Current Research in USWM in Barcelona

Xavier Gabarrell (2014 SGR 1412)
David Sauri, (2014 SGR 351)
Universidad Autònoma de Barcelona

European Conference,
Towards Smart Specialization in Urban Stormwater Management: Integrating Principles into Practice
March 17-18, 2016

Xavier Gabarrell
Sostenipra research group; Institute of Environmental Science and Technology, Department of Chemical, Biological and Environmental Engineering of the Universitat Autònoma de Barcelona;
www.sostenipra.cat

David Sauri
GRATS Research group
Department of Geography, and Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona
www.uab.cat/grats
1. **UAB**
   1.1. ICTA
   1.2. Water-Energy-Food Nexus

2. **The water metabolism in a Mediterranean coastal region**

3. **Optimizing rainwater harvesting systems in urban areas**
   3.1. Pluvisost
   3.2. Aquaenvec
   3.3. LCA and LCC in neighborhoods
<table>
<thead>
<tr>
<th>Category</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduates students</td>
<td>26975</td>
</tr>
<tr>
<td>PhD theses</td>
<td>734</td>
</tr>
<tr>
<td>Bachelor's degrees</td>
<td>81</td>
</tr>
<tr>
<td>Official master's</td>
<td>143</td>
</tr>
<tr>
<td>Phd programs</td>
<td>67</td>
</tr>
<tr>
<td>Teaching and research staff</td>
<td>3,628</td>
</tr>
<tr>
<td>Budget (milion €)</td>
<td>308.6</td>
</tr>
</tbody>
</table>
ICTA-UAB
Edifici ecodissenyat i sostenible (2014)
Water-Energy-Food Nexus

Water

Energy

Food

use, distribution and disposal

2050
55% increase in water demand

2050
27-61% increase in energy demand

2050
60% increase in food demand
The water metabolism in a Mediterranean coastal region

- 27 coastal municipalities of the Barcelona Metropolitan Region
  - Population density > 5000 persons/km$^2$
  - EU average $\approx$ 115 persons/km$^2$

- Intense activities
  - industrial
  - commercial
  - touristic

Maria Christina Fragkou, Teresa Vicent, Xavier Gabarrell
Balance 2001

**Inputs**

- **Total water inputs**: 202,786,923 m³
- **Water imports**: 182,208,170 m³ (89.9%)
- **Domestic water extraction**: 20,578,753 m³
- **Primary water supply losses**: 14,538,367 m³

**System**

- **Reused water**: 1,481,298 m³ (0.95%)

**Outputs**

- **Water outputs**: 154,649,701 m³
- **Secondary water supply losses**: 46,655,925 m³

**Results**

- **Balance 2001**: 61,194,292 m³
- **Rainwater**: 248,052,680 m³
PLUGRISOST®: A MODEL FOR DESIGN, ECONOMIC COST AND ENVIRONMENTAL ANALYSIS OF RAINWATER HARVESTING IN URBAN SYSTEMS


LIFE10 ENV/ES/000520 AQUAENVEC
PLUVISOST.CTM2010-17365
A tool for eco-efficiency assessment of urban water cycle activities

tool.life-aquaenvsec.eu/


Optimizing rainwater harvesting systems: LCA and LCC in neighborhoods

// PhD. Xavier Gabarrell // PhD. Gara Villalba // PhD M. Violeta Vargas// PhD M. Rosa Rovira
# 7 Barcelona neighborhood scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
<th>N5</th>
<th>N6</th>
<th>N7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building height in layers</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Average household area (m²)</td>
<td>120</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>61</td>
</tr>
<tr>
<td>Households per building</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Average households per neighborhood (2013)</td>
<td>2580</td>
<td>6307</td>
<td>7704</td>
<td>13778</td>
<td>10858</td>
<td>14866</td>
<td>11062</td>
</tr>
<tr>
<td>Buildings per neighborhood</td>
<td>215</td>
<td>394</td>
<td>385</td>
<td>574</td>
<td>387</td>
<td>464</td>
<td>307</td>
</tr>
<tr>
<td>collection area (m²)</td>
<td>7</td>
<td>118,256</td>
<td>115,552</td>
<td>172,228</td>
<td>116,332</td>
<td>139,369</td>
<td>74,975</td>
</tr>
<tr>
<td>Tank capacity (m³)</td>
<td>4000.0</td>
<td>7500.0</td>
<td>9000.0</td>
<td>7000.0</td>
<td>7000.0</td>
<td>8000.0</td>
<td>4500.0</td>
</tr>
<tr>
<td>% yield</td>
<td>82%</td>
<td>60%</td>
<td>54%</td>
<td>39%</td>
<td>38%</td>
<td>33%</td>
<td>25%</td>
</tr>
<tr>
<td>Rainwater supply (m³/year)</td>
<td>7</td>
<td>49,268</td>
<td>54,108</td>
<td>70,232</td>
<td>53,453</td>
<td>64,722</td>
<td>36,411</td>
</tr>
</tbody>
</table>

