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Drought and water scarcity risk in the Mediterranean

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Background

The Department of Civil and Environmental Engineering of University of Catania has been involved in several European projects about drought and water scarcity in Mediterranean

Research Oriented Projects

INCO-DC:	DSS-Drought (1997-2001)
INCO-MED:	WAMME (2000-2003)
MEDA WATER:	MEDROPLAN (2003-2007)

INTERREG Projects

INTERREG IIc (1998-2000): Territorial planning and coping with drought

INTERREG IIIB MEDOCC (2001-06): SEDEMED I and II

INTERREG IIIB ARCHIMED (2006-09): PRODIM

The activities carried out have established a network of universities, research centers and public institutions coping with drought risk in Mediterranean countries: Cyprus, Greece, Italy, Portugal, Spain, Egypt, Morocco, Tunisia. Jordan, Israel, Syria

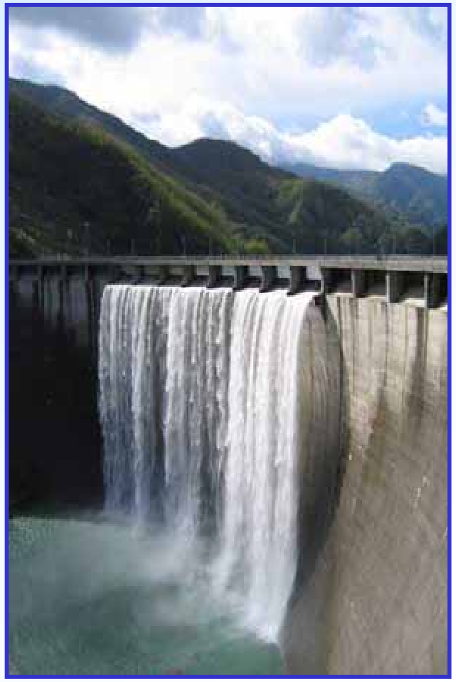
Basic concepts

Phenomenon	Permanent	Temporary
Natural	ARIDITY →	DROUGHT ↓
Anthropic	WATER SCARCITY (structural)	← WATER SHORTAGE (random)

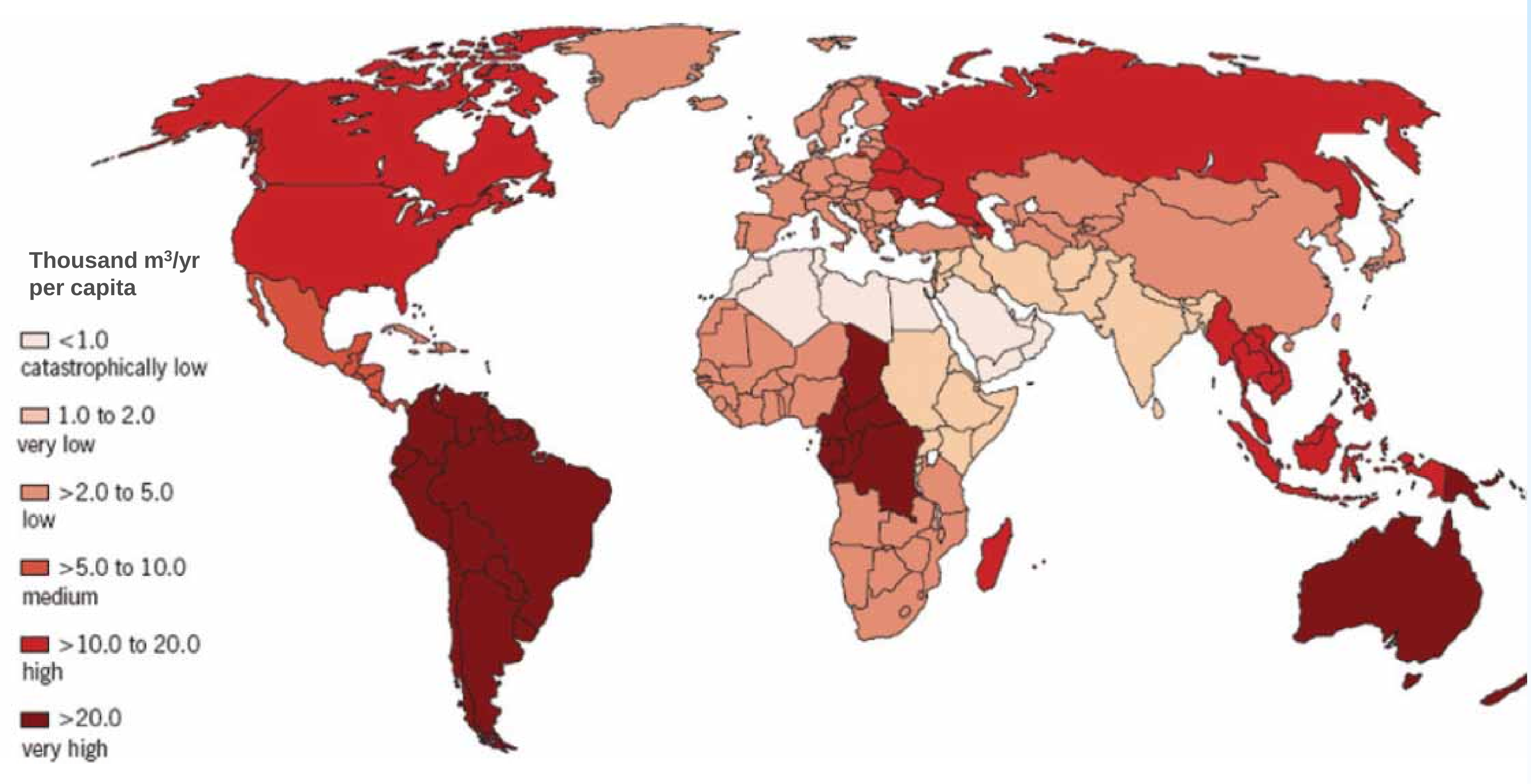
Differences among Mediterranean countries with respect to climate and water resources

- South Mediterranean countries (North Africa and Near East):
  - Arid or semi-arid climate
  - Permanent water scarcity problems (reduced available resources, high water withdrawal mainly for irrigation)
  - Focus on water supply development (new hydraulic infrastructures) with limited but increasing environmental concerns
  - Changes in water policies and water cost allocation under way

- North Mediterranean (European) countries:
  - Semi-arid or wet climate
  - Good availability of water resources
  - Major attention toward increasing efficiency of existing infrastructures, as well as to improve quality of water bodies and satisfy ecological requirements
  - More advanced institutional and legal frameworks on water issues



