

How Do Variations in Heat Islands in Space and Time Influence Household Water Use?

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NEED FOR THE STUDY

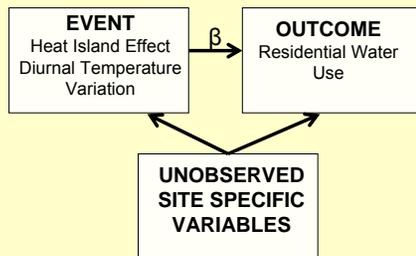
Previous studies have shown that Urban Heat Islands (UHI) have a significant impact on residential water consumption in Phoenix, with each percent rise in nighttime temperatures is estimated to increase consumption of single-family residences by 2% (Guhathakurta and Gober, 2007). These studies, however, have been based on cross-sectional data from a single year, and thus, cannot capture the complex dynamic interaction between UHI and water consumption. Moreover, since UHI and water consumption are jointly determined, unobserved site specific effects (such as soil thermal and moisture properties) in these studies can potentially bias the estimates of the UHI effects.

OBJECTIVES

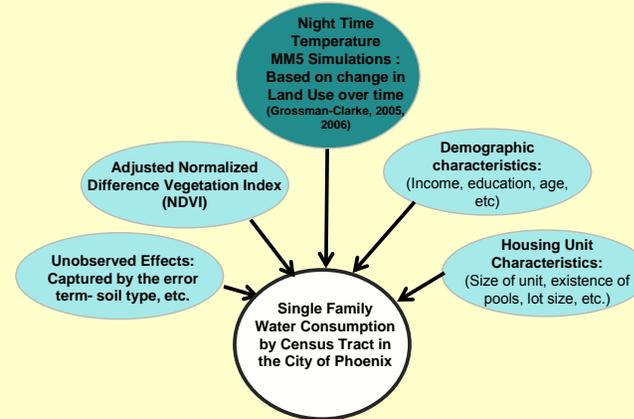
- To examine the changes in intensity and spatial pattern of UHI effect in Phoenix using data from 1990, 1995 and 2000.
- To assess whether the effect of UHI on single family residential water consumption has remained stable over these years.
- To use panel data techniques to control for the unobserved site specific effects and yield more robust estimates of the effect of UHI on residential water consumption in Phoenix.

METHODOLOGICAL INNOVATIONS

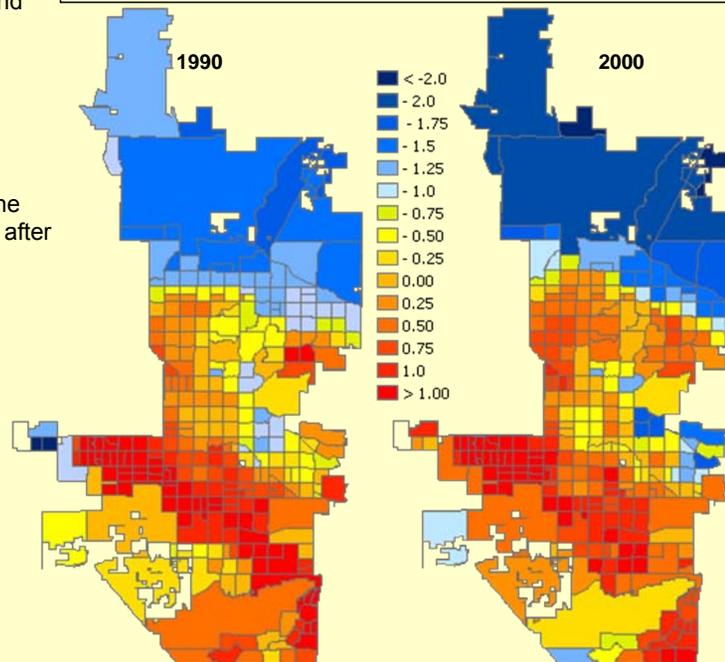
- Landsat TM images are used to estimate change in land use in Phoenix over time (1990 | 1995| 2000)
- The change in land use is incorporated in the fifth-generation Mesoscale Meteorological Model (MM5) to estimate daily minimum and maximum 2 m air temperatures for the Phoenix metropolitan region
- Panel data analysis techniques are used to estimate the relation between heat islands and water consumption, after adjusting for the effect of unobserved variables



CONCEPTUAL FRAMEWORK: Panel data analysis



Changes in Spatial Pattern and Intensity of UHI (Standardized Nighttime temperatures)



MODEL ESTIMATES

Dep. Variable: Natural log of water consumption (in gallons)

VARIABLE	SINGLE YEAR ESTIMATES			PANEL ESTIMATES	
	1990	1995	2000	Fixed effects	Random effects
Income (ln.)	1.05e-06	2.17e-06 *	5.97e-06 **	1.93e-06**	2.07e-06**
Household Size	.0101342	0.0442963 **	.1078881 **	.0089657*	.0135951**
Age of House	.0043394 **	.0067068 **	.0085287 **	.0157474	.0081637**
NDVI	.7533721	1.308924**	1.198813*	-.4868748	-.063908
Lot Size	5.75e-06 **	6.90e-06**	.0000265**	6.90e-06**	.0000106**
Lot Size Squared	-1.71e-11	-1.85e-11	-6.04e-10**	-5.27e-11**	-6.29e-11**
Percentage of pools* Poolsize	.0000117*	8.78e-07	-2.98e-06	-.0000345	5.90e-07
Temperature	.0215787 **	.0216435 **	.0282412 **	.0129652**	.0136099**
Temperature* poolsize	8.92e-06	.0000201**	.0000158 **	.0000245**	.0000165**

* Sig. at 5% ; ** Sig. at 1%

RESULTS

The heat island has expanded spatially over the study period, and also, the elasticity of its impact on water consumption has intensified over time.

Each percent rise in nighttime temperatures is estimated to have increased water consumption of single-family residences from 2.2% in 1990 to 3.0% in 2000. The reasons for this intensification need to be investigated further in future research.

In the panel data models that combine data from the 3 study years and control for unobserved site specific factors, the estimated effect of UHI on water consumption is found to be somewhat lower (around 1.5%).

References

Guhathakurta, S., Gober, P., 2007. The impact of the Phoenix urban heat island on residential water use. *Journal of the American Planning Association* 73(3), 317-329.

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