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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

FINANCING BODIES

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

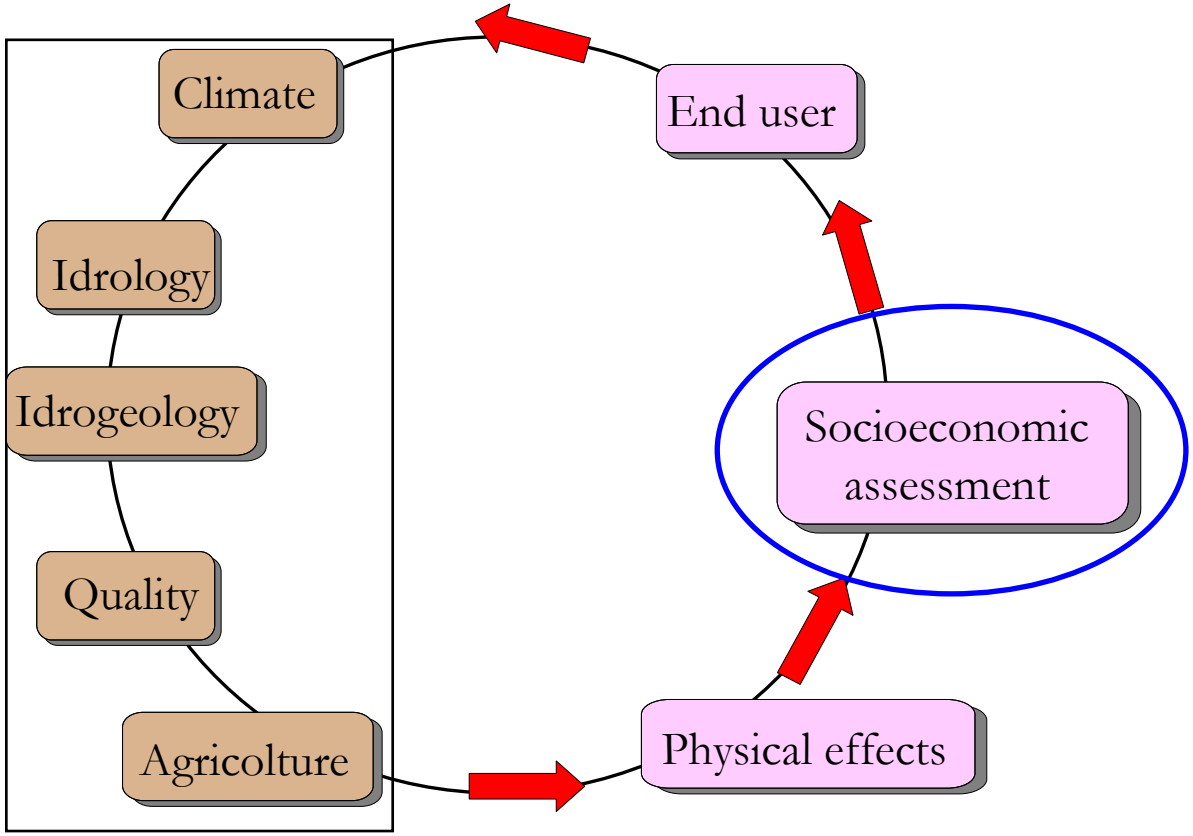
SCIENTIFIC RESEARCH UNITS

- University of Milano – Bicocca
- University of Milano
- University of Pavia

REGIONAL PUBLIC AUTHORITY

- Regione Lombardia
- ARPA Lombardia (Regional environmental protection agency)

Project frame



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

CAUSE → EFFECT

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 frequence 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;

   "SUPPLY SIDE"

   - Effects on the overall water demand;
   - Shifts in demand peaks

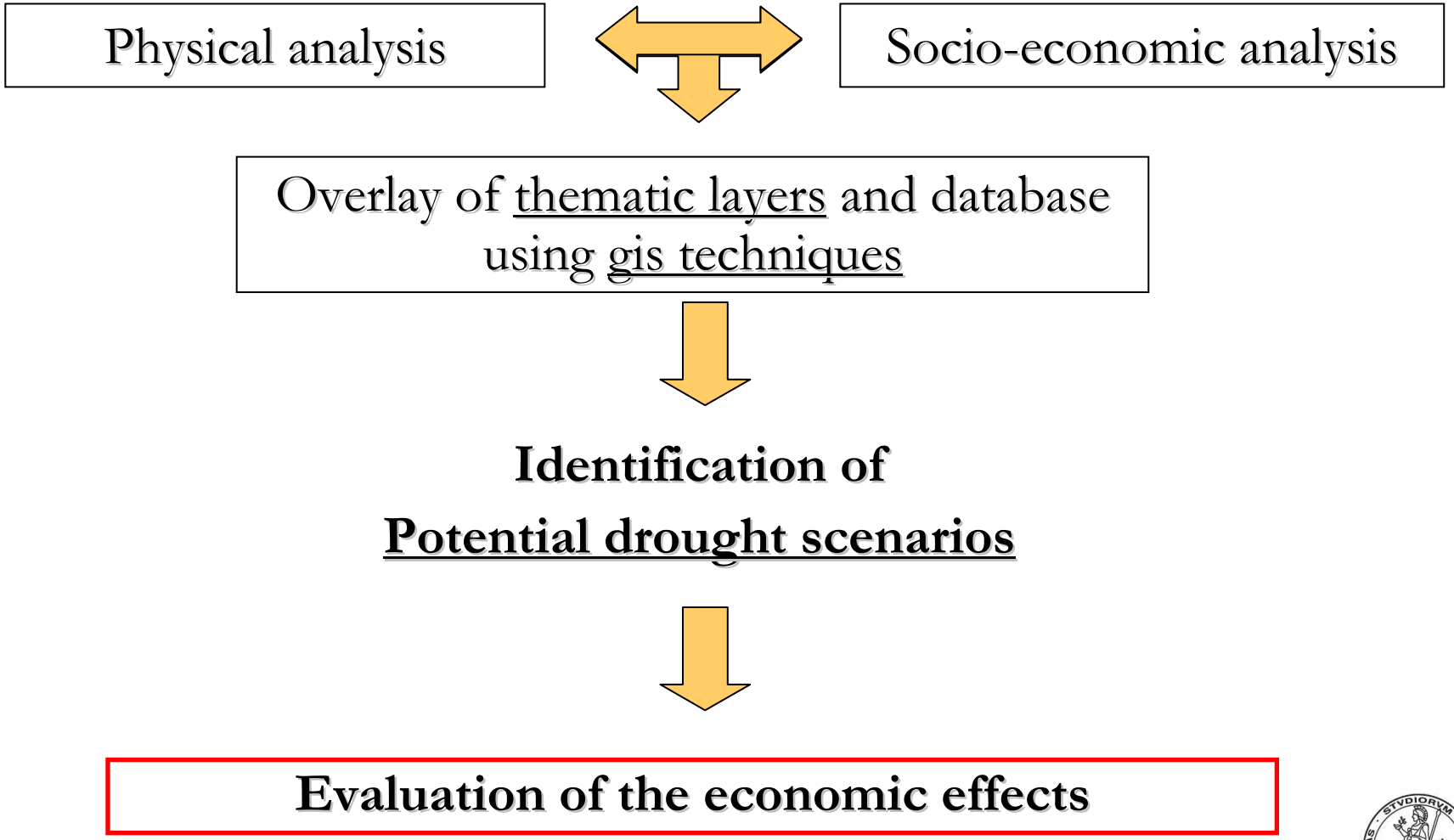
   "DEMAND SIDE"

Socio-economic analysis

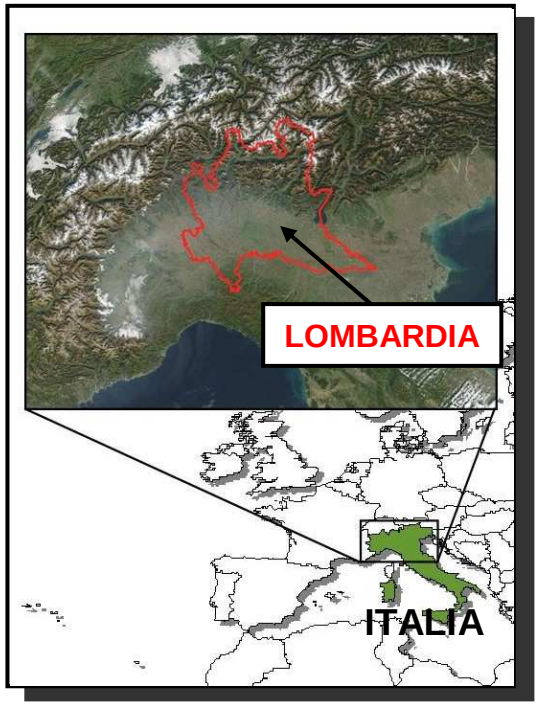
3. Evaluation of socio-economic consequences

- 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.

