Creating a Landscape Water Budget Calculator for a Desert City

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**Objective**

The objectives of this research are to:

1. Develop landscape water budget (WB) calculator.
2. Develop reliable landscape plants coefficients.
3. Use different landscape water budget calculation approaches to satisfy different users backgrounds.

**Introduction**

The main source of water for New Mexico’s Largest city, Albuquerque (Fig. 1), is ground water. Withdrawal from the Albuquerque Basin exceeds replenishment from percolation from Rio Grande River and precipitation (Earp and Witherspoon, 2006). Agricultural and hydrological drought indices showed that New Mexico is suffering from long-term drought (Gutzler, 2003).

We built a web calculator allows residents to view their landscapes by address searches, and calculate their landscape features areas. The interface was supported with different water budget calculation methods with different levels of details and complexity. However, users can follow calculation steps easily (Fig. 2).

**Methodology**

**Water Budget Calculation Approaches**

1. **Modified Landscape Water Budget (MBW),**
   
   
   $$\text{MWB} = (\text{ET}_0)(\text{ZKc})(\text{LA})(\text{CF})$$
   
   (Eq. 1)

2. **Vegetation Fragmented Water Budget (VFWB),**
   
   $$\text{VFWB} = \sum_1^2 \text{Water budget} (V_i)$$
   
   (Eq. 2)

   Where: Water budget ($V_i$) = $\text{ET}_0$ (CF) (Ai) (ViKc)

3. **Species Fragmented Water Budget (SFWB),**
   
   $$\text{SFWB} = \sum_1^2 \sum_1^2 \text{Water budget} (S_{ij})$$
   
   (Eq. 3)

   Where: Water budget (Sij) = $\text{ET}_0$ (CF) (Ai) (jKc)

   Where: ZKc’s: Zip code Mixed Vegetation Coefficient; LA: Total landscape area (P); CF: Conversion Factor (0.632 GFlin); Vi: Vegetation types (Vi = Trees, Vj = Shrubs Vp = Grass); ET0: Monthly or annual zip code reference evapotranspiration; Ai: Total landscape areas of vegetation i (P); ViKc’s: General Vi Coefficient; j: Specific landscape plant specie; Aj: Landscape area of specie (j); Kc: Specie (j) Coefficient.

**Reference Evapotranspiration**

We used Geographic Information System (GIS) and parcels base map to identify the latitudes and longitudes of five purposive ET0 points in each zip code. Penman-Monteith equation was used to calculate the current ET0 using forecasted data from the National Weather Service Forecasting Office. Monthly and yearly historical ET0 (1931-2009) were calculated (Fig. 3) using Hargreaves equation with a coefficient of 0.0023.

**Transfer of Non-Turf Landscape Plants Kc’s**

Non-turf plant Kc’s were transferred from “California guide for estimating irrigation water needs of landscape plantings” (Costello and Jones, 2000), which includes a list of plant Kc’s for each of climate regions. The transfer was done after matching California climate regions with Albuquerque. We compared the ET0 zones (Table 1), and climate divisions parameter (length of growing season (Fig. 4), annual temperatures (Table 2), and spring cold hardiness zones).

Table 1: Root Mean Square Error (RMSE) of monthly historical evapotranspiration between Albuquerque and each of California climate regions.

<table>
<thead>
<tr>
<th>California Climate Regions</th>
<th>Reference Evapotranspiration Zones</th>
<th>Average Mean Square Error (MSE) (in/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Central Coastal (1)</td>
<td>1, 2, 3, 4, 6, 8</td>
<td>1.91</td>
</tr>
<tr>
<td>Central Valley (2)</td>
<td>12, 14, 15, 16</td>
<td>0.39</td>
</tr>
<tr>
<td>South Coastal (3)</td>
<td>1, 2, 4, 6</td>
<td>2.10</td>
</tr>
<tr>
<td>South Inland Valley (4)</td>
<td>9</td>
<td>1.90</td>
</tr>
<tr>
<td>High and Intermediate Desert (5)</td>
<td>14, 17</td>
<td>0.72</td>
</tr>
<tr>
<td>Low Desert (6)</td>
<td>18</td>
<td>0.97</td>
</tr>
</tbody>
</table>

**Results**

- Formulas were embedded in the web interface with easy, simple and flexible calculation workflows.
- California Climate Region # 2 and Albuquerque showed the lowest RMSE in terms of ET0 zones, length of growing season, annual temperatures, and spring cold hardiness zone. This suggests using plants lists of region # 2.
- Landscape plants Kc’s were transferred and added to the web interface for users choices.
- The web interface is ready to be released (Fig. 2), and it is available at: [www.nmclimate.nmsu.edu/wb](http://www.nmclimate.nmsu.edu/wb)

**Literature Cited**

