A Prototype Scenario-Based Planning Support System (SB-PSS) to Model Water Consumption Spatial Distribution

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Water is used unsustainably in the United States, more so in some places than others. This problem needs remediation in order for future generations to have access to water everywhere. Climate change further threatens our water resources.
Research Purpose

The study aims to increase the awareness of water resource conservation among water consumers by promoting the idea “think globally, act locally, start with me!”

A water consumption model is built into a scenario-based planning support system (SB-PSS) to enable planners to illustrate water conservation alternatives in ways that are easily understood.
Planning Support Systems

Stimulate plan making to set and achieve goals of conservation

The scenario-based planning process works by creating a set of plausible scenarios and their possible outcomes.
Methodology

Data Requirements

- GIS data
- Other forms of data (i.e. Current Population/Employment, etc.)

Calculation

- Indoor Consumption
- Pool Consumption
- Turf Consumption
SB-PSS Inputs – Consumption Rates

Indoor: Per capita by Land use

Pool
SB-PSS Inputs – Consumption Rates

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Turf April</th>
<th>Turf May</th>
<th>Turf June</th>
<th>Turf July</th>
<th>Turf Aug</th>
<th>Turf Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>6.07</td>
<td>9.37</td>
<td>10.79</td>
<td>11.86</td>
<td>8.47</td>
</tr>
</tbody>
</table>

Turf by month
### SB-PSS Inputs – Precip. & Temp.

#### By month

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Temp Jan</th>
<th>Temp Feb</th>
<th>Temp March</th>
<th>Temp April</th>
<th>Temp May</th>
<th>Temp June</th>
<th>Temp July</th>
<th>Temp Aug</th>
<th>Temp Sep</th>
<th>Temp Oct</th>
<th>Temp Nov</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Conservation</td>
<td>40.10</td>
<td>44.00</td>
<td>57.00</td>
<td>65.00</td>
<td>74.00</td>
<td>83.00</td>
<td>84.00</td>
<td>86.00</td>
<td>80.00</td>
<td>69.00</td>
<td>58.00</td>
</tr>
</tbody>
</table>

**Graphical**

- **Prec April**: 0.413
- **Prec May**: 1.381
- **Prec June**: 1.397
- **Prec July**: 1.377
- **Prec Aug**: 2.64
- **Prec Sep**: 3.04
SB-PSS Inputs – Climate Change

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Pa</th>
<th>Pb</th>
<th>TaAS</th>
<th>TbAS</th>
<th>TaOM</th>
<th>TbOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Conservation</td>
<td>-0.032</td>
<td>0.16</td>
<td>0.0164</td>
<td>-0.2473</td>
<td>0.0061</td>
<td>0.6443</td>
</tr>
</tbody>
</table>

Climate Change:
- None
- Temp
- Prec
- None
Dynamic Attributes
– Indoor Water Consumption

Daily indoor water consumption for the $k^{th}$ month & land use type $u$

$$WC_{k,u}^i = WR_{u}^i \times N_p \times Adj_k$$

$WR_u^i = \text{per capita Indoor daily water usage rate for land use type } u$

$N_p = \text{Number of people/employees/guests}$

$Adj_k = \text{Climate change adjustment for the } k^{th} \text{ month}$

Monthly indoor water consumption for the $k^{th}$ month

$$WC_{im}^k = WC_{idk} \times D_k$$

$WC_{im}^k = \text{indoor water consumption for the } k^{th} \text{ month}$

$D_k = \text{number of days in the } k^{th} \text{ month}$

Annual indoor water consumption

$$WC_{iy}^i = \sum WC_{im}^k, \text{ for } k = 1 \ldots 12$$
Dynamic Attributes
– Turf Water Consumption

Monthly turf water consumption

\[ WC_{tk}^{tm} = WR_{tk}^t \cdot A^t \cdot Adj_k \]

- \( WC_{tk}^{tm} \) = turf water consumption for the \( k^{th} \) month, \( k = 1, 2, \ldots 12 \)
- \( WR_{tk}^t \) = turf water usage rate per unit area for the \( k^{th} \) month
- \( A^t \) = turf area (square feet)

Annual turf water consumption

\[ WC^{ty} = \sum WC_{tk}^{tm}, \text{ for } k = 1 \ldots 12 \]
Dynamic Attributes
– Pool & Total Water Consumption

Annual pool water consumption
\[ WC^{py} = V^{p} + E^{p} \times A^{p} \]
- \( V^{p} \) = volume of a pool (gallons)
- \( E^{p} \) = annual pool evaporation rate (gallons per square foot)
- \( A^{p} \) = pool surface area (square foot)

Total annual water consumption
\[ WC = WC^{iy} + WC^{ty} + WC^{py} \]
### Indoor Conservation Methods

#### Table 1: Indoor Conservation Methods

<table>
<thead>
<tr>
<th>Indoor Conservation</th>
<th>Total amount conserved (Gallons per Capita per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilets</td>
<td>10.3</td>
</tr>
<tr>
<td>Shower heads</td>
<td>2.8</td>
</tr>
<tr>
<td>Faucets</td>
<td>0.1</td>
</tr>
<tr>
<td>Bath</td>
<td>0</td>
</tr>
<tr>
<td>Clothes Washers</td>
<td>5</td>
</tr>
<tr>
<td>Leaks</td>
<td>5.5</td>
</tr>
<tr>
<td>Dishwashers</td>
<td>0.3</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
</tr>
<tr>
<td>Sum</td>
<td>24</td>
</tr>
</tbody>
</table>

#### Table 2: Land Use and Conservation Methods

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Total Amount conserved (Gallons per Capita per day)</th>
<th>Indoor Conservation Methods Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-Family</td>
<td>19</td>
<td>Toilets, Shower heads, Faucets, Leaks, Dishwashers</td>
</tr>
<tr>
<td>Commercial</td>
<td>15.9</td>
<td>Toilets, Faucets, Leaks</td>
</tr>
<tr>
<td>Industrial</td>
<td>15.9</td>
<td>Toilets, Faucets, Leaks</td>
</tr>
<tr>
<td>Resort and Casino</td>
<td>15.9</td>
<td>Toilets, Faucets, Leaks</td>
</tr>
<tr>
<td>Employee</td>
<td>15.9</td>
<td>Toilets, Faucets, Leaks</td>
</tr>
<tr>
<td>Resort and Casino</td>
<td>21.2</td>
<td>Toilets, Faucets, Leaks, Clothes Washers, Dishwashers</td>
</tr>
<tr>
<td>Guest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Golf Course</td>
<td>15.9</td>
<td>Toilets, Faucets, Leaks</td>
</tr>
<tr>
<td>Public Facility</td>
<td>15.9</td>
<td>Toilets, Faucets, Leaks</td>
</tr>
<tr>
<td>Single Family</td>
<td>24</td>
<td>All Methods</td>
</tr>
</tbody>
</table>
Scenarios

No Conservation
Pool Cover Utilization
50% Xeriscape
100% Xeriscape Conversion
Indoor Conservation
Indoor Conservation with Climate Change
All Conservation
Water Conservation Scenarios
Total Water Consumption

No Conservation

All Conservation

Low

High
Conclusions

A SB-PSS model can be created to show water conservation scenarios.

The All Conservation scenario had the largest drop in water consumption. Therefore multiple conservation opportunities are the best option.

This model gives citizens and decision makers the tools needed to make decisions about water consumption.

They can decide on incentives or rebates to offer to reach a water conservation goal.
Question?

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