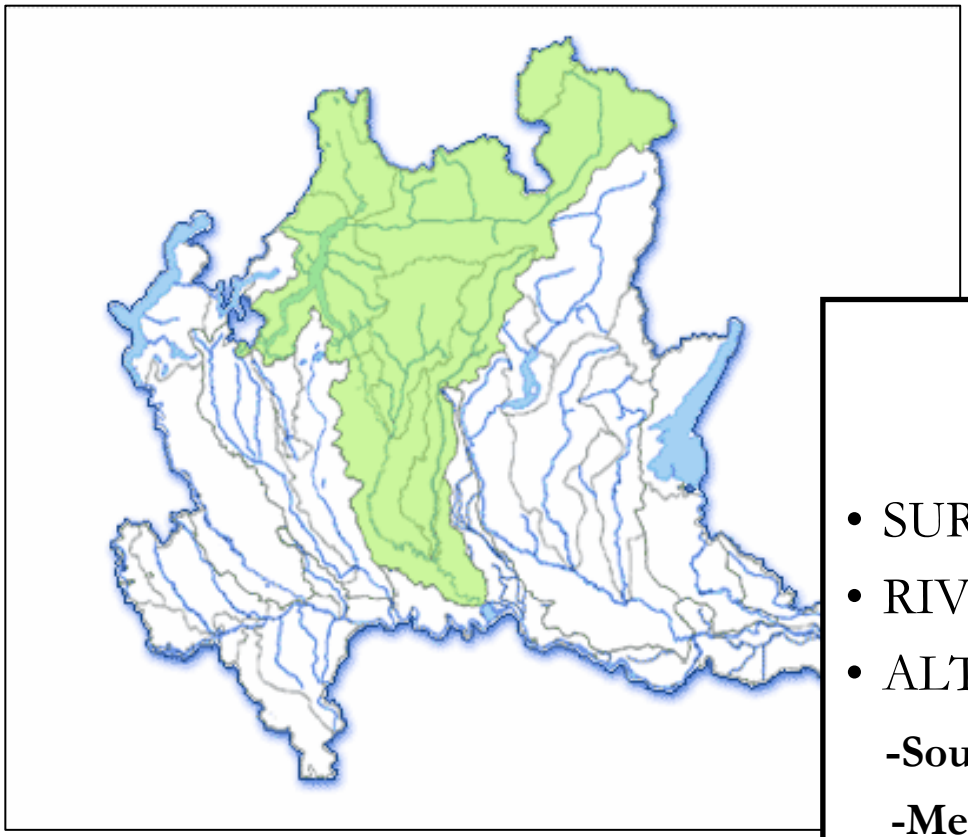
Quantitative cause-effect correlation



Study area



Physical characterization



Main characteristics

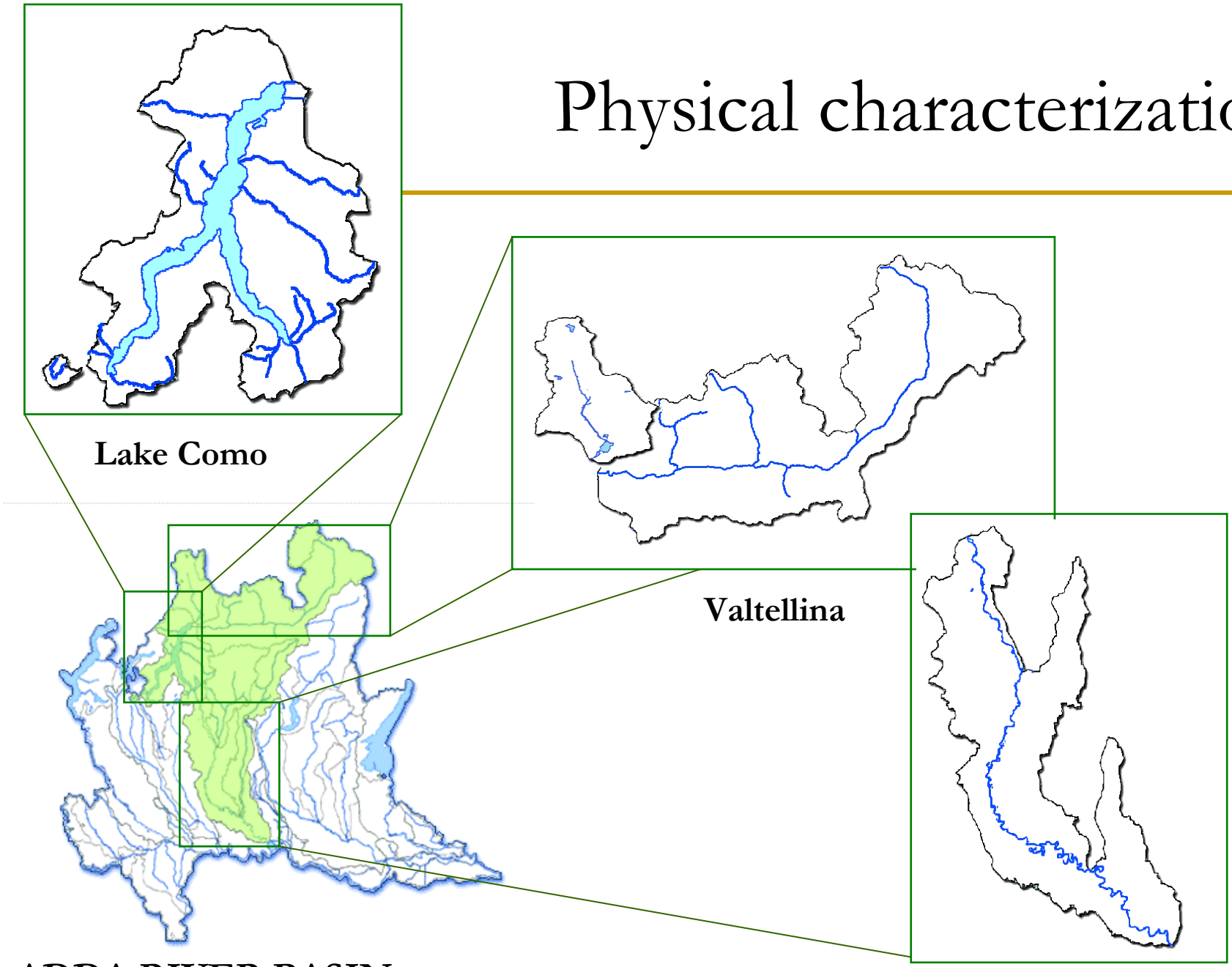
- SURFACE DRAINED: 7.979 km^2
- RIVER LENGHT: 313 km
- ALTITUDE RANGE:

