The Dynamics of Urban Water Consumption

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Abstract

Freshwater provisioning is a key ecosystem service for all cities. Global analyses of water consumption typically occur at the country level, yet city behavior, particularly those in the developing world, can differ greatly from national norms. We assessed the influence of biophysical conditions, population size and growth rate, wealth, and national development on urban water use for 103 international cities. City wealth was the most important determinant of urban water consumption. Population size was not significantly correlated to urban water use. Precipitation, runoff, and NPP were negatively correlated to urban water consumption. Consumption behavior at the city level differed from national expectations; rapidly industrializing cities consumed water at quantities similar to US cities, whereas water use in European cities resembled that of cities in low and middle income nations. As urbanization continues into the future, achieving sustainable urban living will require accurate evaluation of the dynamic relationship between cities and the resources upon which they depend.

Introduction

As centers of commerce, cities reside at the interface between their home country and the global economy often adopting consumptive traits similar to high income nations (Varis, 2006). Our knowledge of how the biophysical environment influences urban water consumption is minimal.

How do socio-economic conditions and the biophysical environment of cities influence urban water consumption?

Does national water consumption reflect water consumption at the city level?

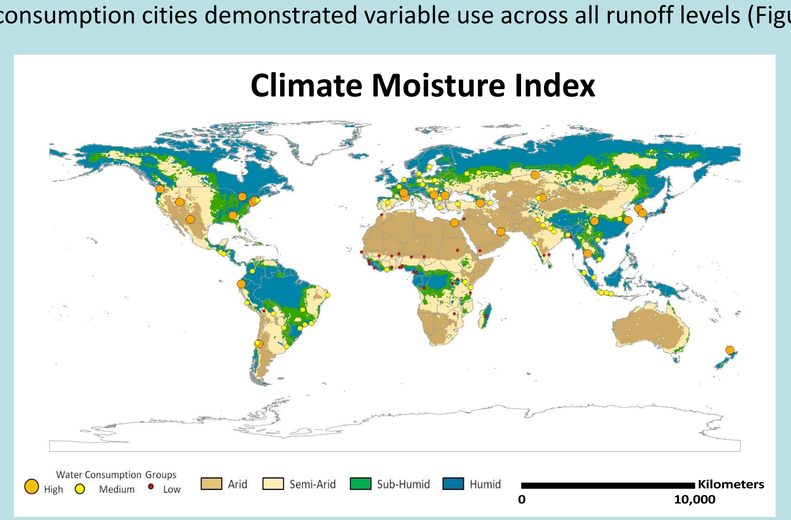
Methods

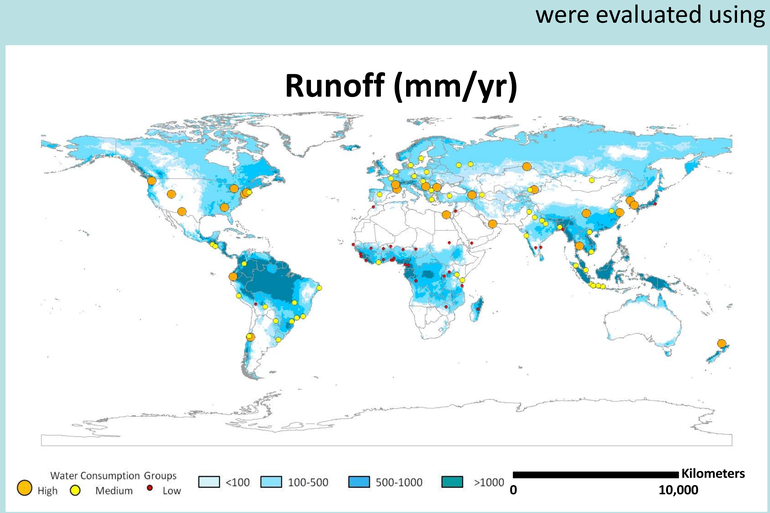
Variables	
Socio-Economic	*Environmental*
Water Consumption (L capita^{-1} day^{-1})	Precipitation (mm/yr)
City Product ($ 1998 US capita^{-1})	Evapotranspiration (mm/yr)
Population Size	Runoff (mm/yr)
Population Growth Rate	Climate Moisture Index
	NPP (kgC/m^2/yr)
Databases	
Socio-Economic	*Environmental*
UN HABITAT Global Urban Observatory Databases I &II (1993 and 1998)	Global Water Systems Project Digital Water Atlas
UN World Urbanization Prospectus (2007)	SAGE Biosphere Atlas
Water Consumption Groups (L capita-1 day-1)	
Low	<100
Medium	100-250
High	>250

