Adapting water allocation management to drought scenarios.

Paolo Giacomelli, Marta Brambilla, Andrea Rossetti

RICLIC WARM – Regional Impact of CLImate Change in Lombardy Water Resources: Modelling and applications.
Outline

• Water scarcity on the Adda River basin: RICLIC-WARM project;
• The concept of drought;
• Methodology;
• Study area: physical and economic characteristics;
• Human activities and hydrological cycles;
• Discussion and future developments
Summer 2003 – direct effects observed

- AGRICULTURE: crop losses, damage to crop quality;
- TOURISM: reduction in recreational uses (e.g.: navigation, bathing) on Lake Como;
- POWER GENERATION: change in hydropower potential through the year, altered potential for run-of-river power;
- PUBLIC WATER SUPPLY: reduction in availability of summer municipal water, increase of water demand.
RICLIC-WARM project

Develop a scientific methodology to assess climatic impacts on water resources and provide a support to decision-making processes on water management

SCIENTIFIC RESEARCH UNITS
- University of Milano – Bicocca
- University of Milano
- University of Pavia

FINANCING BODIES
- Regione Lombardia
- ARPA Lombardia (Regional environmental protection agency)
Project frame

- Climate
- Idrology
- Idrogeology
- Quality
- Agriculture

End user

Socioeconomic assessment

Physical effects
The concept of drought (NDMC, 2006)

- **Meteorological drought**: degree of dryness and duration of the dry period, compared to the average conditions;

- **Agricultural drought**: when conditions of precipitation shortage, reduced groundwater levels and high evapotranspiration levels occur at the same time, during the most susceptible stages of crop development;

- **Hydrological drought**: how the deficiency of precipitation plays out through the hydrologic system;

- **Hydrological drought due to land use**: a condition of water deficit produced by a change in land use; human actions alter the frequency of water shortage, even when no change in the frequency of meteorological drought has been observed;

- **Socio-economic drought**: when the demand for an economic good exceeds supply as a result of a water-related shortfall in water supply.
The suggested approach

1° Phase: identification of the causes and the physical effects

2° Phase: assessment of the socio-economic consequences
Physical analysis

1. Physical causes:
   - Variation on general atmospheric circulation;
   - Rise of temperature;
   - Variation on pluviometric regimes;
   - Increase of the frequency of extreme events

2. Physical effects:
   - Variations on water flows (rivers) and water stocks (lakes, reservoirs);
   - Effects on snow and ice accumulation/melt;
   - Effects on groundwater recharge;
   - Effects on the overall water demand;
   - Shifts in demand peaks

   "SUPPLY SIDE"

   "DEMAND SIDE"
3. **Evaluation of socio-economic consequences**

- Collection and critical analysis of statistical data about population dynamics and economic sectors;
- Identification of the *most sensible socio-economic frames* and communities on the territory;
- Comprehension and analysis of (local and/or remote) socio-economic *interrelationships* between the areas exposed with other areas.
Quantitative cause-effect correlation

Physical analysis

Overlay of thematic layers and database using gis techniques

Identification of Potential drought scenarios

Evaluation of the economic effects
Study area
Physical characterization

Main characteristics

- SURFACE DRAINED: 7.979 km²
- RIVER LENGTH: 313 km
- ALTITUDE RANGE:
  - Sources of Adda: 2.237 m asl
  - Mean Lake Como elevation: 198 m asl
  - Join with Po river: 36 m asl
Physical characterization

ADDA RIVER BASIN

Lake Como

Valtellina

Padana Plain
The socio-economic system

<table>
<thead>
<tr>
<th>SUB-AREA</th>
<th>n. of PROVINCES</th>
<th>N. of MUNICIPALITIES</th>
<th>POPULATION</th>
<th>SURFACE (km²)</th>
<th>DENSITY (inh/Km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VALTELLINA</td>
<td>1</td>
<td>78</td>
<td>174.116</td>
<td>3.212</td>
<td>54</td>
</tr>
<tr>
<td>LAKE COMO</td>
<td>2</td>
<td>57</td>
<td>267.344</td>
<td>700</td>
<td>382</td>
</tr>
<tr>
<td>PADANA PLAIN</td>
<td>5</td>
<td>125</td>
<td>658.998</td>
<td>1.119</td>
<td>589</td>
</tr>
</tbody>
</table>

Socio-economic analysis
Valtellina

- Railway and road connection not streamlined;
- Low population density (54 inh/Km$^2$);
- Great number of floating population (tourists and commuters);
- **Tourism**: >1/3 added value;
- **Agriculture**: high quality products (DOC wines and PDO cheeses and meat)

Source: ISTAT, 2003
Socio-economic analysis
Lake Como

- Communities settled along the lake;
- Higher population density (382 inh/Km²);
- Different specialization on the three branches of the lake:
  - north: tourism;
  - east: metallurgical industry;
  - west: silk, textile industry.