-Sources of Adda: 2.237 m asl

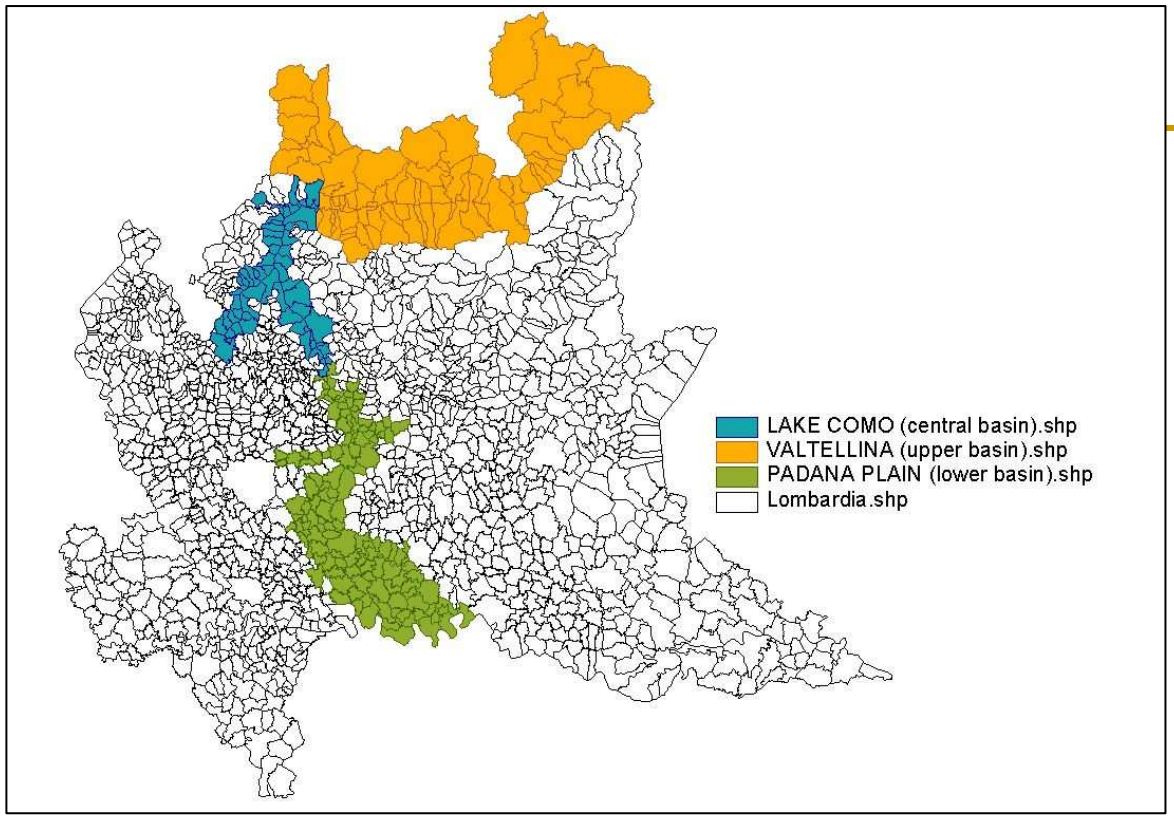
-Mean Lake Como elevation: 198 m asl

-Join with Po river: 36 m asl

Physical characterization



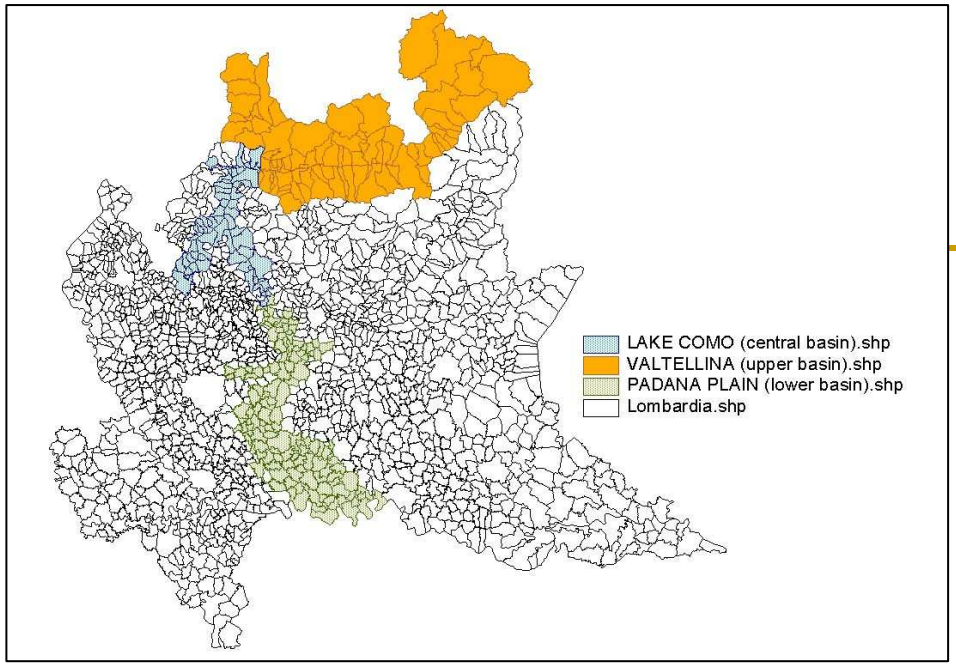
The socio-economic system

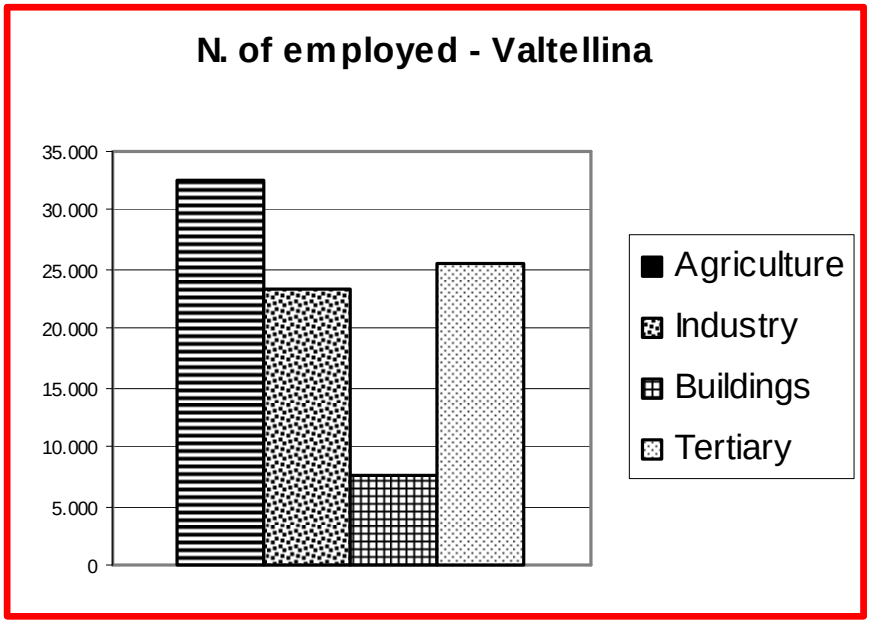


SUB-AREA	n. of PROVINCES	N. of MUNICIPALITIES	POPULATION	SURFACE (km^2)	DENSITY (inh/Km^2)
VALTELLINA	1	78	174.116	3.212	54
LAKE COMO	2	57	267.344	700	382
PADANA PLAIN	5	125	658.998	1.119	589

SOURCE: ISTAT, 2003.

