# AGENT-BASED MODELING OF MUNICIPAL WATER PROVIDER ADAPTATION TO SEA LEVEL RISE

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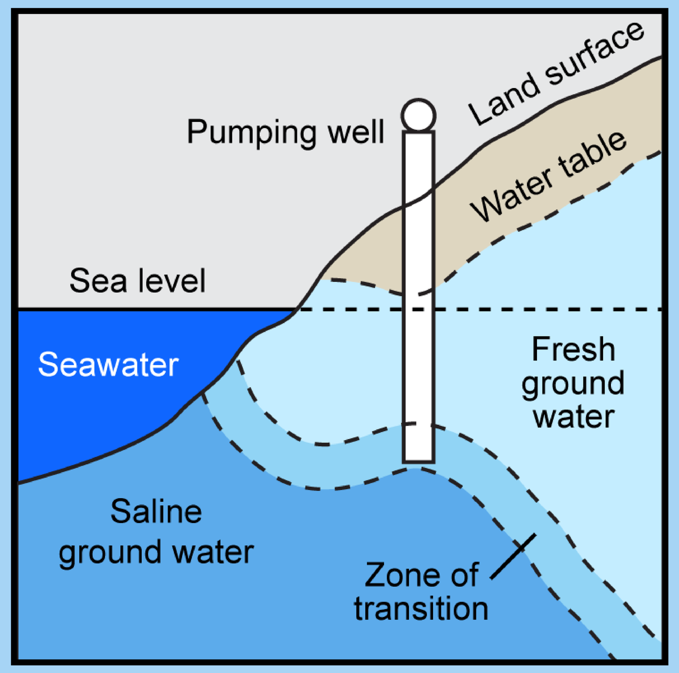
## Introduction

### Research Question

How will society adapt if sea levels continue to rise? Can we even answer this question? We have models of climate systems and models of water infrastructure systems,but we don't have models of how these systems might interact in response to climate change.

### Research Objective

Our research goal was to characterize the decision-making processes of connected municipal water systems as they adapt to salt water intrusion into drinking water wells.