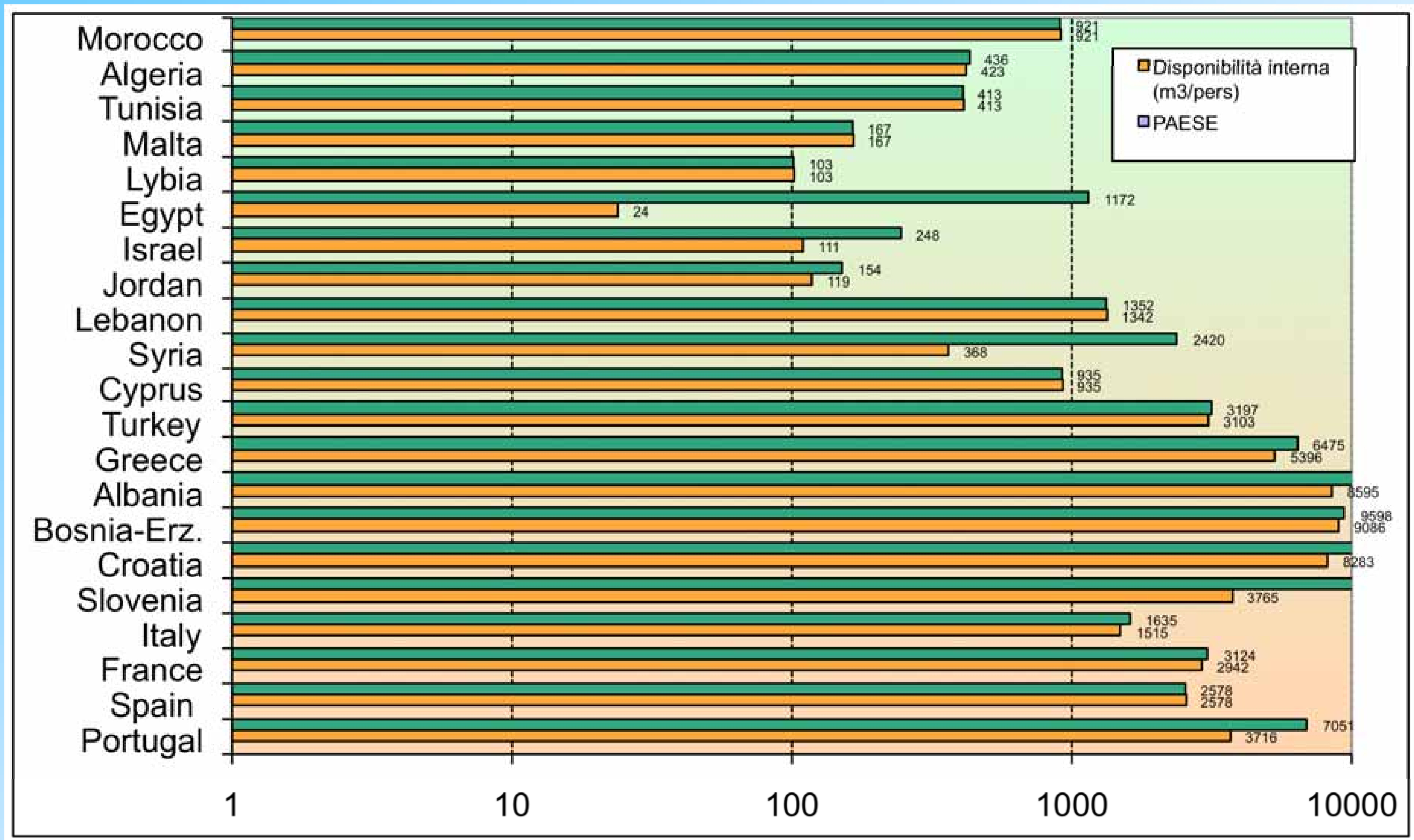
Water availability



Commonly, 2000 m3/person/year is the threshold for water stress, 1000 for water scarcity
Many countries experience less than 500 m3/person year of available water

(UNEP, 2002)

Per capita available water resources in Mediterranean countries



(UNStat, 2007)

Increasing risk of water scarcity in Mediterranean countries

- Risk of water scarcity on the two shores of the Mediterranean is expected to increase due to:
  - Decrease in available resources (climate change, degradation of water quality, exploitation of non-renawable resources)
  - Increase of water demands (population growth, better standard of living, tourism)

- However appropriate measures for conservation and saving water, improved system's operation, transboundaries agreements, demand management and use of unconventional resources could mitigate water scarcity.

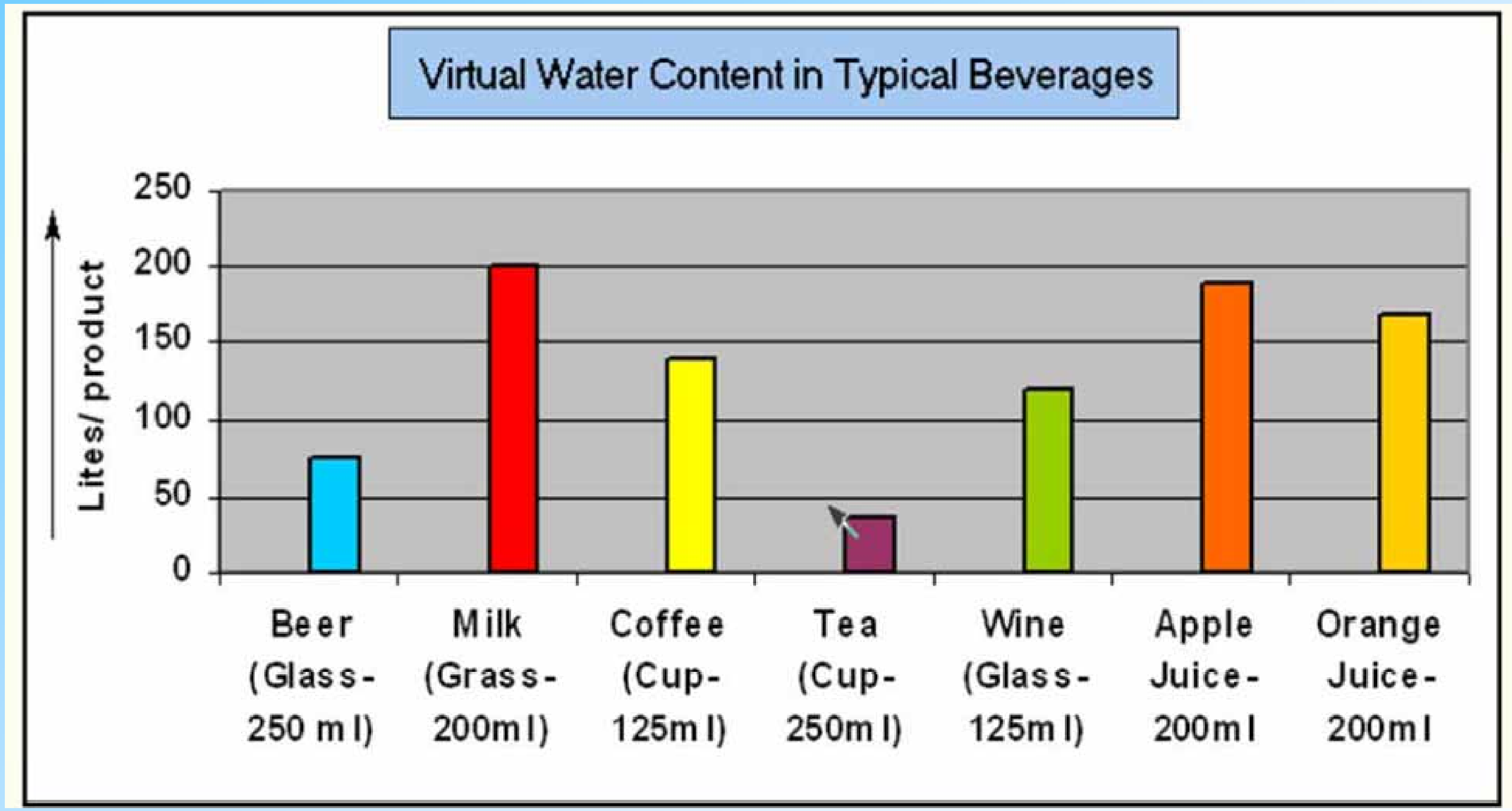
Strategic proposals to fight water scarcity