Socio-economic analysis Valtellina

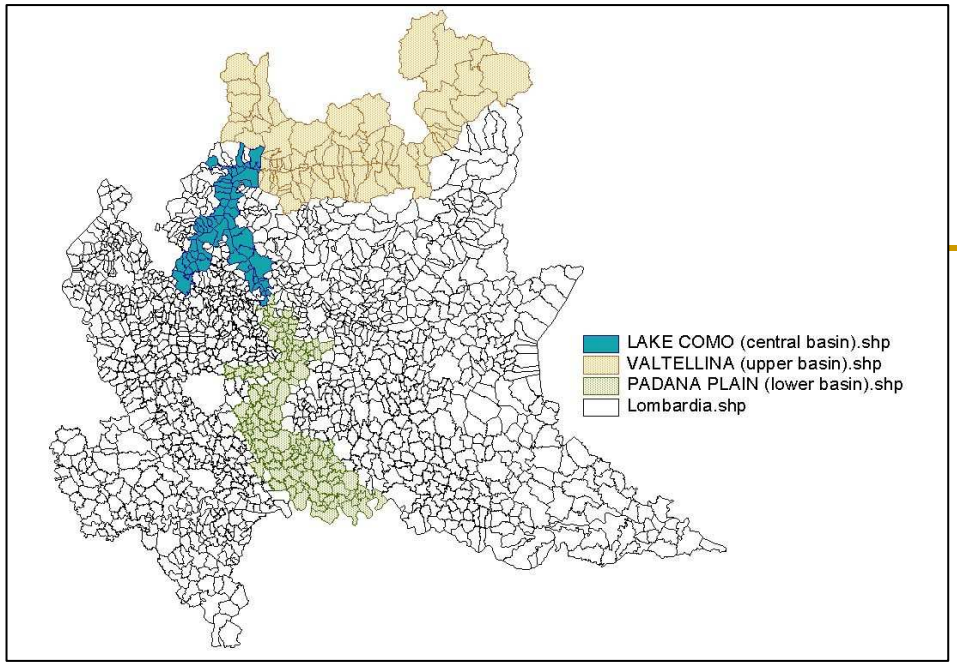


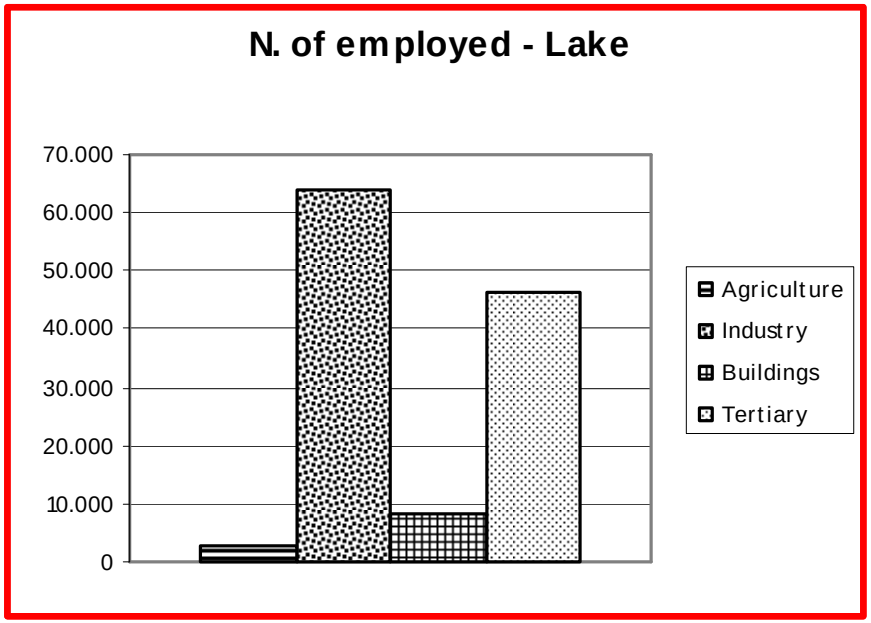


Source: ISTAT, 2003

- 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)

Socio-economic analysis
Lake Como

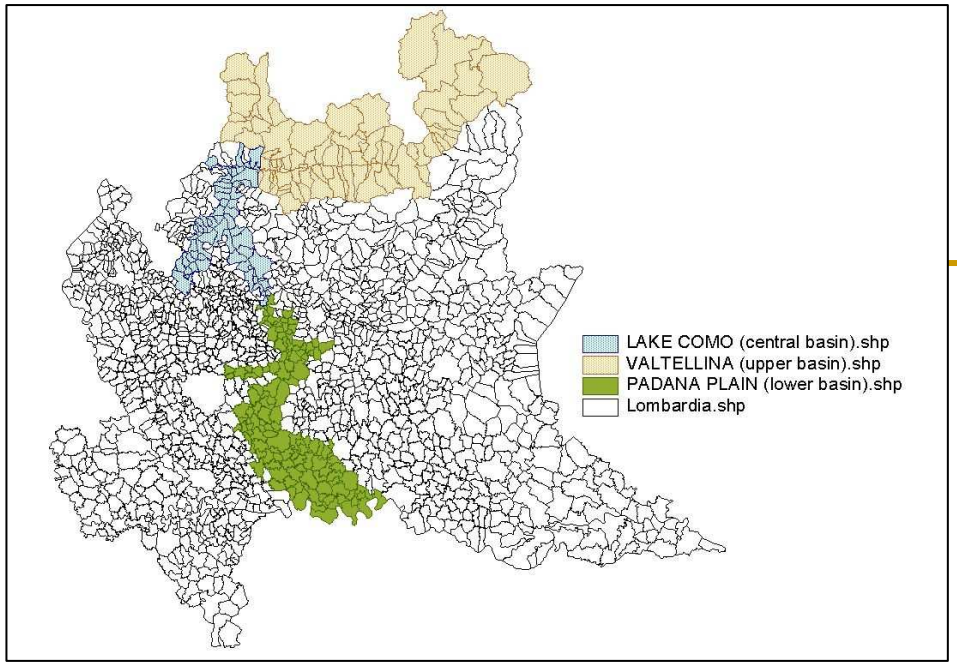




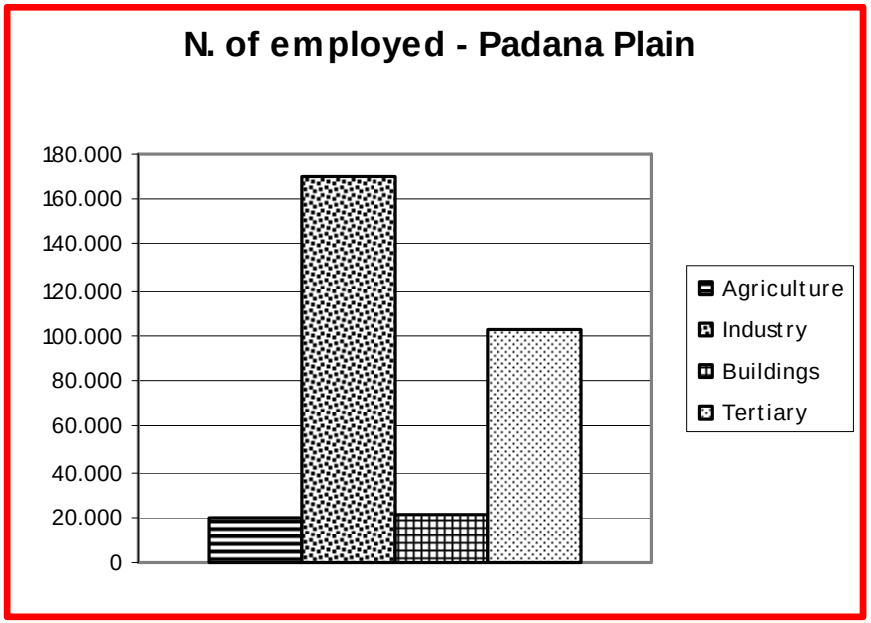
Source: ISTAT, 2003

- Communities settled along the lake;
- Higher population density (382 inh/Km^2);
- Different specialization on the three branches of the lake:
  - north: tourism;
  - east: metallurgical industry;
  - west: silk, textile industry.

Socio-economic analysis
Padana Plain



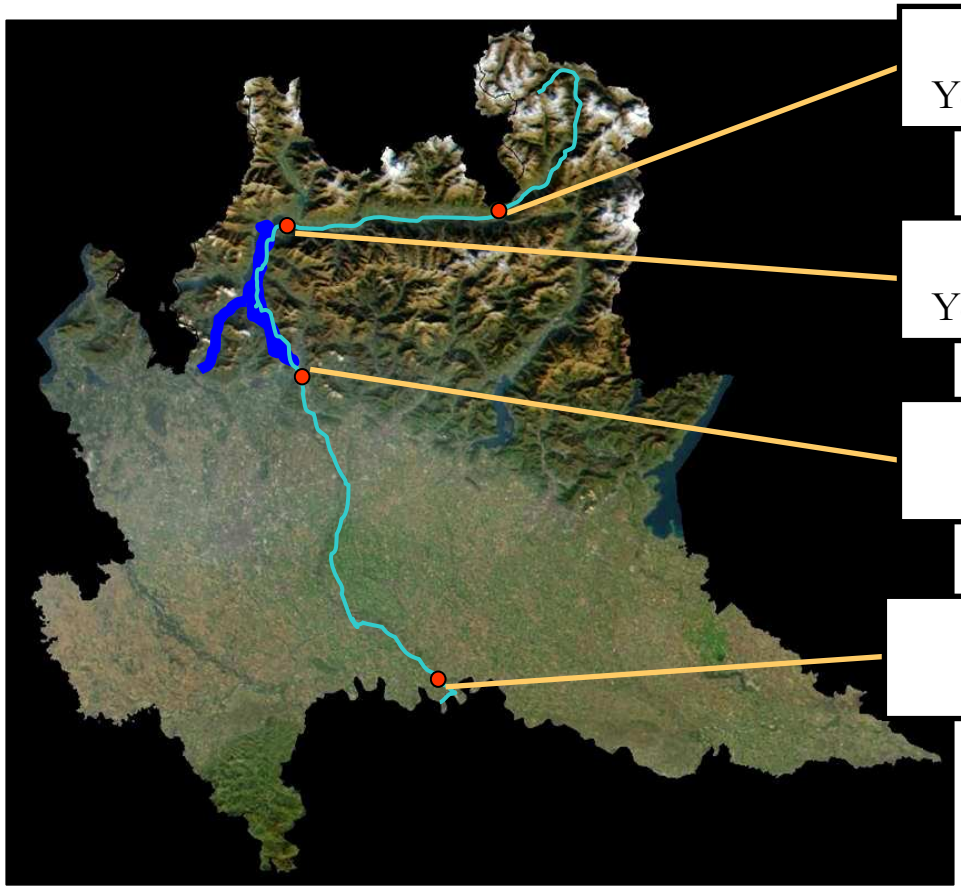
- Most important productive area of Italy;
- Great inflow of commuters;
- Intensive land exploitation;
- 81% UAA;
- 65% agriculture added value from cattle-breeding;



	surface (ha)	UAA (ha)	%
Valtellina	321.200	92.363	29
Lake Como	70.000	6.208	9
Padana Plain	111.900	90.317	81

