We use multiple linear regression analysis to explore structural relationships between the dependent variable, monthly average water consumption per household and independent variables from the survey, climate, built environment and socio-demographic data.

Data is currently being processed so it is too early to discuss results. However, we expect to find variations in water use behaviors and conservation attitudes by climate, income, housing characteristics, and environmental attitudes. In addition to socio-economic and the built environment, we expect attitudes and beliefs to be significant predictors of water conservation.

Ultimately the project goal is to link water consumption patterns with socio-economic information of each household, housing and built environment characteristics, local climate, water use behaviors, environmental attitudes and attitudes to conserving water. This will allow us to evaluate determinants of water use and conservation behaviors across households that vary across climatic, socio-economic, household, and building characteristics.

References

(1) Vörösmarty, C. J.; Green, P.; Salisbury, J.; Lammers, R. B. *Science* **2000**, *289* (5477), 284–288.

(2) Barsugli, J. J.; Vogel, J. M.; Kaatz, L.; Smith, J. B.; Waage, M.; Anderson, C. J. *Journal of Water Resources Planning and Management* **2012**.

(3) Bardsley, T.; Wood, A.; Hobbins, M.; Kirkham, T.; Briefer, L.; Niermeyer, J.; Burian, S. *American Meteorological Society* **2013**, *17* (23).

(4) Hale, R. L.; Armstrong, A.; Baker, M. A.; Bedingfield, S.; Betts, D.; Buahin, C.; Buchert, M.; Crowl, T.; Dupont, R. R.; Ehleringer, J. R.; Endter-Wada, J.; Flint, C.; Grant, J.; Hinners, S.; Horsburgh, J. S.; Jackson-Smith, D.; Jones, A. S.; Licon, C.; Null, S. E.; Odame, A.; Pataki, D. E.; Rosenberg, D.; Runburg, M.; Stoker, P.; Strong, C. *Earth's Future* **2015**, *3* (3), 110–132.

(5) Shandas, V.; Parandvash, G. H. *Environ Plann B Plann Des* **2010**, *37* (1), 112–128.

(6) Grafton, R. Q.; Ward, M. B.; To, H.; Kompas, T. *Water Resources Research* **2011**, *47* (8).

(7) House-Peters, L.; Pratt, B.; Chang, H. *JAWRA Journal of the American Water Resources Association* **2010**, *46* (3), 461–472.

(8) Russell, S.; Fielding, K. *Water Resour. Res.* **2010**, *46* (5), W05302.