High technology

- Desalination (municipal supply)
  - Increased costs
  - Difficult to apply for most developing countries
- Wastewater reuse (irrigation supply)
  - Hygenic constraints and allocation of extra costs
- Increased efficiency in irrigation
- Water saving
- Water harvesting
- Deficit irrigation
- Virtual water trade
  - Many virtual water importers among water rich countries
  - Many countries tend to guarantee food self sufficiency

Low technology

Virtual water content in beverages



Numbers are indicative and should be adjusted to local conditions

(from Schreier, 2006)

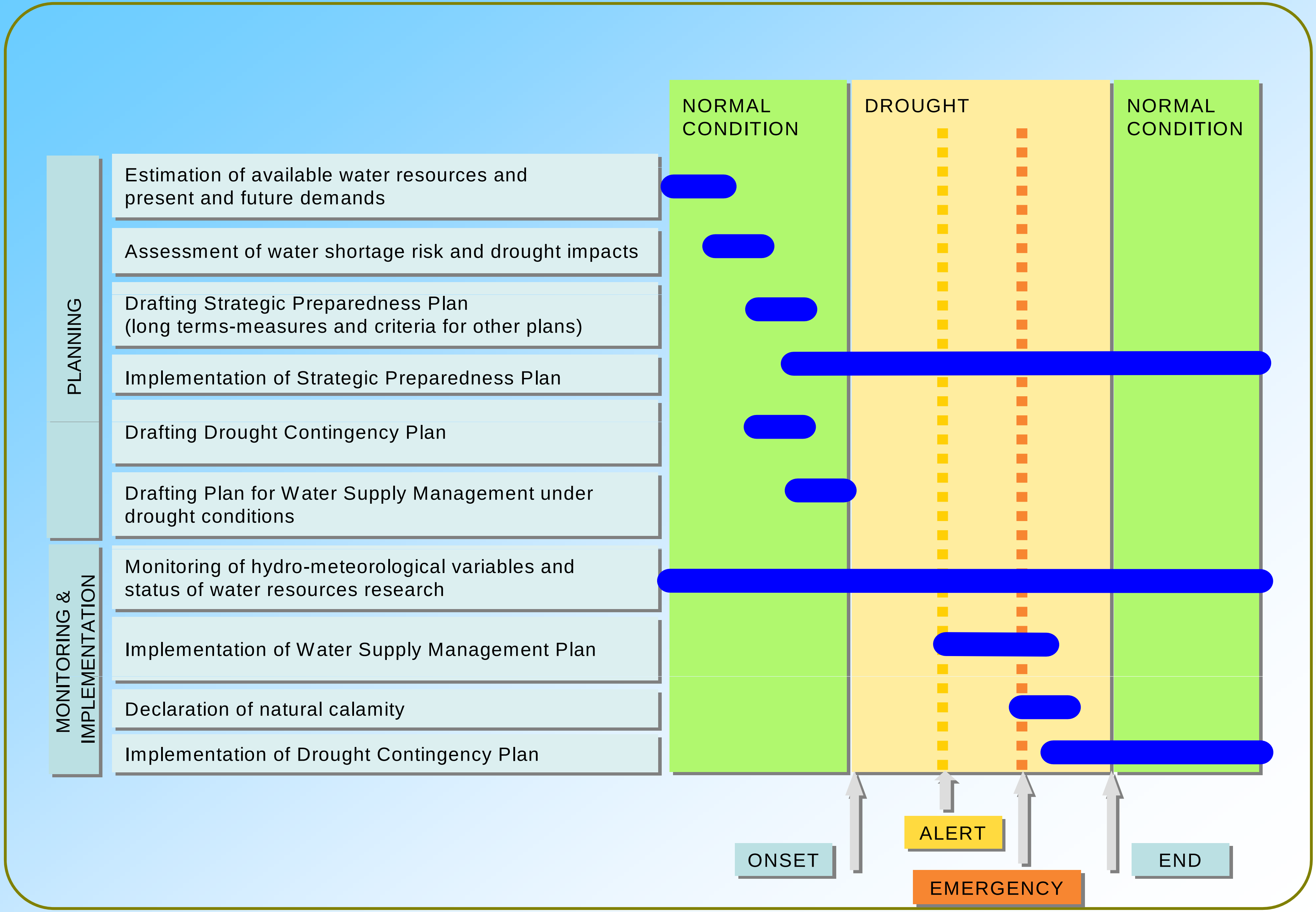
Coping with drought and water shortage risk

- Drought consists in a ***temporary*** but ***significant*** reduction of precipitation and related hydrologic variables amount for a ***long*** duration and ***large*** spatial extension
- A severe drought is a natural disaster, but its impacts on society depend on **vulnerability** of affected sectors and **preparedness** to implement mitigation measures
- The risk of water shortage in water supply systems depends on drought severity, but also on infrastructures features and operation rules under drought conditions.
- Such risk can be effectively reduced by planning in advance appropriate strategies oriented to improve preparedness and to mitigate drought impacts