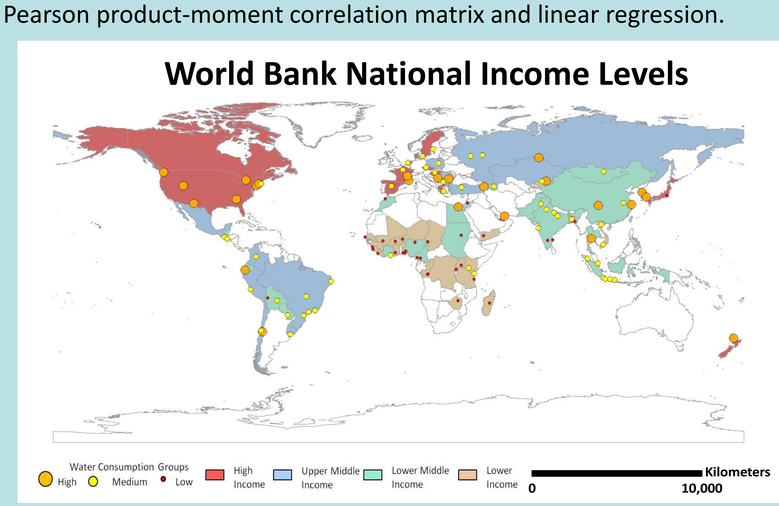
The normality of the data were assessed, and when necessary were log transformed. The variables were evaluated using the Pearson product-moment correlation matrix and linear regression.

Results

Population size had no significant impact on water consumption. Growth rate, precipitation, runoff, and NPP were negatively correlated to water consumption. City product positively influenced water consumption with the strongest explanatory relationship (Figure 1; $R^2 = .359$). Low and medium groups used water at similar rates while high consumption cities demonstrated variable use across all runoff levels (Figure 2).







Discussion

City wealth had the greatest influence on urban water consumption (Figure 1). The results suggest the primary feedback between cities and their water use is human demand not environmental constraint. In fact, high consumption cities in arid regions consumed more water than humid regions. For US cities Jenerette et al. (2005) found increased water use with lower water availability. The UN-HABITAT (2003) results were similar: cities in water-stressed regions had greater water accessibility than water rich. Likely, economic scarcity not physical scarcity constrains water consumption in low and middle income cities. In contrast the moderate consumption of European cities demonstrates that water efficiency can reduce use in high-income cities. Conducting analyses at the city level can reveal new insights regarding water use not evident at the national level. Our next step will be to examine the ecosystem extent of urban water provisioning systems.

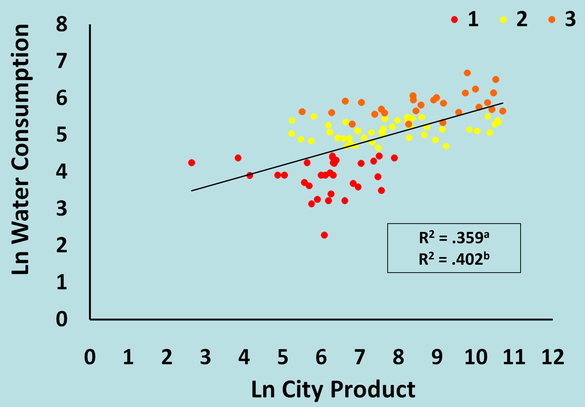


Figure 1. R^2 for a = city product and water consumption; b = city product, water consumption, precipitation, and runoff.

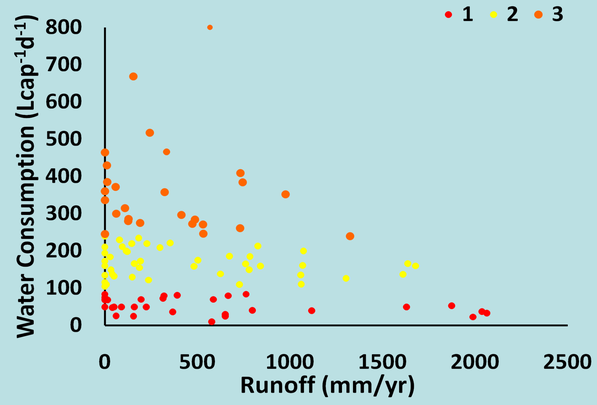


Figure 2. Runoff (mm/yr) and water consumption (L cap^{-1} day^{-1}) by group.

Acknowledgments

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