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:

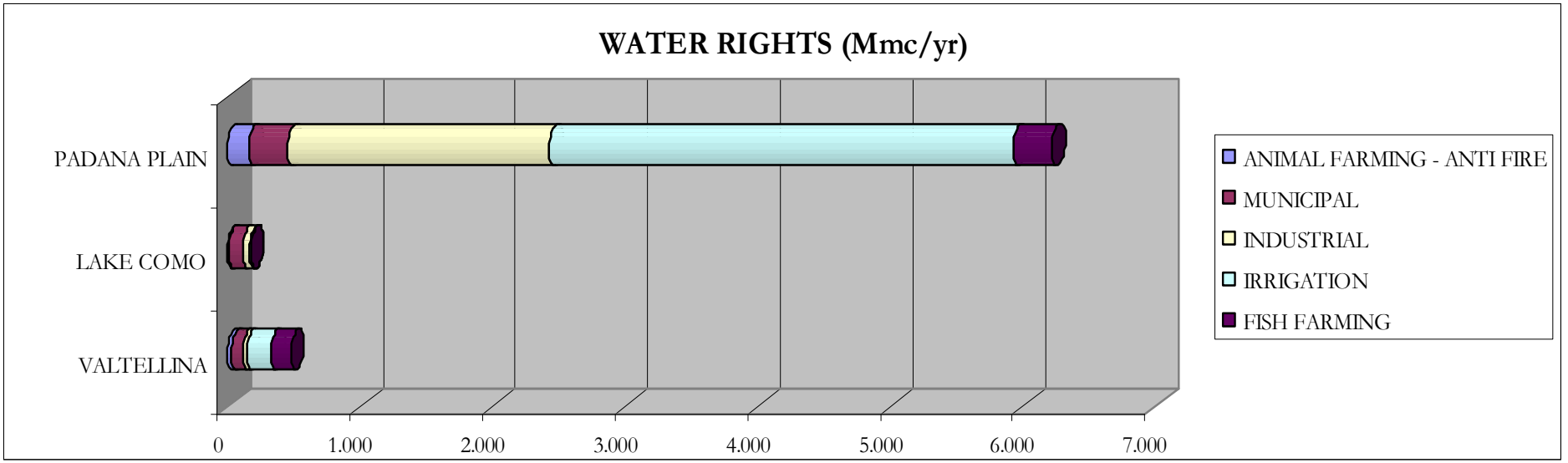
- 21 reservoirs (44 power stations): 515 Mm^3

It is an artificially regulated system (Olginate floodgate)

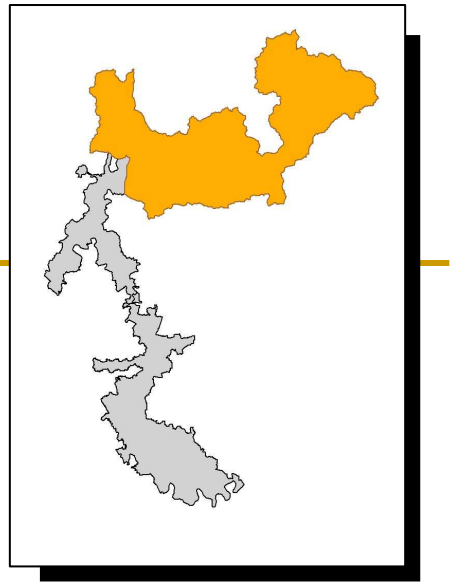
Demand side – water rights

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

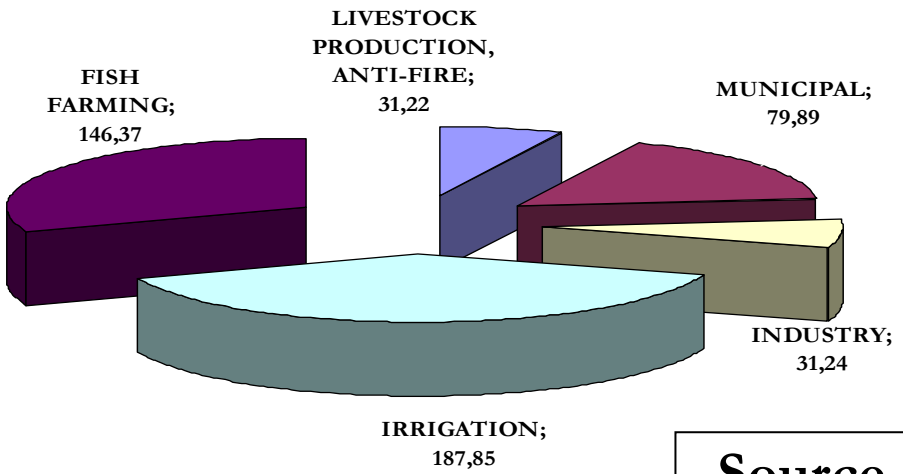
SOURCE: Lombardy Region, 2003.



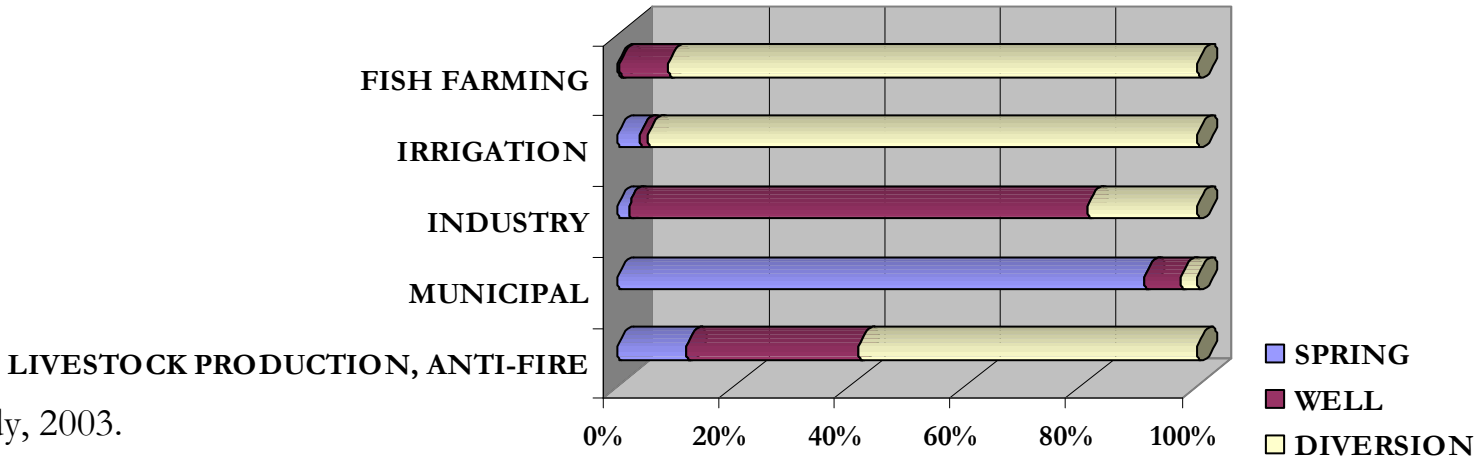
Demand side - Valtellina



Water consumption (Mm^3/yr water rights)

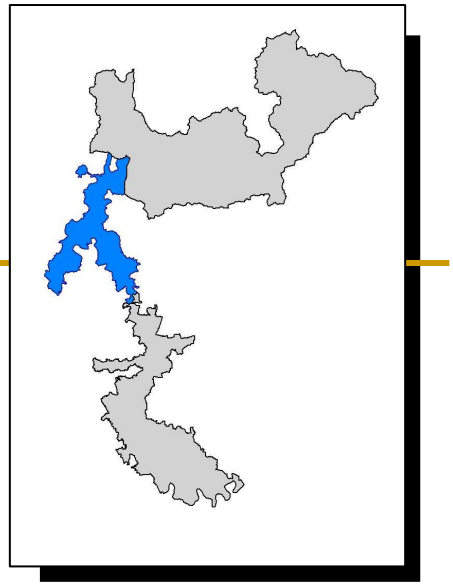


Source of water supply (% water rights)



SOURCE: CUI Lombardy, 2003.