Drought vulnerability of Mediterranean countries

- Despite the differences in climate, available water resources and institutions, all Mediterranean countries are highly vulnerable to drought.
- Drought occurrence and severity have been increasing during the last decades
- Drought risk is expected to grow in the future due to:
  - climate changes
  - increasing water demands (e.g. tourism in coastal areas)
  - irrigated agriculture (food self sufficiency for the South, social stability for the North)
- Reactive approach (crisis management) is current response to drought
- The exchange of "best practices" is too limited

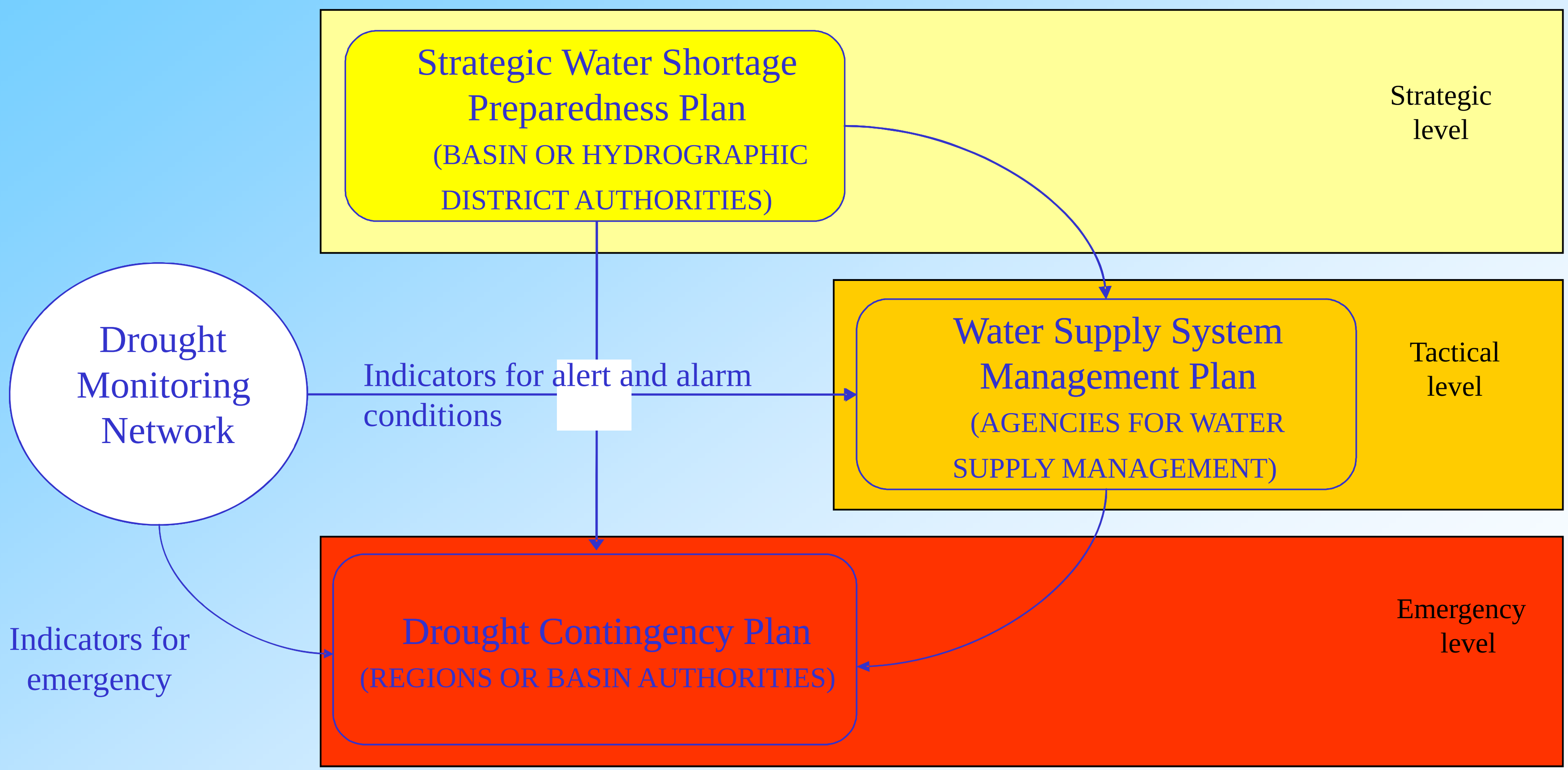
Sequential steps for a proactive approach to drought management



Managing droughts in Europe

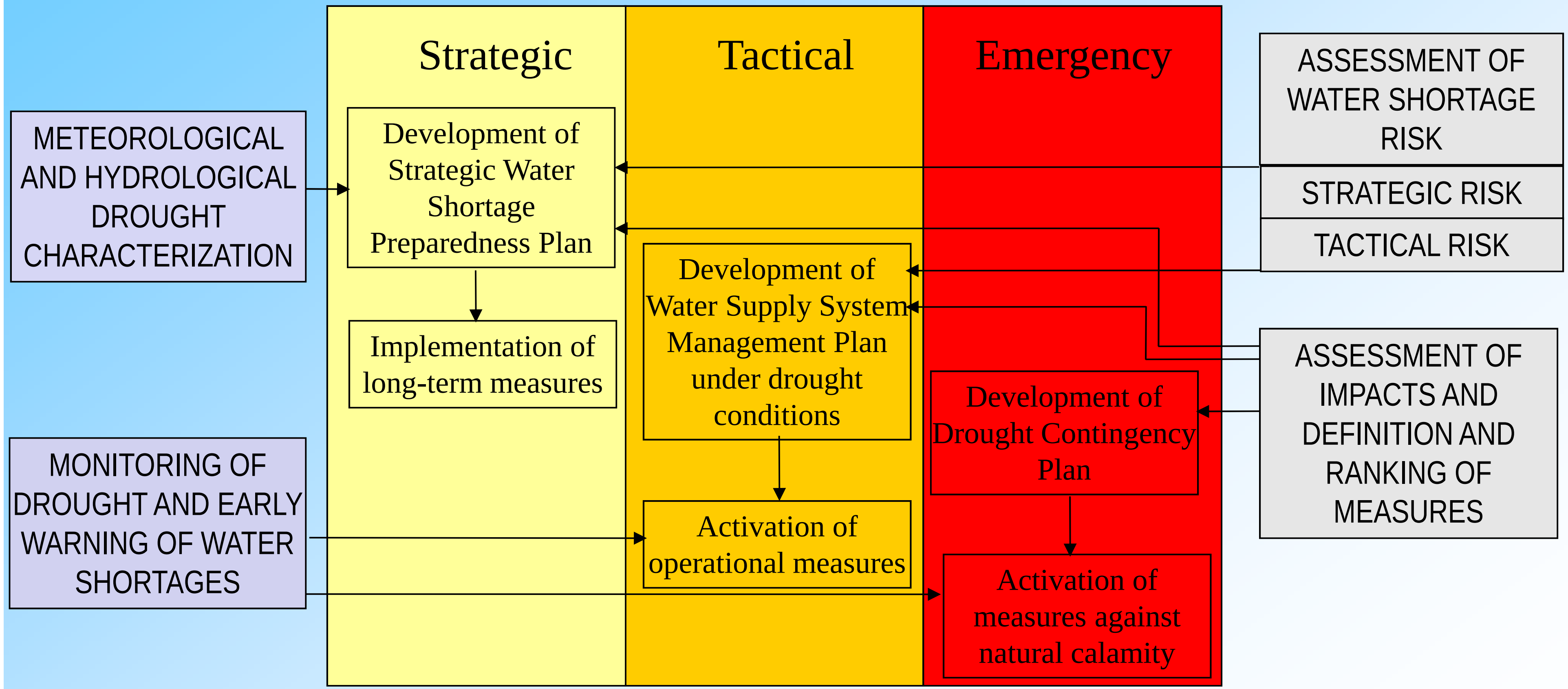
- Droughts are not adequately addressed in European legislation
- Efforts to foster a proactive approach to drought management in European policy
- Nonetheless, the need arises to adapt the proposals to the specific situation in each country depending on the peculiar institutional and legislative framework for managing water resources

