REGIONAL IMPACT OF METEOROLOGICAL EXTREME EVENTS:
CLIMATIC CAUSES AND SOCIO-ECONOMIC EFFECTS

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(2) DISAT – Environmental Sciences Dept., University of Milan-Bicocca
FINAL GOALS
DEVELOP A SCIENTIFIC METHODOLOGY TO ASSESS CLIMATIC IMPACTS ON WATER RESOURCES AND PROVIDE A SUPPORT TO DECISION-MAKING PROCESSES ON WATER MANAGEMENT

RICLIC-WARM

SCIENTIFIC RESEARCH UNITS
- University of Milano-Bicocca (UNIMIB)
- University of Milano (UNIMI)
- University of Pavia (UNIPV)

REGIONAL PUBLIC AUTHORITY
- Regione Lombardia
- ARPA Lombardia (Regional environmental protection agency)
PROJECT FRAME

WP1
CLIMATIC DATASET MANAGEMENT
Prof. Valter Maggi
DISAT
University of Milano - Bicocca

WP8
DAMAGES AND RISK EVALUATION
Prof. Paolo Giacomelli
DEPAAA - University of Milano
METEO-CLIMATIC STATIONS

44 PLAIN AND HILL STATIONS
44 ALPINE STATIONS
YEARLY MEAN TEMPERATURES ANOMALIES

ALPINE ZONE (Lago Venina)

PRE-ALPINE ZONE (San Pellegrino)

PLAIN ZONE (Brescia)
LOW WINTER TEMPERATURES

Average of low winter temperature (DJFM)

-4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0

Y ears

° C

Brescia
Clusone
Cremona
Lodi
Mi-Brera
Salò
SanPellegrino
Voghera

Lineare (Voghera)
Lineare (Brescia)
Lineare (Clusone)
Lineare (Cremona)
Lineare (Lodi)
Lineare (Mi-Brera)
Lineare (Salò)

NUMBER OF FROSTY DAYS VARIATION

Standardized average anomalies of frosty days 1962-1970 in comparison to baseline 1961-1990

- +2 days/winter
- +12 days/winter
- +5 days/winter

Standardized average anomalies of frosty days 1988-1996 in comparison to baseline 1961-1990

- -12 days/winter
- -16 days/winter
- -10 days/winter
Tropical temperature (T>=33°C) increase 1951-1979 VS 1980-2003
TROPICAL TEMPERATURE DAYS

MilanoBrera-Tropical days

Brescia-Tropical days

YEAR 2003
## Hydrological Year 2003: Rainfall Deficit

### Alpine Zone Deficit %2003
(Prese Frodolfo)

<table>
<thead>
<tr>
<th>Month</th>
<th>Baseline 1961-1990 (mm)</th>
<th>Year 2003 (mm)</th>
<th>Deficit %2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>73.8</td>
<td>37.0</td>
<td>-49.9</td>
</tr>
<tr>
<td>October</td>
<td>58.4</td>
<td>47.4</td>
<td>-18.9</td>
</tr>
<tr>
<td>November</td>
<td>68.1</td>
<td>241.0</td>
<td>253.9</td>
</tr>
<tr>
<td>December</td>
<td>38.9</td>
<td>11.6</td>
<td>-70.1</td>
</tr>
<tr>
<td>January</td>
<td>38.2</td>
<td>1.4</td>
<td>-96.3</td>
</tr>
<tr>
<td>February</td>
<td>30.7</td>
<td>0.0</td>
<td>-100.0</td>
</tr>
<tr>
<td>March</td>
<td>34.4</td>
<td>0.0</td>
<td>-100.0</td>
</tr>
<tr>
<td>April</td>
<td>52.0</td>
<td>19.2</td>
<td>-63.1</td>
</tr>
<tr>
<td>May</td>
<td>88.4</td>
<td>72.0</td>
<td>-18.5</td>
</tr>
<tr>
<td>July</td>
<td>76.9</td>
<td>42.4</td>
<td>-44.9</td>
</tr>
<tr>
<td>June</td>
<td>80.5</td>
<td>87.2</td>
<td>8.3</td>
</tr>
<tr>
<td>August</td>
<td>94.0</td>
<td>76.4</td>
<td>-18.7</td>
</tr>
<tr>
<td><strong>Annual total</strong></td>
<td>734.3</td>
<td>635.6</td>
<td>-13.4</td>
</tr>
</tbody>
</table>

