Complicating_Vulnerability

Building a Multivariate Model for Sea Level Rise Succeptability in Urban Southeast Florida

Background_ Current projections for sea level rise related to anthropogenic climate change predict, even in the most conservative of estimates, at least a 2-foot rise by the end of the century. However, vulnerability to sea level rise cannot be simply equated to slowly filling elevation contours. Coastal metropolitan areas are each uniquely vulnerable as "a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2007). The Miami Metropolitan Area, in Southeast Florida, is distinctly vulnerable, as a function of its particularly low elevation, porous limestone bedrock, and a unique combination of other social, economic, and environmental variables. To interpret and analyze the vulnerability of Urban Southeast Florida to rising seas demands the construction of a model as unique and complex as its distinct characteristic attributes.

Methodology_ To create a complex vulnerability index for sea level rise (SLR) in Urban Southeast Florida required the identification of pertinent variables and the calculation of their respective weights. The following ten variables were identified as potentially significant to SLR vulnerability:

Variable / *Description*	*Mean Value* (*Std. Deviation*)	*Assumption*
Elevation / US feet above sea level	9.60336 (6.24102)	Lower elevations are at greater risk of coastal flooding.
Geological Epoch / In quaternary period or later (dummy variable)	0.910199 (0.285896)	Southeast Florida sits almost entirely on porous quaternary era limestone, allowing water to seep up from water table through the bedrock.
Impervious Surfaces / Percent impervious by surface	26.5011 (24.4333)	Impervious surfaces are less able to absorb flood surges, increasing the severity of local effects.
Soil Permeability / Percent permeability by surface	21.6586 (23.7195)	Soil that is more permeable is better able to absorb surface water and aliviate local effects.
Location within Flood Zone / In FEMA 1% Annual Flood Risk Zone (dummy variable)	0.513319 (0.499823)	Location within FEMA defined 100yr flood zone is intended to be directly reflective of a high possibility of flooding events.
Population Density / Population per sq. mile	5898.17 (4388.44)	Areas of great density significantly feel the social and economic impacts of flooding events.
Median Income / Median income by US census block group in 2014 US dollars	62933.1 (33117.2)	Lower income population is less likely to take preemptive protective measures and less able to cope with capital destrcution of flooding events.
Percent of Population Not-White by Race / Percent per total US census block group population	27.6746 (26.8144)	Areas of greater non-white population are at greater risk of institutional inequalities in flood preparation and disaster relief.
Percent of Population Hispanic by Origen / Percent per total US census block group population	36.3587 (29.2074)	Areas of greater hispanic population are at greater risk of institutional inequalities in flood preparation and disaster relief.
Percent Renter-Occupied Households / Percent per total US census block group households	30.7634 (23.3801)	Renters are less likely to make capital investments preparing for flooding, and as a result are impacted greater by disaster events.

A spatial ordinary least squares (OLS) regression model was built to determine the respective correlation of these variables and a common numerical value. Flood insurance premiums for parcels within the urban area would have been the ideal independent variable for regression because it is a dollar value calculated to be accurately representative of individualized flood risk. Due to the inaccessibility of these premiums to the public, land value per acre at the parcel level was selected instead, on the assumption that land value would be representative of flood exposure and insurance premiums lagged over time.

Cited Literature

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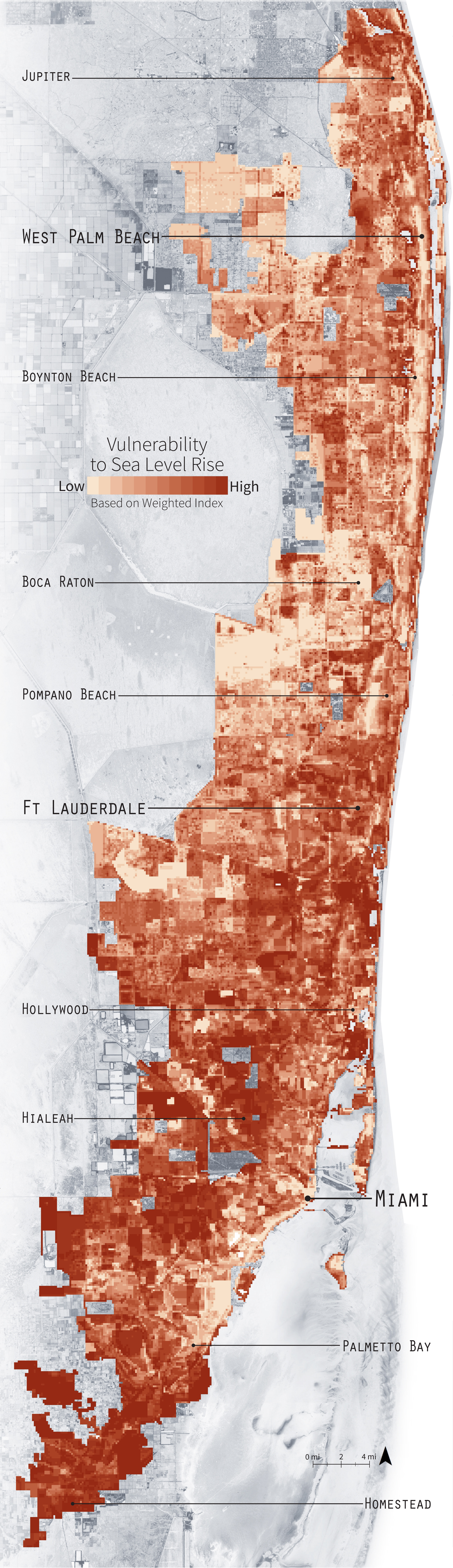