Proposed planning framework for coping with drought and water shortage risk

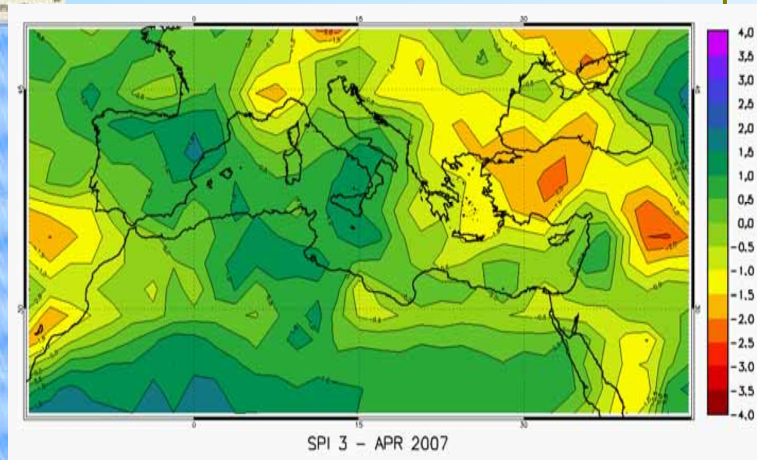


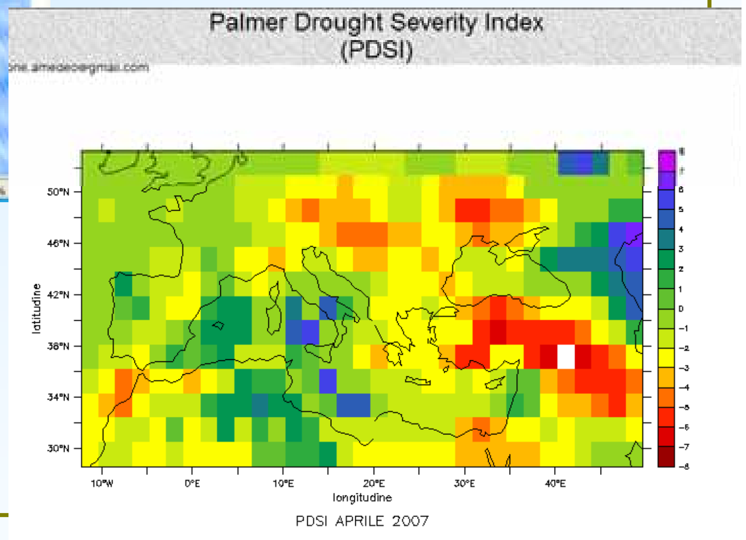
(from Rossi et al. (2008))

Planning framework for drought risk management



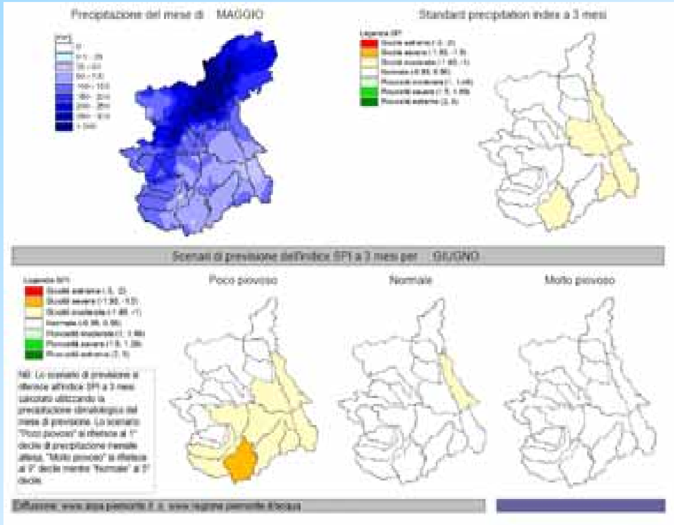
Examples of drought bullettin monitoring systems



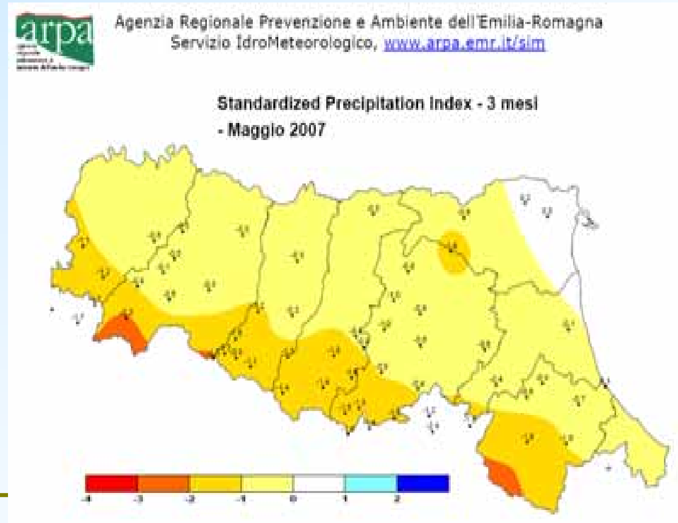


Examples of Regional Drought Monitoring Systems

ARPA Piemonte (www.arpa.piemonte.it)