### Plain Zone Deficit %2003 (Lodi)

<table>
<thead>
<tr>
<th>Month</th>
<th>Baseline 1961-1990 (mm)</th>
<th>Year 2003 (mm)</th>
<th>Deficit %2003</th>
</tr>
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<tbody>
<tr>
<td>September</td>
<td>57.3</td>
<td>48.0</td>
<td>-16.2</td>
</tr>
<tr>
<td>October</td>
<td>93.3</td>
<td>54.5</td>
<td>-41.6</td>
</tr>
<tr>
<td>November</td>
<td>81.9</td>
<td>203.5</td>
<td>148.4</td>
</tr>
<tr>
<td>December</td>
<td>54.0</td>
<td>62.7</td>
<td>16.2</td>
</tr>
<tr>
<td>January</td>
<td>57.2</td>
<td>18.0</td>
<td>-68.5</td>
</tr>
<tr>
<td>February</td>
<td>57.8</td>
<td>0.0</td>
<td>-100.0</td>
</tr>
<tr>
<td>March</td>
<td>66.1</td>
<td>5.5</td>
<td>-91.7</td>
</tr>
<tr>
<td>April</td>
<td>71.3</td>
<td>24.0</td>
<td>-66.3</td>
</tr>
<tr>
<td>May</td>
<td>76.4</td>
<td>22.0</td>
<td>-71.2</td>
</tr>
<tr>
<td>July</td>
<td>58.5</td>
<td>56.0</td>
<td>-4.2</td>
</tr>
<tr>
<td>June</td>
<td>49.3</td>
<td>41.5</td>
<td>-15.8</td>
</tr>
<tr>
<td>August</td>
<td>78.3</td>
<td>0.6</td>
<td>-99.2</td>
</tr>
<tr>
<td><strong>Annual total</strong></td>
<td>801.3</td>
<td>536.3</td>
<td>-33.1</td>
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**% Annual deficit**
MAIN CHARACTERISTICS

- **SURFACE DRAINED**: 7.927 kmq
- **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
**ADDa RIVER BASIN**

**TIRANO (441 m asl)**
Year average discharge: 26.75 m³/s

**FUENTES (198 m asl)**
Year average discharge: 88.0 m³/s

**MALGRATE (198 m asl)**
Year average discharge: 158.2 m³/s

**JOIN WITH PO RIVER (36 m asl)**
Year average discharge: 287.72 m³/s

**STORAGE CAPACITIES**

- **LAKE COMO**
  - Absolute capacity: 22,500 Mmc
  - Regulation (available) capacity: 254.3 Mmc

- **HYDROELECTRIC RESERVOIRS:**
  - 27 reservoirs (44 power stations): 515 Mmc

**SOURCE:**
SOCIO-ECONOMIC ANALYSIS – STUDY AREA

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<thead>
<tr>
<th>SUB-AREA</th>
<th>N. of MUNICIPALITIES</th>
<th>POPULATION</th>
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<tr>
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<td>78</td>
<td>174,116</td>
<td>112</td>
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<tr>
<td>LAKE COMO (CENTRAL BASIN)</td>
<td>57</td>
<td>267,344</td>
<td>382</td>
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<tr>
<td>PADANA PLAIN (LOWER BASIN)</td>
<td>125</td>
<td>658,998</td>
<td>589</td>
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<td>OVERALL</td>
<td>260</td>
<td>1,100,458</td>
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**OVERALL**: 260 | 1,100,458 | 361

### SOCIO-ECONOMIC ANALYSIS – STUDY AREA

#### N. of Municipalities, Population, and Density (ab/Km²)

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**SOURCE:** ISTAT, 2003.
### SOCIO-ECONOMIC ANALYSIS – STUDY AREA

#### Table: Sub-areas of the study area

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<th>N. of Municipalities</th>
<th>Population</th>
<th>Density (ab/Km²)</th>
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<td>Valtellina (Upper Basin)</td>
<td>78</td>
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<td>112</td>
</tr>
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<td>Lake Como (Central Basin)</td>
<td>57</td>
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<td>382</td>
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<td>125</td>
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**Source:** ISTAT, 2003.
OVERALL SUB-AREAS WATER CONSUMPTION (Mmc/yr WATER RIGHTS)

- Valtellina (Upper Basin): 476,6
- Lake Como (Central Basin): 174,5
- Padana Plain (Lower Basin): 10805,3

OVERALL SOURCE OF WATER SUPPLY (Mmc/yr WATER RIGHTS)