Demand side - Lake Como



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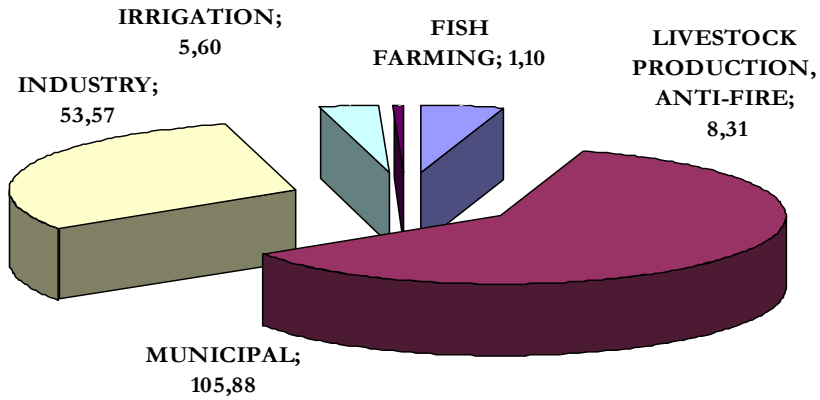

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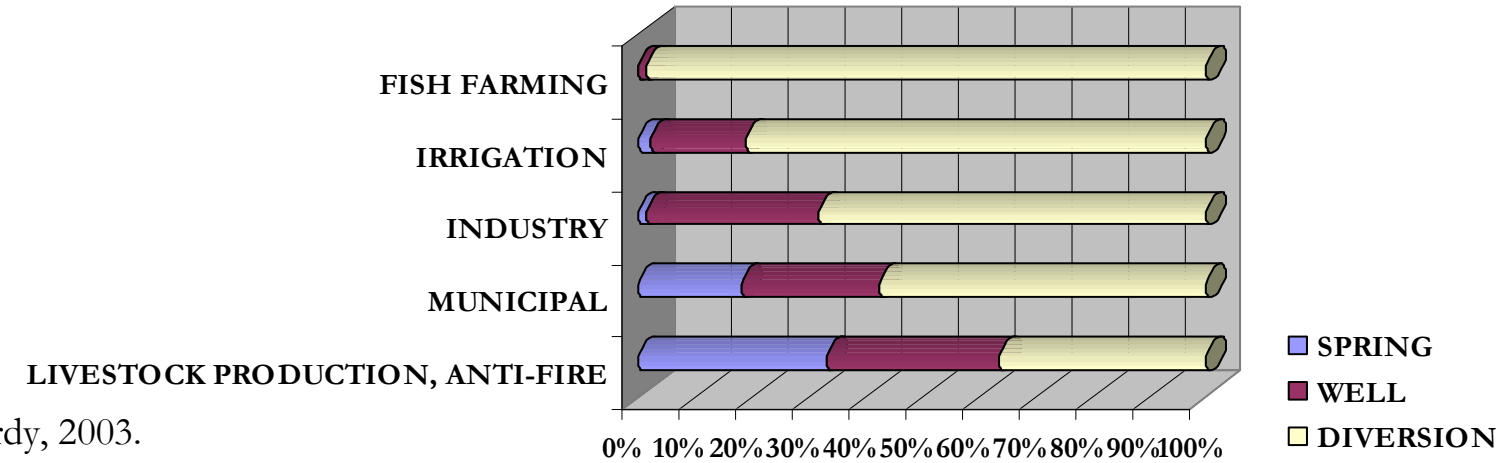
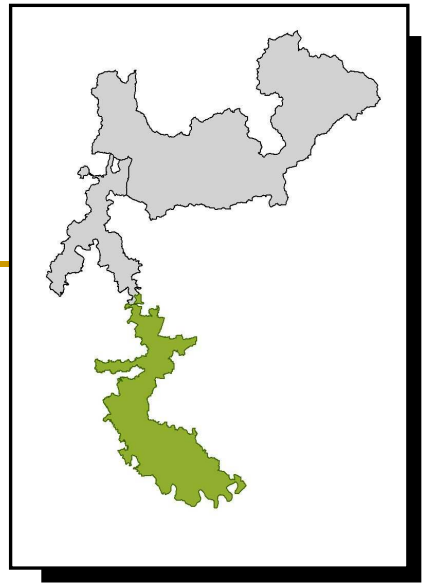


SOURCE: CUI Lombardy, 2003.

Demand side - Padana Plain



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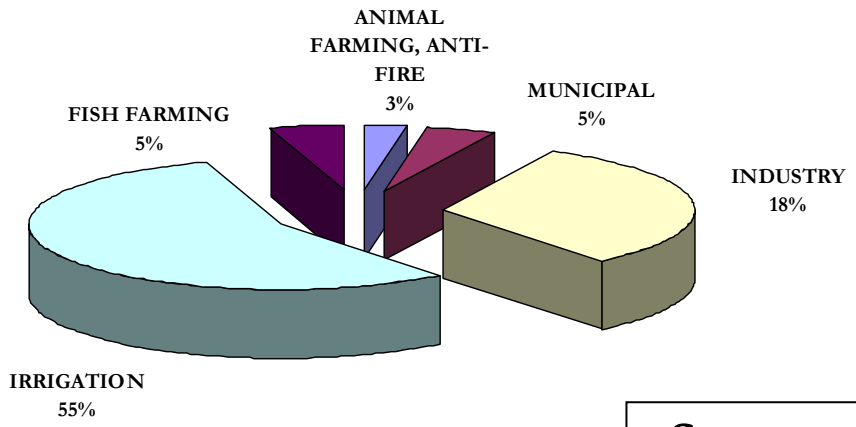

