Building water-efficient cities

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How much water single-family residences use is closely related to a community's built environment, according to a University of Arizona-led study. In particular, design factors such as vegetated land cover, housing density and lot size appear to have a strong impact on water use.

The results can provide key data for city planners and water managers looking to develop sustainable water use strategies for their communities, the authors suggest in the paper that was published today in the *Journal of the American Planning Association*.

Philip Stoker, assistant professor in the UA College of Architecture, Planning and Landscape Architecture, and a team of researchers focused on how water use is influenced by the built environment, which Stoker defines as "the way cities take shape—what the materials are made out of, what the land cover consists of, the arrangement of buildings and what kind of buildings are there."

The team obtained single-family residential property water-use records from 2011 in Phoenix; Salt Lake City; Portland, Oregon; and Austin, Texas. Researchers estimated models for both annual water use and water use during the summer months of June through August. The cities were selected because they each offer insights relative to the impacts of both climate change and rapid urban population growth on residential water consumption. Single-family residences are the principal form of residential development in each city and make up a large share of overall water use.

"As cities, especially in the Western U.S., continue to grow, planners need to think about their water supplies moving into the future," said Stoker, whose co-authors included then-graduate student Gabrielle Jehle, Elizabeth Wentz and Brint Crow-Miller of Arizona State University, and Matthew Bonnette of Portland State University. "With this study, we wanted to give them information to develop a strategy. We wanted to show how the planning and design of cities influence how water is used."

City Design is Key

The researchers examined the influence of five built environment measures on single-family residential water use: housing density, tax assessed value, lot size, vegetative cover and the age of housing. They found in each city, the built environment poses a stronger influence on urban water use than previously reported.

"In Austin, for example, we were able to explain 85% of the variation in water use among Austin neighborhoods with just the five measures of the built environment," Stoker said.

Some measures impacted water use across the board. The researchers found increased vegetated cover, combined with larger lots, in newer homes, with higher assessed values, were associated with higher water use in each city.

Vegetated cover was associated with an increased water demand more than any other built-environment variable in the drier cities. The effect was greatest in Salt Lake City, where each 1% increase in average vegetated surface was tied to a 0.48% increase in annual water use and a 0.7% increase in summer use.

Higher housing density was associated with lower water use in every city except Salt Lake City, where the measure was not statistically

significant.

Surprises in the Data

Stoker says researchers had expected lot size to be a consistent predictor of water use. However, those findings varied across the four cities.

In Austin and Portland, larger lots were associated with higher water use. In Austin, a 1% increase in lot size was associated with an approximate 0.32% increase in summer water use. Lot size was not significantly associated with annual or summer water use in Salt Lake City, and there was an inverse relationship in Phoenix, with larger lot size tied to lower water use.

Stoker says he was also surprised by the findings on the age of housing, as the expectation was that newer housing would be associated with lower water use because of higher-efficiency appliances. However, the opposite was true in Austin, Portland and Salt Lake City. The association was strongest in Salt Lake City, where, for every 1% increase in housing age there was an approximate 0.31% decrease in annual water use and about 0.33% decrease in summer use.

Planning for Water Efficiency

Stoker says city planners and water managers can use the data to work together on developing zoning ordinances, form-based codes and landscaping ordinances that can lead to more efficient water usage. Regulations could, for example, specify smaller lot sizes for future developments, or call for reduced or different types of vegetated cover on single-family properties. In implementing these regulations, Stoker says, city leaders must balance factors such as whether the water-use reduction outweighs the benefit vegetated land has on temperature-

cooling efforts.

More information: Philip Stoker et al, Building Water-Efficient Cities, *Journal of the American Planning Association* (2019). DOI: 10.1080/01944363.2019.1638817

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