- Well: 768,70
- Spring: 107,52
- River Diversion: 10580,13

VALTELLINA (UPPER BASIN)

WATER CONSUMPTION (Mmc/yr WATER RIGHTS)

FISH FARMING: 146,37
LIVESTOCK PRODUCTION, ANTI-FIRE: 31,22
MUNICIPAL: 79,89
INDUSTRY: 31,24
IRRIGATION: 187,85

SOURCE OF WATER SUPPLY (% WATER RIGHTS)

FISH FARMING
IRRIGATION
INDUSTRY
MUNICIPAL
LIVESTOCK PRODUCTION, ANTI-FIRE

**WATER CONSUMPTION (Mmc/yr WATER RIGHTS)**

- **MUNICIPAL:** 105.88
- **INDUSTRY:** 53.57
- **IRRIGATION:** 5.60
- **FISH FARMING:** 1.10
- **LIVESTOCK PRODUCTION, ANTI-FIRE:** 8.31

**SOURCE OF WATER SUPPLY (% WATER RIGHTS)**

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

**SOURCE:** CUI Lombardy, 2003.
PADANA PLAIN (LOWER BASIN)

WATER CONSUMPTION (Mmc/yr WATER RIGHTS)

- MUNICIPAL: 291.05
- INDUSTRY: 1977.14
- FISH FARMING: 288.73
- IRRIGATION: 8083.64


SOURCE OF WATER SUPPLY (% WATER RIGHTS)

- FISH FARMING
- IRRIGATION
- INDUSTRY
- MUNICIPAL
- LIVESTOCK PRODUCTION, ANTI-FIRE

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
CLIMATE CHANGE AND SOCIO-ECONOMIC SYSTEM

CAUSE – EFFECT QUANTITATIVE CORRELATION

ASSESSMENT OF THE QUANTITATIVE INTERDEPENDENCE BETWEEN PHYSICAL CAUSES AND ECONOMIC EFFECTS
QUANTITATIVE CAUSE-EFFECT CORRELATION

**PHYSICAL ANALYSIS**

1\textsuperscript{st} step: Identification of the physical causes;

2\textsuperscript{nd} step: Determination of the physical effects.

**SOCIO-ECONOMIC ANALYSIS**

3\textsuperscript{rd} step: Evaluation of the main features and the most relevant socio-economic drivers;

4\textsuperscript{th} step: Assessment and evaluation of the economic consequences (i.e. competition and damages).
QUANTITATIVE CAUSE-EFFECT CORRELATION

Physical Analysis

Socio-Economic Analysis

Overlay of thematic layers and database using GIS techniques

Identification of potential drought scenarios

Evaluation of the economic effects generated from the physical impacts
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 MAIN FEATURES

• 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.
4. ASSESSMENT AND QUANTIFICATION OF SOCIO-ECONOMIC EFFECTS

**DIRECT EFFECTS**
PRIMARY CONSEQUENCES OF WATER SHORTAGE ON THE SOCIO-ECONOMIC ACTIVITIES

**INDIRECT EFFECTS**
SECONDARY EFFECTS (LONG-TERM) OF WATER RESOURCES SCARCITY ON THE SOCIO-ECONOMIC SYSTEM
YEAR 2003 – DIRECT EFFECTS OBSERVED

SOME DIRECT EFFECTS OF WATER SHORTAGE ON:

- 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.
PROJECT RICLIC–WARM AGENDA

PROJECT KICK-OFF: SEPTEMBER 2005, DURATION 3 YEARS.

1st YEAR OF ACTIVITIES:
- Collection and geocoding of past physical data by every single Work Package.

2nd YEAR OF ACTIVITIES:
- Analysis and modeling of the data collected, integration on a multi-disciplinary level, creation of future scenarios and forecasting;
- Collection and critical analysis of the socio-economic system.

3rd YEAR OF ACTIVITIES:
- Assessment and quantification of socio-economic direct and indirect effects;
- Creation, management and constant update of a scientific multi-disciplinary database;
- Supplying of decision-making instruments for watershed management.
TAKE HOME MESSAGE

PAST SCENARIOS ↔ FORECASTING

CAUSE ↔ EFFECT

WATER DEMAND ↔ WATER SUPPLY

TECHNICAL SCIENCES ↔ ECONOMICS

modeling

quantitative correlation

scarcity

exchange of knowledge
PROJECT RICLIC – WARM
Regional Impact of CLImatic Change in Lombardy WAter Resources: Modelling and applications.

THANK YOU FOR YOUR ATTENTION

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