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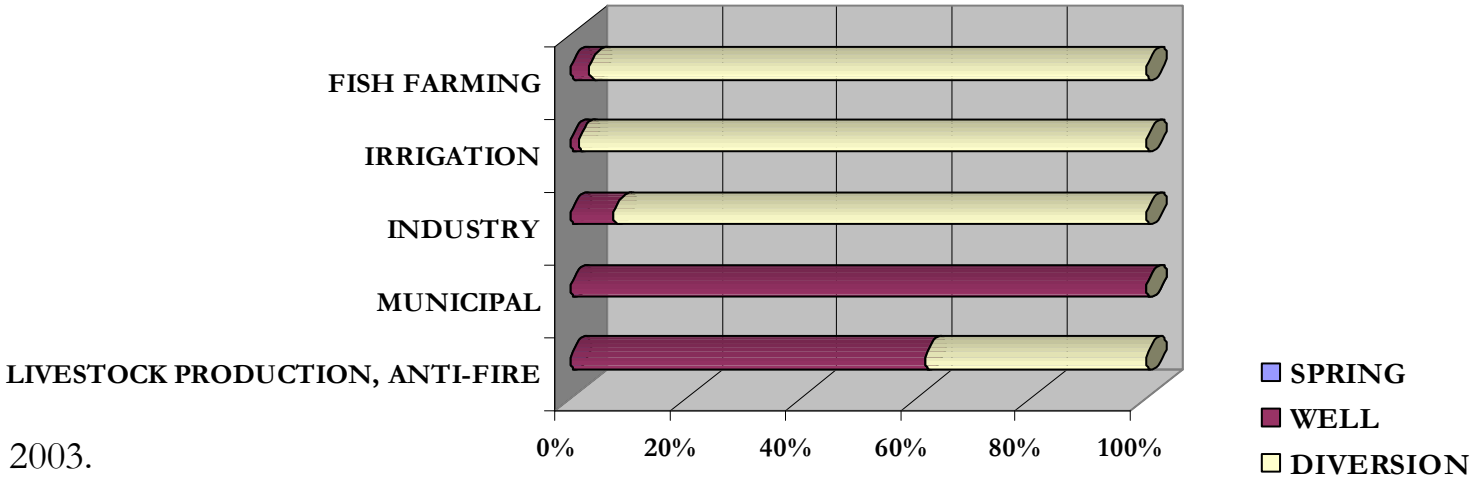
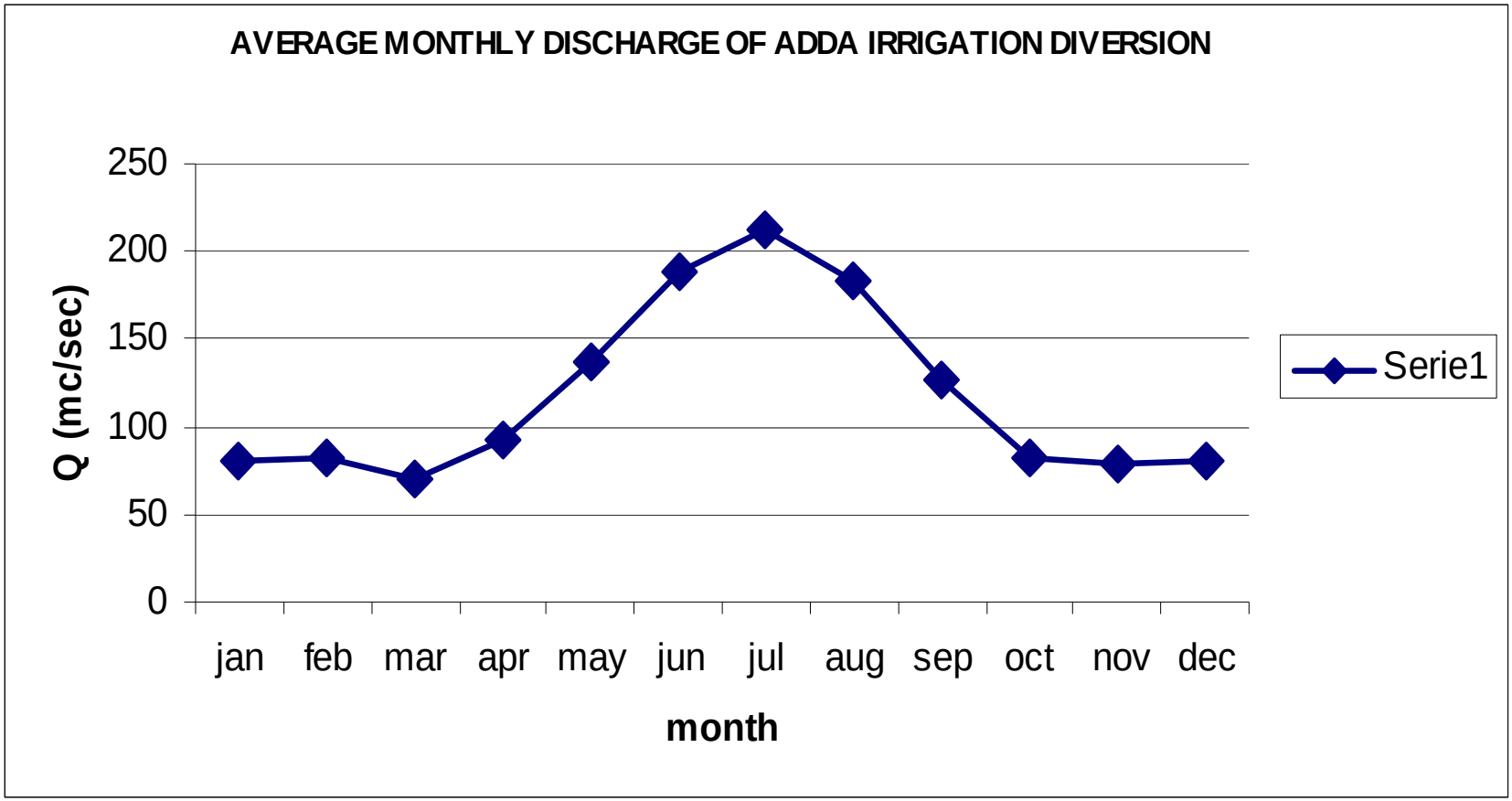
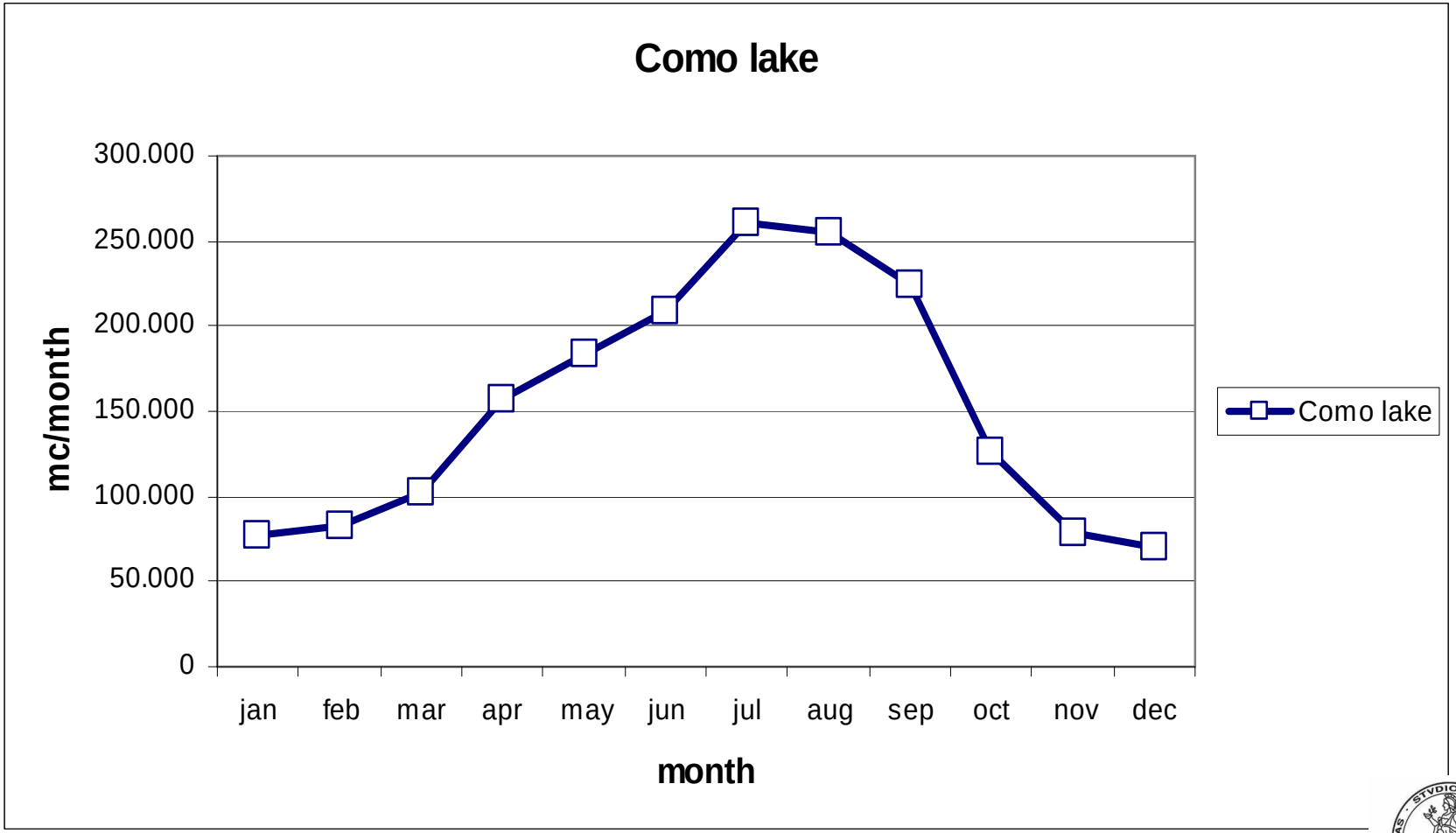


SOURCE: CUI Lombardy, 2003.