Analysis_

Independant Variable / *Desciption*	*Mean Value* (*Std. Deviation*)	*Number of Observations*
LDV_ACRES / Parcel land value per acre in 2011 US dollars	779875 (3.8225e+007)	1500821
		R Squared = 0.000236

Dependant Variable / *Description*	*Coefficient* / *Mean Std. Error*	*Outcome*
M_ELEV_F / Elevation	-100805*** (8057.75)	Not as Predicted. Lower elevations are correlated with higher land value.
EPOCH / Geological Epoch	288058** (120588)	Not as Predicted. Quaternary and later geologic layers are correlated with higher land value.
M_IMPV / Impervious Surfaces	1419.9 (1285.56)	Not as Predicted. Greater impervious surfaces are correlated with higher land value.
M_SOIL / Soil Permeability	6299.53*** (1414.54)	As Predicted. Greater soil permeability is correlated with higher land value.
IN_100 / Location within Flood Zone	-626612*** (73998.9)	As Predicted. Location within a flood zone is correlated with lesser land value
POP_DENS / Population Density	-64.1335*** (8.65642)	As Predicted. Greater population density is correlated with lesser land value and greater risk.
MED_INC / Median Income	-11.0131*** (1.21811)	Not as Predicted. Higher median income is correlated with lower land value.
PCT_NWHI / Percent of Population Non-White by Race	-2234.08 (1431.07)	As Predicted. Higher percentage non-white population is correlated with lesser land value.
PCT_HISP / Percent of Population Hispanic by Origen	5488.22*** (1361.42)	Not as Predicted. Higher percentage hispanic population is correlated with higher land value.
PCT_RENT / Percent Renter-Occupied Households	-4579.2*** (1696.01)	As Predicted. Higher percentages renters is correlated with lesser land value.

***significant at the 0.01 level
**significant at the 0.05 level

Vulnerability Index = $\beta_{M\_ELEV\_F}(M\_ELEV\_F) + \beta_{M\_SOIL}(M\_SOIL) + \beta_{MED\_INC}(MED\_INC) + \beta_{POP\_DENS}(POP\_DENS) + \beta_{PCT\_HISP}(PCT\_HISP) + \beta_{PCT\_RENT}(PCT\_RENT) + \beta_{IN\_100}(IN\_100) + \beta_{EPOCH}(EPOCH)$

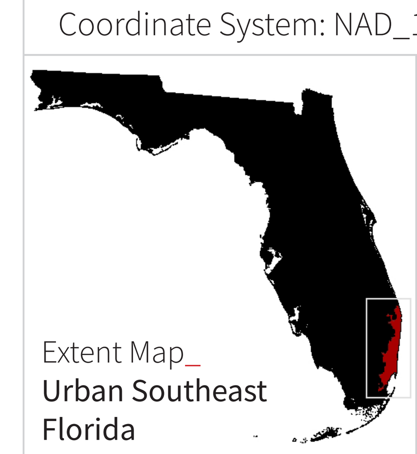
Discussion_ Much of the results of this spatial regression were counterintuitive to assumptions about social, economic, environmental and physical indicators of vulnerability to sea level rise in Urban South Florida. Specifically, the highly significant negative correlation between Elevation and Parcel Land Value by Acre is indicative that land value does not necessarily reflect vulnerability to sea level rise by elevation alone. This could be interpreted as an indicator that land value is not as good of an independent variable to weight metrics for sea level rise vulnerability though spatial regression as hypothesized; given the assumption that it would reflect the temporal lag effects of flood insurance premiums and past flooding events.

However, these results could also be indicative of the unexpected outcome that land value in Urban Southeast Florida may not yet reflect true vulnerability to sea level rise. Even thinking about elevation alone, much of the highest valued land in the Miami area is nearest to beaches and waterways, such as the cities of Miami Beach and Palm Beach. This phenomenon does not rationally reflect the possibility of flooding due to a changing climate. Rather, it could be indicative of hedonic effects, market rigidities and consumer ignorance. This outcome alone validates the need for complex, multivariate models for mapping vulnerability to sea level rise in coastal urban areas.

Cartography and Analysis by Slide Kelly

UEP 294_Advanced Geographic Information Systems_Fall 2016

Coordinate System: NAD_1983_2011_StatePlane_Florida_East_FIPS_0901_Ft_US



Extent Map_
Urban Southeast Florida

Data Sources

Florida Geographic Data Library (FGDL): www.fgdl.org
US Census Bureau: www.census.gov
American Community Survey 5 year estimates 2009-2014: http://factfinder.census.gov
United States Geological Survey: www.usgs.gov
University of Florida Geoplan Center: www.geoplan.ufl.edu/
Florida Geological Survey: http://dep.state.fl.us
National Land Cover Database: http://www.mrlc.gov