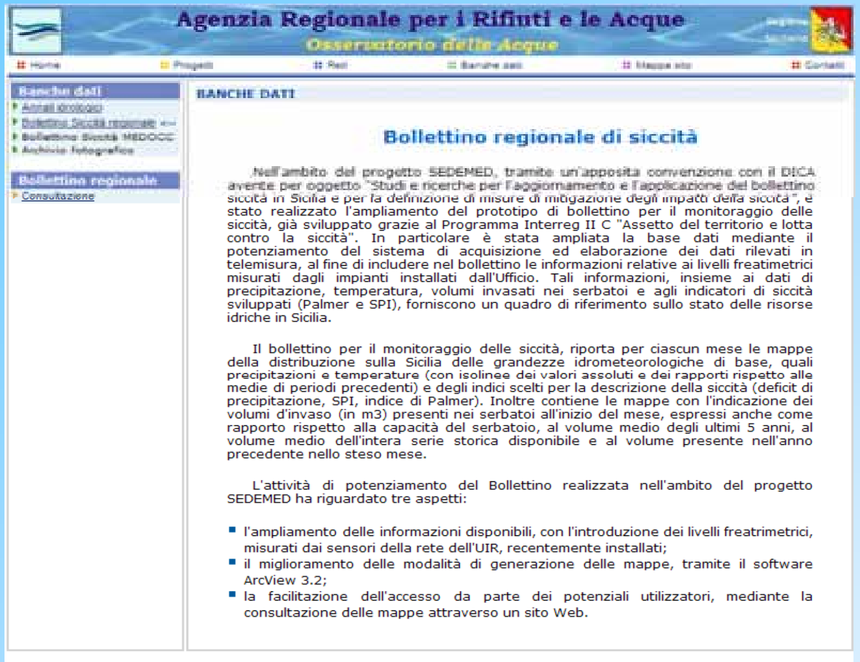


ARPA Emilia Romagna (www.arpa.emr.it/ia_siccita)



Examples of Regional Drought Monitoring Systems

Osservatorio delle Acque Sicily



Agenzia Regionale per i Rifiuti e le Acque

Osservatorio delle Acque

Home | Progetti | Reti | Banche dati | Mappe sito | Contatti

Banche dati

- Annali idrologici
- Bollettino Siccità regionale
- Bollettino Siccità MEDOCC
- Archivio fotografico

Bollettino regionale

- Consultazione

BANCHE DATI

Bollettino regionale di siccità

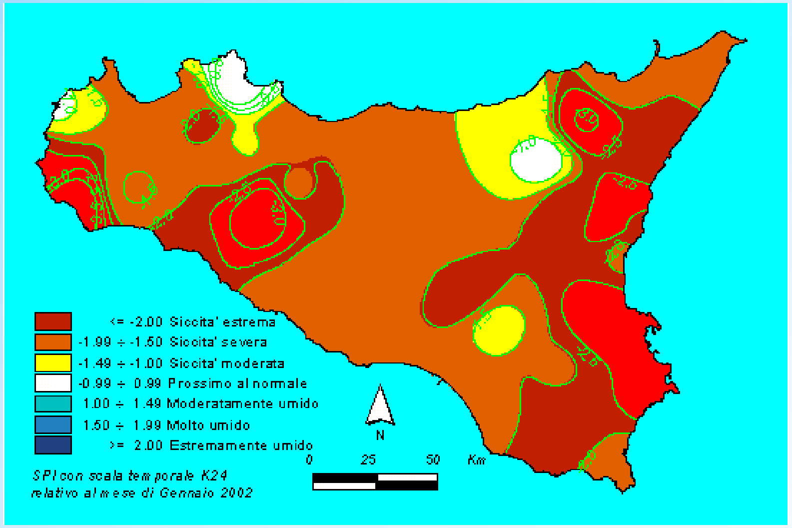
Nell'ambito del progetto SEDEMED, tramite un'apposita convenzione con il DICA avente per oggetto "Studi e ricerche per l'aggiornamento e l'applicazione del bollettino siccità in Sicilia e per la definizione di misure di mitigazione degli impatti della siccità", è stato realizzato l'ampliamento del prototipo di bollettino per il monitoraggio delle siccità, già sviluppato grazie al Programma Interreg II C "Assetto del territorio e lotta contro la siccità". In particolare è stata ampliata la base dati mediante il potenziamento del sistema di acquisizione ed elaborazione dei dati rilevati in telemisura, al fine di includere nel bollettino le informazioni relative ai livelli freatimetrici misurati dagli impianti installati dall'Ufficio. Tali informazioni, insieme ai dati di precipitazione, temperatura, volumi invasati nei serbatoi e agli indicatori di siccità sviluppati (Palmer e SPI), forniscono un quadro di riferimento sullo stato delle risorse idriche in Sicilia.

Il bollettino per il monitoraggio delle siccità, riporta per ciascun mese le mappe della distribuzione sulla Sicilia delle grandezze idrometeorologiche di base, quali precipitazioni e temperature (con isolinee dei valori assoluti e dei rapporti rispetto alle medie di periodi precedenti) e degli indici scelti per la descrizione della siccità (deficit di precipitazione, SPI, indice di Palmer). Inoltre contiene le mappe con l'indicazione dei volumi d'invaso (in m3) presenti nei serbatoi all'inizio del mese, espressi anche come rapporto rispetto alla capacità del serbatoio, al volume medio degli ultimi 5 anni, al volume medio dell'intera serie storica disponibile e al volume presente nell'anno precedente nello steso mese.

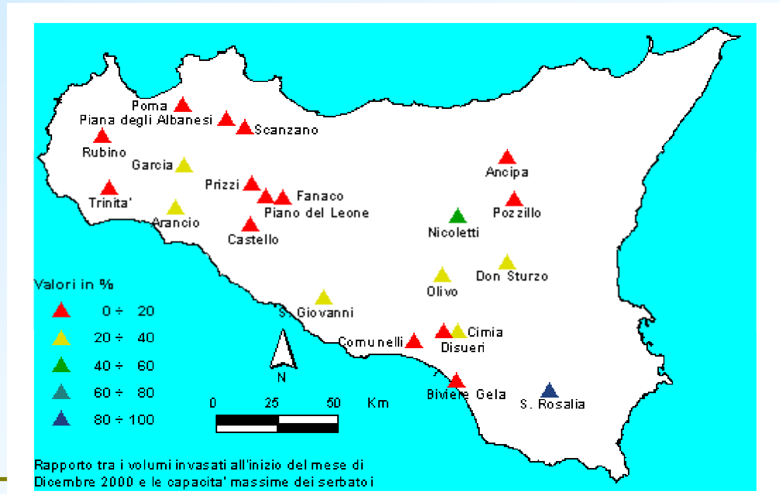
L'attività di potenziamento del Bollettino realizzata nell'ambito del progetto SEDEMED ha riguardato tre aspetti:

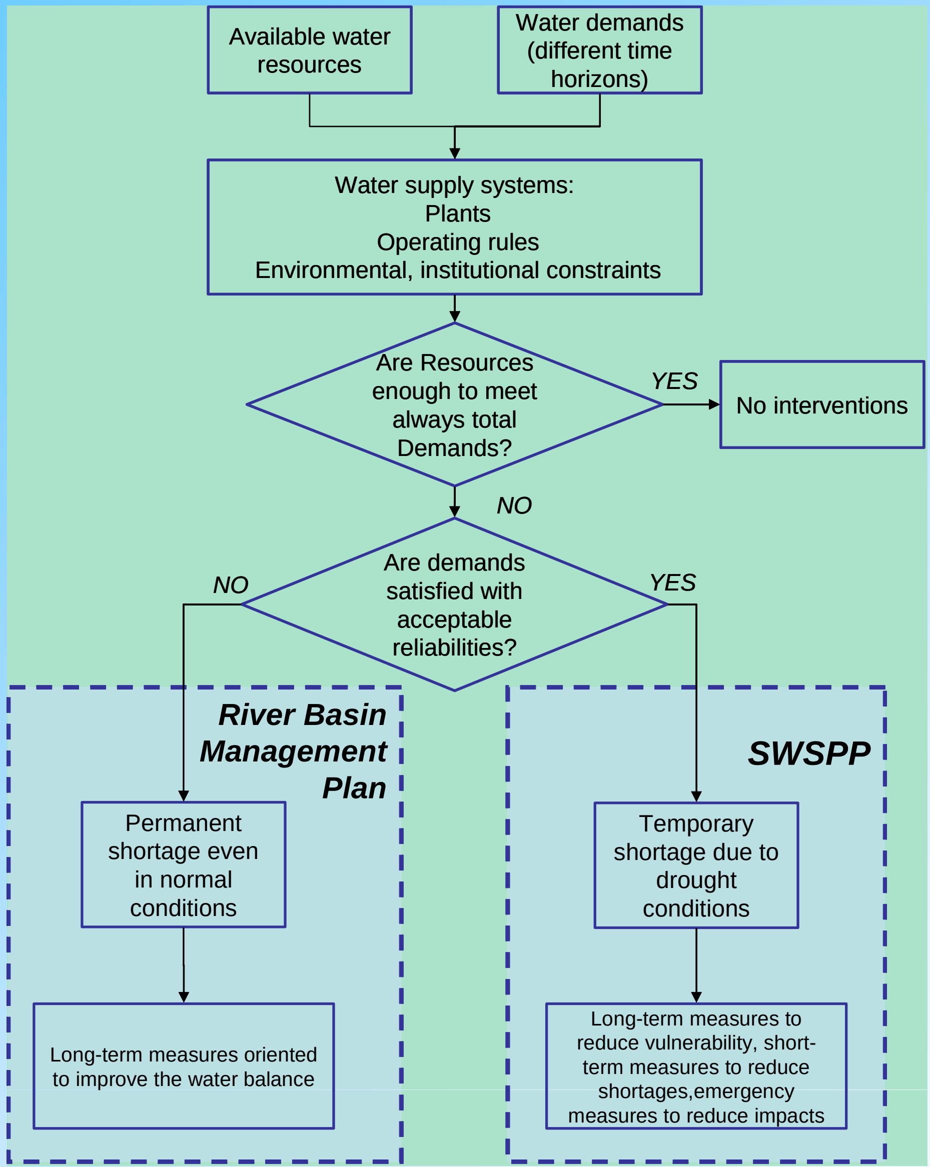
- l'ampliamento delle informazioni disponibili, con l'introduzione dei livelli freatrimetrici, misurati dai sensori della rete dell'UIR, recentemente installati;
- il miglioramento delle modalità di generazione delle mappe, tramite il software ArcView 3.2;
- la facilitazione dell'accesso da parte dei potenziali utilizzatori, mediante la consultazione delle mappe attraverso un sito Web.

SPI at k=24 months



Stored volumes in reservoirs





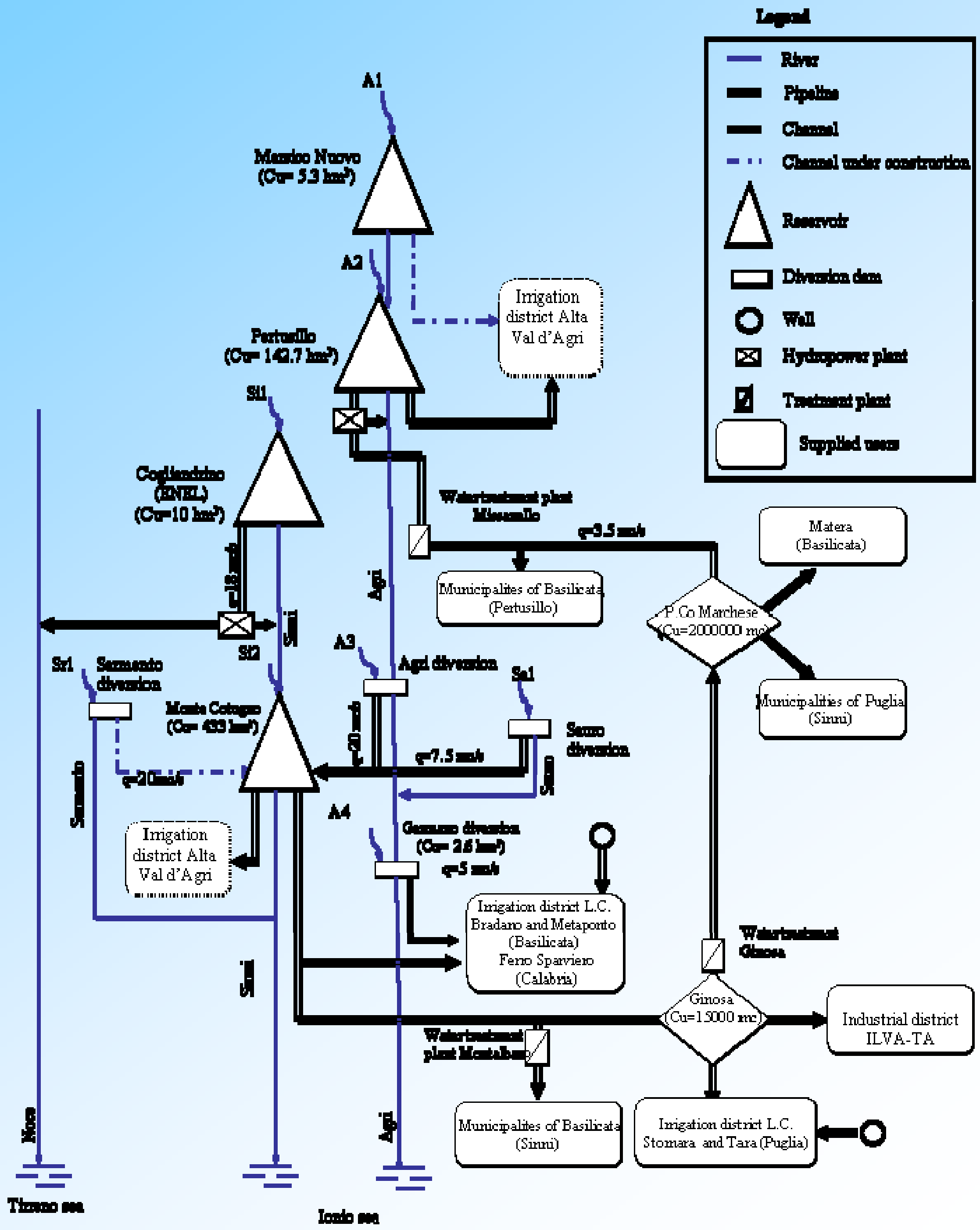
Analysis of permanent and temporary water shortages in the region to identify drought vulnerable areas