Tank was calculated using Plugrisost software [Gabarrell, et al., 2014]

### Optimizing Rainwater Harvesting Systems: LCA and LCC in Neighborhoods

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV (euros)</th>
<th>IRR</th>
<th>PB (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>12,798,278</td>
<td>58%</td>
<td>1.8</td>
</tr>
<tr>
<td>N2</td>
<td>32,966,755</td>
<td>73%</td>
<td>1.4</td>
</tr>
<tr>
<td>N3</td>
<td>40,851,441</td>
<td>81%</td>
<td>1.3</td>
</tr>
<tr>
<td>N4</td>
<td>67,175,722</td>
<td>84%</td>
<td>1.2</td>
</tr>
<tr>
<td>N5</td>
<td>46,392,875</td>
<td>83%</td>
<td>1.2</td>
</tr>
<tr>
<td>N6</td>
<td>56,041,016</td>
<td>85%</td>
<td>1.2</td>
</tr>
<tr>
<td>N7</td>
<td>29,452,117</td>
<td>77%</td>
<td>1.3</td>
</tr>
</tbody>
</table>
GRATS

Water and urbanization: Research areas

• The water cycle in urban environments: past and present

• Urban and tourist water consumption

• Alternative water resources for urban areas (greywater, rainwater)

• Floods and climate change in coastal areas
Mediterranean extremes

Can we turn hazards into resources?
Determinación teóricamente recuperable de RW en los tejados de viviendas unifamiliares en St. Cugat del Valles, España

\[ V_{\text{roofterunoff}} = \psi_{RT} \cdot A_{RT} \cdot \sum_{p \in RT} P_p = A_{ef} \cdot \sum_{p \in RT} P_p \]

<table>
<thead>
<tr>
<th>Category</th>
<th>Rooftop area (ha)</th>
<th>Domestic water consumption (2007) (hm³/year)</th>
<th>Potential volume of rainwater harvested ( P_F \cdot A_{RT} ) (hm³/year)</th>
<th>Volume of rainwater harvested ( P_F \cdot A_{RT} \cdot \psi_{RT} ) (hm³/year)</th>
<th>Replacement percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>222.35</td>
<td>4.70</td>
<td>1.33</td>
<td>1.06</td>
<td>21.28</td>
</tr>
</tbody>
</table>

### A SIMPLIFIED MULTICRITERIA ANALYSIS OF DIFFERENT WATER SUPPLY SYSTEMS

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Criteria</th>
<th>Centralized water sources</th>
<th>Decentralized water sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Desalinated water</td>
<td>Reclaimed water</td>
</tr>
<tr>
<td><strong>ECONOMIC</strong></td>
<td>Capital cost of the system</td>
<td>0.23 €/m³</td>
<td>0.42 €/m³</td>
</tr>
<tr>
<td></td>
<td>O&amp;M cost</td>
<td>0.4 €/m³</td>
<td>0.21 €/m³</td>
</tr>
<tr>
<td><strong>SOCIAL</strong></td>
<td>Public acceptability</td>
<td>Moderate</td>
<td>More or less good</td>
</tr>
<tr>
<td></td>
<td>Health risk</td>
<td>Very good</td>
<td>More or less good</td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL</strong></td>
<td>Energy consumption</td>
<td>4 kwh/m³</td>
<td>1.24 kwh/m³</td>
</tr>
<tr>
<td></td>
<td>Other environmental impacts</td>
<td>More or less bad</td>
<td>More or less good</td>
</tr>
<tr>
<td><strong>TECHNOLOGICAL</strong></td>
<td>Technological simplicity</td>
<td>More or less bad</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Water security</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

Domènech, March, Saurí, 2012
Conventional urban water management approaches are struggling to meet the emerging challenges required for sustainability. New discourses on urban water management emphasize the need for a transformative change by moving to a system that manages a diversity of water sources and scales of infrastructure, through an integrative planning approach.

UrbanRain examines the opportunities and challenges regarding the planning for the up-scaling and expansion of rainwater harvesting (RWH) systems as socio-technical devices in order to enhance water management sustainability in urban areas of Europe; although, it is expected that its lessons and recommendations will have a wider, global impact.
Actor Map in new governance systems for urban water

**Actors involved**

- **Executers:** Companies installing RWH systems
- **Find Providers:**
  - Sant Cugat del Vallès City Council
  - Owners
- **“Finders”:**
  - Sant Cugat del Vallès City Council
- **Operation and maintenance:**
  - Users
  - O&M companies
- **Users:**
  - Owners and residents in buildings
EXAMPLE OF SPECIFIC PROJECTS
RWH IN Sant Cugat del Vallès

Period: Since 2002

Project: Part of the Water Saving Ordinance

Installation: rainwater tanks (2002-2008 gardens > 1,000 m² / Since 2008: gardens > 300 m² plus xeric species)
• Swimming pool water reuse (gardens > 40 m²)
• Greuwater reuse (apartment buildings > 8 apartaments)

Aim: Reduce water consumption of the city
THANK YOU VERY MUCH FOR YOUR ATTENTION!!