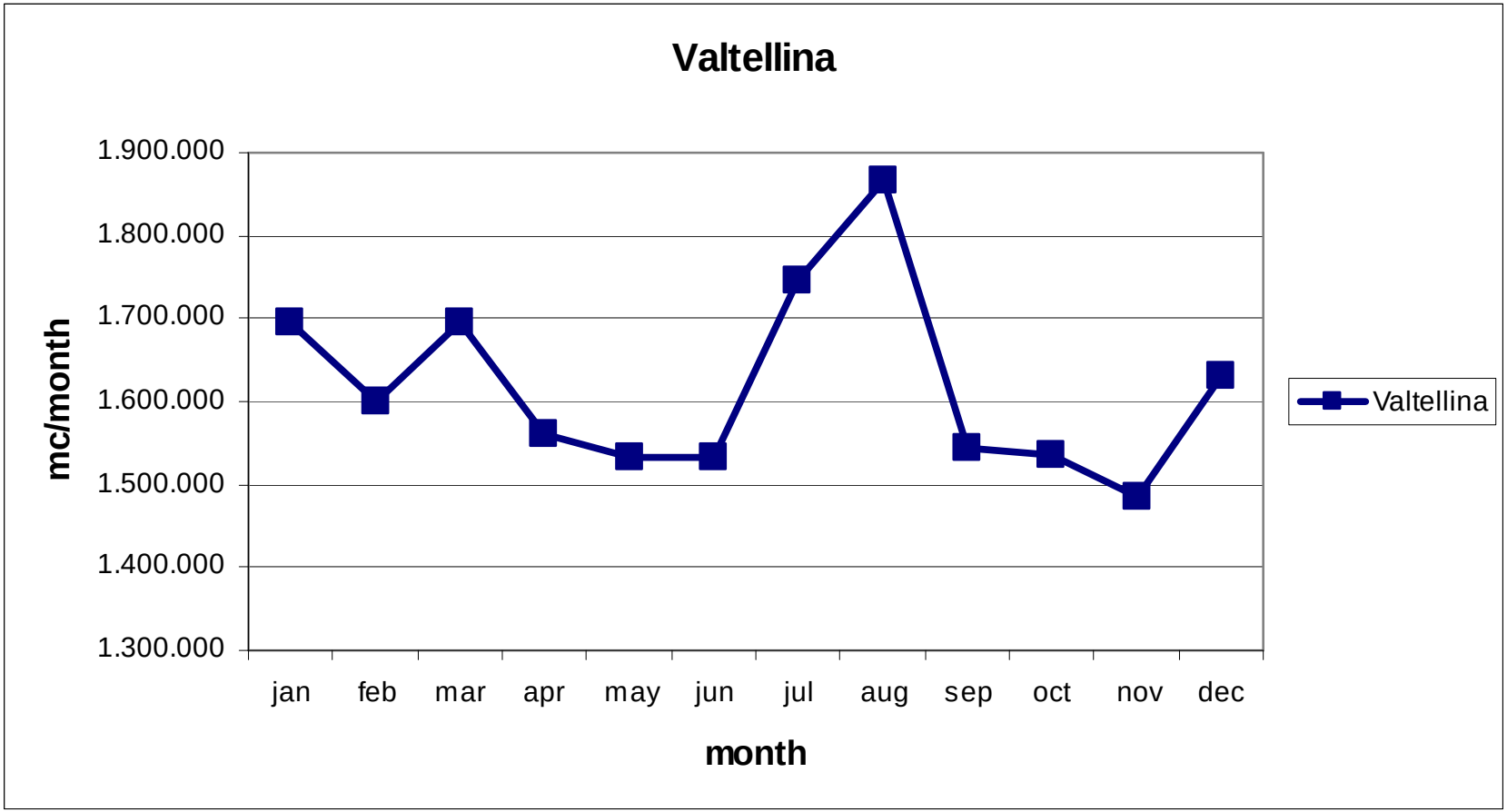
Demand side - agriculture



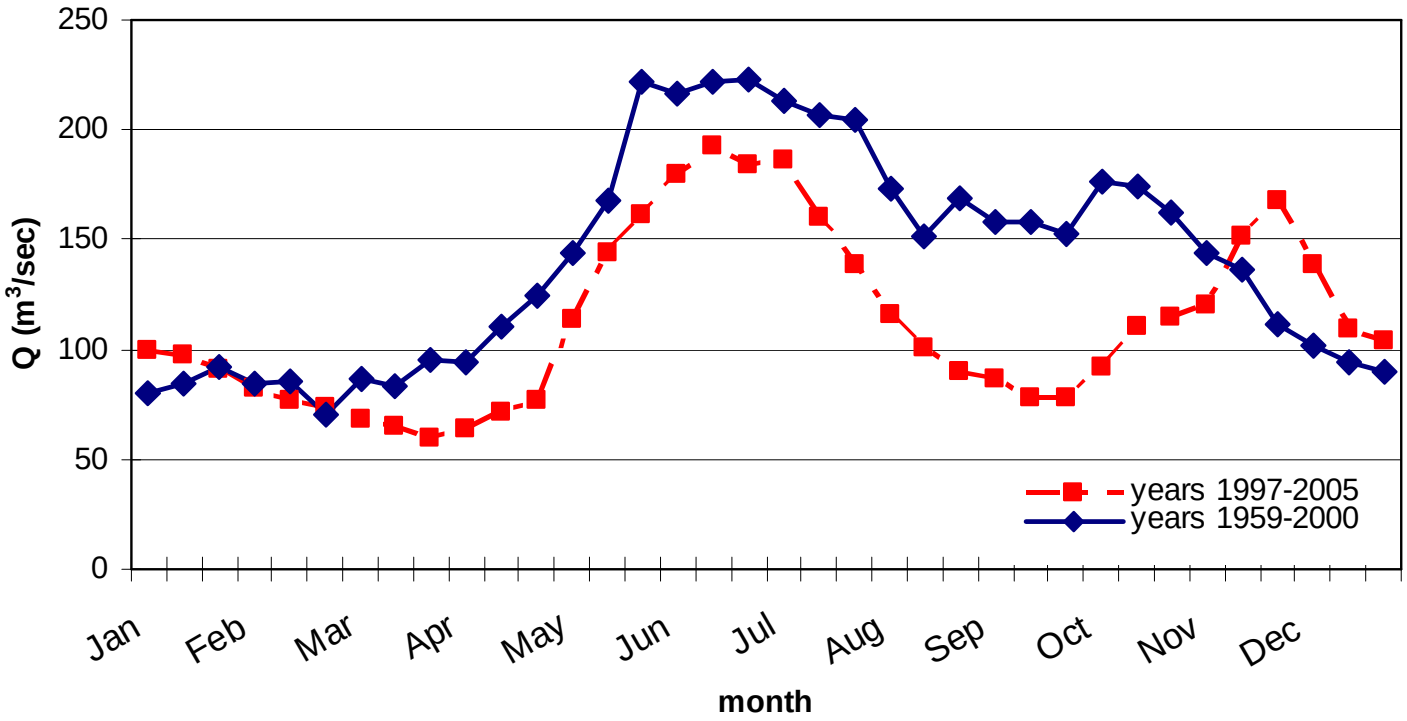
Demand side - tourism



Demand side - tourism



Regulation – Olginate floodgate



Supply side - regulation

Yearly average	Average discharge (m^3/sec)	Average volume (Mm^3)		**Summer average (May-Aug)**	Average discharge (m^3/sec)	Average volume (Mm^3)	
Years '59 - '00	140,65	4.435,42			176,13	2.328,34	
Years '96 -'05	112,40	3.544,23			132,10	1.746,28	
Water deficit	**-28,25**	**-891,19**	**-20,09%**		**-44,03**	**-582,06**	**-25,00%**

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

BETWEEN PHYSICAL CAU AND ECONOMIC EFFECTS

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

Take home message

Cause ⟺ Effect

quantitative correlation

Water demand ⟺ Water supply

scarcity

Technical sciences ⟺ Economics

exchange of knowledge

marta.brambilla1@unimi.it
rossetti.andrea@unimib.it
paolo.giacomelli@unimi.it

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