Water balances for MUS in Colombia

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Background

- MSc project supervised by Mr. Ian Smout from WEDC, Loughborough University
- Previous studies on MUS in the case study area
- Intended contributions to the knowledge in the topic:
  - Necessity to combine qualitative and quantitative methods to understand demands for MUS, integrating knowledge and tools from different disciplines
  - Increase the knowledge on the supply side on MUS, introducing the green water branch to the process of planning for the blue water branch
  - Address equity issues: how different users benefit from the possibility to use the water for productive activities within the system
Conceptual framework

Planning of rural water supply systems for MUS in rural areas

Multiple uses
- Domestic
- Livestock
- Agriculture
- Other

Water availability
- Green water
- Blue water

Water balances and budgets

Poverty alleviation
Sustainable livelihoods approach
Demand responsive approach
Sustainability
Water balances for MUS: La Palma Tres Puertas case study
The case study area

- Households: 437
- Main livelihoods: agriculture and animal husbandry
- Water service coverage: 100%
- Intermittent service
- Storage tanks at household level
- Water committee in charge of management
- Differentiated water tariff according to consumption
System boundaries, inflows and outflows

• Temporal boundaries: June – July 2010

• Spatial boundaries
Water availability - inflows (l)

- **Water supply**
  - Measurement of the water entering to the centralized storage tank of the water supply system
  - Five days during the analysis period
  - Volume supplied was calculated as the average of the data taken

![Graph showing flow in liters per second from 07/07/2010 to 23/07/2010 with average and Series 1 lines.](chart.png)
Water availability - inflows (II)

- Rainfall
  - Obtained from records of a Climate Station located in the area
  - Total rainfall during the period was 169,5 mm
Water demand - outflows (I)

Two sources of information

• Household survey to collect information significant for a “disaggregated” demand estimation
  ▫ Household size
  ▫ Total area of the household
  ▫ Cropped area by type of main crops
  ▫ Number of animals per species

• Records from household meters
Balance adjustment

**Blue water branch**

\[ THC = DC + LC + CPC + SBC + CBWC + other \]

Where:

- THC = Total Household Consumption provided from meters records
- DC = Domestic Consumption
- LC = Livestock Consumption
- CPC = Coffee Processing Consumption
- SBC = Small Business Consumption
- CBWC = Crop Blue Water Consumption

**Green water branch**

\[ P = CGWC + DW + GW \]

Where:

- P = Precipitation
- CGWC = Crop green water consumption (irrigated + rainfed)
- DW = Downstream
- GW = Groundwater
# Water demand - example of some outflows estimation

<table>
<thead>
<tr>
<th>Water Use</th>
<th>Formula</th>
<th>Variable</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic consumption (DC)</td>
<td>( DC = \text{Household size} \times \text{Domestic per capita consumption} \times \frac{60}{1000} )</td>
<td>Household size</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Domestic per capita consumption (lpcd)</td>
<td></td>
</tr>
<tr>
<td>Livestock consumption (LC)</td>
<td>( LC = \left( \sum_{i=7}^{\text{Number of animals especie}_i} \right) \times \text{Water consumption factor especie}_i \times \frac{60}{1000} )</td>
<td>Number of cows</td>
<td>40 l/head*day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of chickens</td>
<td>0,15 l/head*day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of pigs</td>
<td>20 l/head*day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of horses</td>
<td>20 l/head*day</td>
</tr>
<tr>
<td>Coffee processing consumption (CPC)</td>
<td>( CP = \text{Productivity factor} \times \text{Water consumption system factor} \times \text{Cropped area} \times \frac{60}{1000} )</td>
<td>Water consumption system factor</td>
<td>0,0042 m³/KgPC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Productivity factor</td>
<td>0,035 KgPC/m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cropped area (m²)</td>
<td></td>
</tr>
<tr>
<td>Crop green water consumption (CGWC)</td>
<td>( CGWC = \sum_{i=14} \text{Area crop}_i \times \text{Green water consumption factor crop}_i )</td>
<td>Cropped area with coffee</td>
<td>0,1465 m/period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cropped area pineapple</td>
<td>0,0465 m/period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cropped area beans</td>
<td>0,0705 m/period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cropped area maize</td>
<td>0,1465 m/period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cropped area vegetables</td>
<td>0,1465 m/period</td>
</tr>
<tr>
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<td></td>
<td>Cropped area pitaya</td>
<td>0,0837 m/period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cropped area lulo</td>
<td>0,1465 m/period</td>
</tr>
</tbody>
</table>
Results at the system level

Blue water - Water supply system
- Domestic: 40%
- Livestock: 30%
- Coffee processing: 21%
- Blue water irrigated crops: 7%

Green water - Rainfall distribution
- Green water rainfed crops: 59%
- Green water irrigated crops: 14%
- Runoff: 11%
- Infiltration/down stream: 16%

Graphs showing:
- Volume (m³) for Domestic, Livestock, Coffee processing, and Crops across Stratum 1, 2, and 3.
- Volume (m³) for Green water rainfed crops and Green water irrigated crops across Stratum 1, 2, and 3.
Results at the household level

- Per capita domestic consumption varied from 88 to 109 lpcd
- Per capita consumption for productive purposes varied from 19 lpcd to 413 lpcd
Conclusions

• Water balance concepts and budgets probed to be flexible tools to:

  ▫ Understand the dynamics of the hydrological cycle and the human cycle in a MUS system
  ▫ Suit the objectives of a study, scale, and availability of information
  ▫ The stratified analysis allowed estimating water consumption for domestic and productive uses, making clear differences between categories of subscribers within the system
Other initiatives - MUS guidelines

- Book “Guidelines to design and manage of multiple uses of water supply systems for rural areas in Colombia” by Inés Restrepo, Isabel Domínguez, Silvia Corrales and Sandra Bastidas published by Universidad del Valle in 2010.

- Structure of the guidelines

Concrete principles, activities and tools to address during planning and management for MUS:

- Equity and poverty reduction
- Multiple uses
- Multiple sources
- Sustainable use of water
- Technological alternatives
- Cost recovery
- Tariffs and management rules
Thank you !!!

Project report available at MUS website: http://www.musgroup.net/
Contact: isabel_doming75@hotmail.com