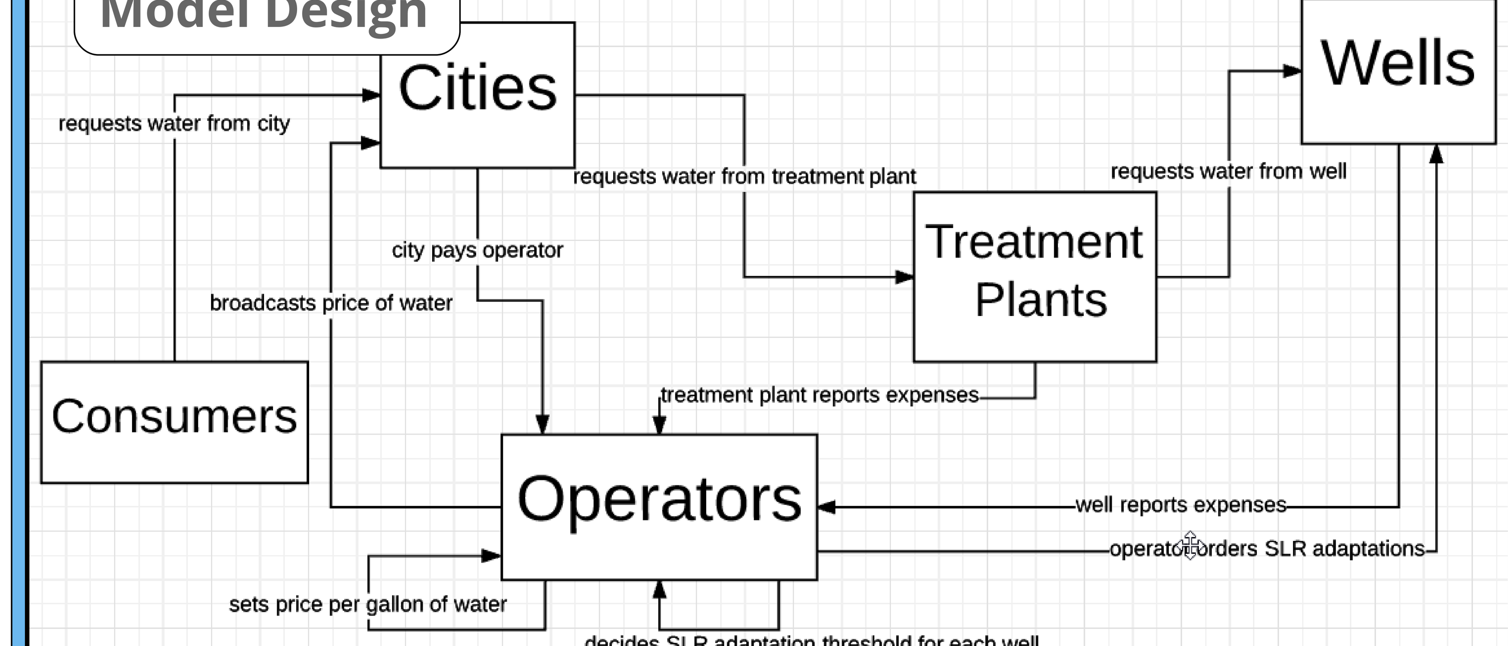



## Methods

### Modeling Approach

We used the AnyLogic 8 (Personal Learning Edition) agent-based modeling software program to build the model. An agent-based model is essentially a computer game where all the players (Agents) are pieces of the program. Agents can demonstrate sophisticated behavior in the aggregate while individually following simple rules.

### Model Design




### A Few Model Assumptions (out of many...)

**Demand**

We modeled water demand as a uniform monthly event, at a rate of 100 gallons a day per consumer, based on government estimates of demand.

**Sea Level Rise (SLR) Vulnerability**

We defined SLR in terms of a vulnerability score (VS) from 0 to 100, assigned to each of 6 wells; two wells with score 30, two wells with a score of 60 and two wells with a score of 90.

**Sea Level Rise**

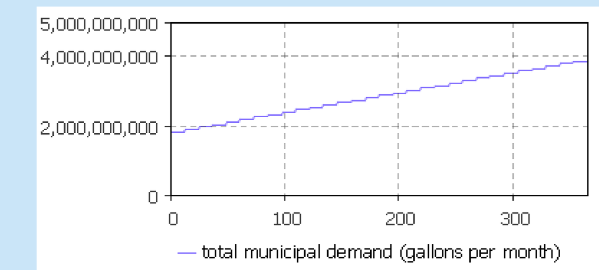
SLR events were defined as a linear progression (over 30 years) in the model's global SLR score from 0 to 30 (SLR "slow") or 0 to 60 (SLR "moderate").

**Operating Costs**

We assigned a fixed cost to Well agent monthly expenses and assigned two cost multipliers to represent a linearly increasing cost of water treatment due to increased salinity and a cost associated with preventing SLR.

## Results

Population Growth over 360 Months (30 years)





## Analysis

### Downward drifts in Price Per Gallon

Our assumptions result in economies of scale with respect to population growth, which lower the net unit cost of production until SLR or SLR adaptation cost factors are triggered.

### Jumps in Well Expenses and Water Price

```
double cost_factor = 1;
double mitigationCostFactor = 1;
if (isRespondingToSLR) { mitigationCostFactor = 3; }
double diff = ( this.vulnerability_score - main.scenarioSLRscore ) ;
if (diff < 0 ) { diff = 0; }
if ( diff < 30.0 ) { cost_factor = 1000 * (  ((float)( 30 - diff )) / 30.0 ); }
this.operating_cost_current = (operating_cost_current * cost_factor * mitigationCostFactor);
```

The code above shows that when the model's sea level rise score increases to within 30 points of a well's SLR vulnerability score, the cost of operating that well jumps by a factor of 1000 * (1/30), or 333%. Operating costs for that well then increase linearly (by 333% per year) for 30 years.

### Price Stabilization as Perceived SLR increases

```
tempPricePerGallon = ( currentExpenses / ( currentRevenue / pricePerGallon ) );
pricePerGallon = tempPricePerGallon;
```

The code selection directly above shows that the price of water each month is based on both the previous month's price and the current price of water. **We have not yet identified a causal mechanism** for the smoothing observed**.**

## Contribution

This preliminary model generated time series data that forced us to clarify our thinking about model features, suggesting that agent-based modeling has great potential as a tool for hypothesis generation.

## Acknowledgements

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## References

"South Florida Water, Wastewater, and Stormwater Facilities Study FINAL REPORT" SFWMD Project #C-15798