Source: ISTAT, 2003
Socio-economic analysis
Padana Plain

- Most important productive area of Italy;
- Great inflow of commuters;
- Intensive land exploitation;
- 81% UAA;
- 65% agriculture added value from cattle-breeding;

### Surface to UAA

<table>
<thead>
<tr>
<th>Area</th>
<th>Surface (ha)</th>
<th>UAA (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valtellina</td>
<td>321.200</td>
<td>92.363</td>
<td>29</td>
</tr>
<tr>
<td>Lake Como</td>
<td>70.000</td>
<td>6.208</td>
<td>9</td>
</tr>
<tr>
<td>Padana Plain</td>
<td>111.900</td>
<td>90.317</td>
<td>81</td>
</tr>
</tbody>
</table>

Source: ISTAT, 2003
Supply side - flows

- **TIRANO (441 m asl)**
  - Year average discharge: 26.75 m$^3$/s

- **FUENTES (198 m asl)**
  - Year average discharge: 88.0 m$^3$/s

- **MALGRATE (198 m asl)**
  - Year average discharge: 158.2 m$^3$/s

- **JOIN WITH PO RIVER (36 m asl)**
  - Year average discharge: 287.72 m$^3$/s

Source: PTUA, Lombardy, 2003
Supply side - stocks

Lake:
- Absolute capacity: 22,500 Mm$^3$
- Hydrometric level of regulation: -40 cm to 120 cm
- Regulation capacity: 254,3 Mm$^3$ (9% of annual input)

Hydroelectric reservoirs:
- 21 reservoirs (44 power stations): 515 Mm$^3$

It is an artificially regulated system (Olginate floodgate)
## Demand side – water rights

<table>
<thead>
<tr>
<th>V [Mm³/yr]</th>
<th>ANIMAL FARMING, ANTI-FIRE</th>
<th>FISH FARMING</th>
<th>INDUSTRY</th>
<th>IRRIGATION</th>
<th>MUNICIPAL</th>
<th>OVERALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>VALTELLINA</td>
<td>31,22</td>
<td>146,37</td>
<td>31,24</td>
<td>187,85</td>
<td>79,89</td>
<td>476,57</td>
</tr>
<tr>
<td>LAKE COMO</td>
<td>8,31</td>
<td>1,1</td>
<td>53,57</td>
<td>5,60</td>
<td>105,88</td>
<td>174,46</td>
</tr>
<tr>
<td>PADANA PLAIN</td>
<td>164,76</td>
<td>288,73</td>
<td>1977,14</td>
<td>3500</td>
<td>291,05</td>
<td>6221,68</td>
</tr>
<tr>
<td>OVERALL</td>
<td>204,29</td>
<td>436,2</td>
<td>2061,95</td>
<td>3693,45</td>
<td>476,83</td>
<td></td>
</tr>
</tbody>
</table>

Demand side - Valtellina

Water consumption (Mm³/yr water rights)

Source of water supply (% water rights)

Demand side - Lake Como

Water consumption (Mm³/yr water rights)

**Source of water supply (% water rights)**

**Demand side - Lake Como**

**Water consumption (Mm³/yr water rights)**

- **MUNICIPAL**: 105,88
- **INDUSTRY**: 53,57
- **LIVESTOCK PRODUCTION**: 11,0
- **ANTI-FIRE**: 8,31
- **IRRIGATION**: 5,60
- **FISH FARMING**: 1,10

**Source of water supply (% water rights)**

- **MUNICIPAL**: Spring, Well
- **INDUSTRY**: Spring
- **LIVESTOCK PRODUCTION, ANTI-FIRE**: Spring
- **FISH FARMING**: Spring
- **IRRIGATION**: Spring

**Source**: CUI Lombardy, 2003.
Demand side - Padana Plain

Water consumption (Mm³/yr water rights)

Source of water supply (% water rights)

Demand side - agriculture

AVERAGE MONTHLY DISCHARGE OF ADDA IRRIGATION DIVERSION

Q (mc/sec)

month

jan  feb  mar  apr  may  jun  jul  aug  sep  oct  nov  dec

Serie1
Demand side - tourism

Como lake

mc/month

month

jan feb mar apr may jun jul aug sep oct nov dec
Demand side - tourism

![Chart showing demand side tourism for Valtellina]

- Valtellina

- Demand side - tourism
### Supply side - regulation

<table>
<thead>
<tr>
<th></th>
<th>Average discharge (m³/sec)</th>
<th>Average volume (Mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yearly average</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years '59 - '00</td>
<td>140.65</td>
<td>4.435.42</td>
</tr>
<tr>
<td>Years '96 -'05</td>
<td>112.40</td>
<td>3.544.23</td>
</tr>
<tr>
<td><strong>Water deficit</strong></td>
<td>-28.25</td>
<td>-891.19</td>
</tr>
<tr>
<td></td>
<td>-20.09%</td>
<td>-20.09%</td>
</tr>
<tr>
<td><strong>Summer average</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(May-Aug)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>176.13</td>
<td>2.328.34</td>
</tr>
<tr>
<td></td>
<td>132.10</td>
<td>1.746.28</td>
</tr>
<tr>
<td></td>
<td>-44.03</td>
<td>-582.06</td>
</tr>
<tr>
<td></td>
<td>-25.00%</td>
<td>-25.00%</td>
</tr>
</tbody>
</table>
Climate change and socio-economic system

Strong inter-connection between natural cycles and human activities

- Climate change: influence on water resources distribution (stocks/flows)
- Socio-economic system: influence of competing water users on water balances

- High stress on water resources under current conditions
- High sensitivity of the socio-economic system to variations on water inputs
Take home message

**Cause**
- Water demand
- Technical sciences

**Effect**
- Water supply
- Economics

*Quantitative correlation*  
*Scarcity*  
*Exchange of knowledge*
http://www.riclic.unimib.it/

ARPA Lombardia (Regional environmental protection agency)
Regione Lombardia
Università degli Studi di Milano - Bicocca
Università degli Studi di Milano
Università degli Studi di Pavia