Rossi et al. (2008)

Risk of shortages due to drought in complex water supply systems: Application to an Italian case study

Calabria

Agri-Sinni water supply system



Analyses carried out for the Agri-Sinni water supply system (1/2)

Five sets of simulations have been carried out for the entire system:

SIMULATION 0

<u>Current configuration</u> of the system considering the demands fixed by the Coordination Committee for 2007 and a progressive satisfaction of demands

(90% municipal and industrial, 60% irrigation, 10% municipal and industrial, 40% irrigation)

SIMULATION 1

As simulation 0 with <u>improved management</u> considering target storages in reservoirs to guarantee municipal demands

$$TS_i = 0.8 \sum_{k=i+1}^{N} Dm_k \qquad i = 3 \rightarrow 9 \quad N = 10$$

SIMULATION 2

<u>Future configuration</u> of the system considering an increase of 20% of municipal demands and target volumes on reservoirs

Analyses carried out for the Agri-Sinni water supply system (2/2)

SIMULATION 3

As simulation 2

LONG TERM Drought Mitigation Measures

•Wastewater reuse from Basilicata and northern Puglia wastewater treatment plants

•Upstream re-pumping drains from irrigation

SHORT TERM Drought Mitigation Measures

•Salento (Puglia) groundwater over-exploitation

SIMULATION 4

As simulation 2

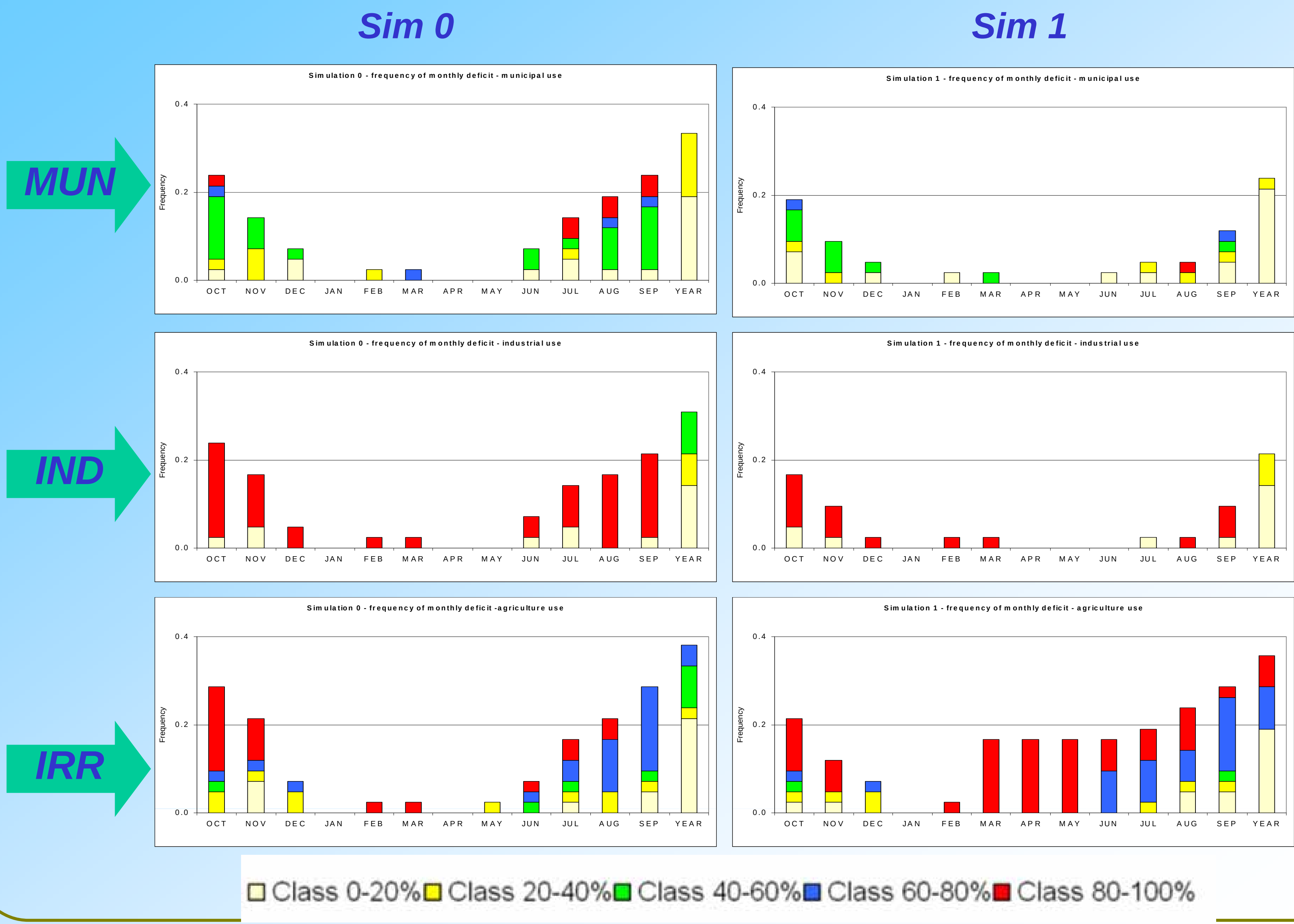
LONG TERM

As simulation 3

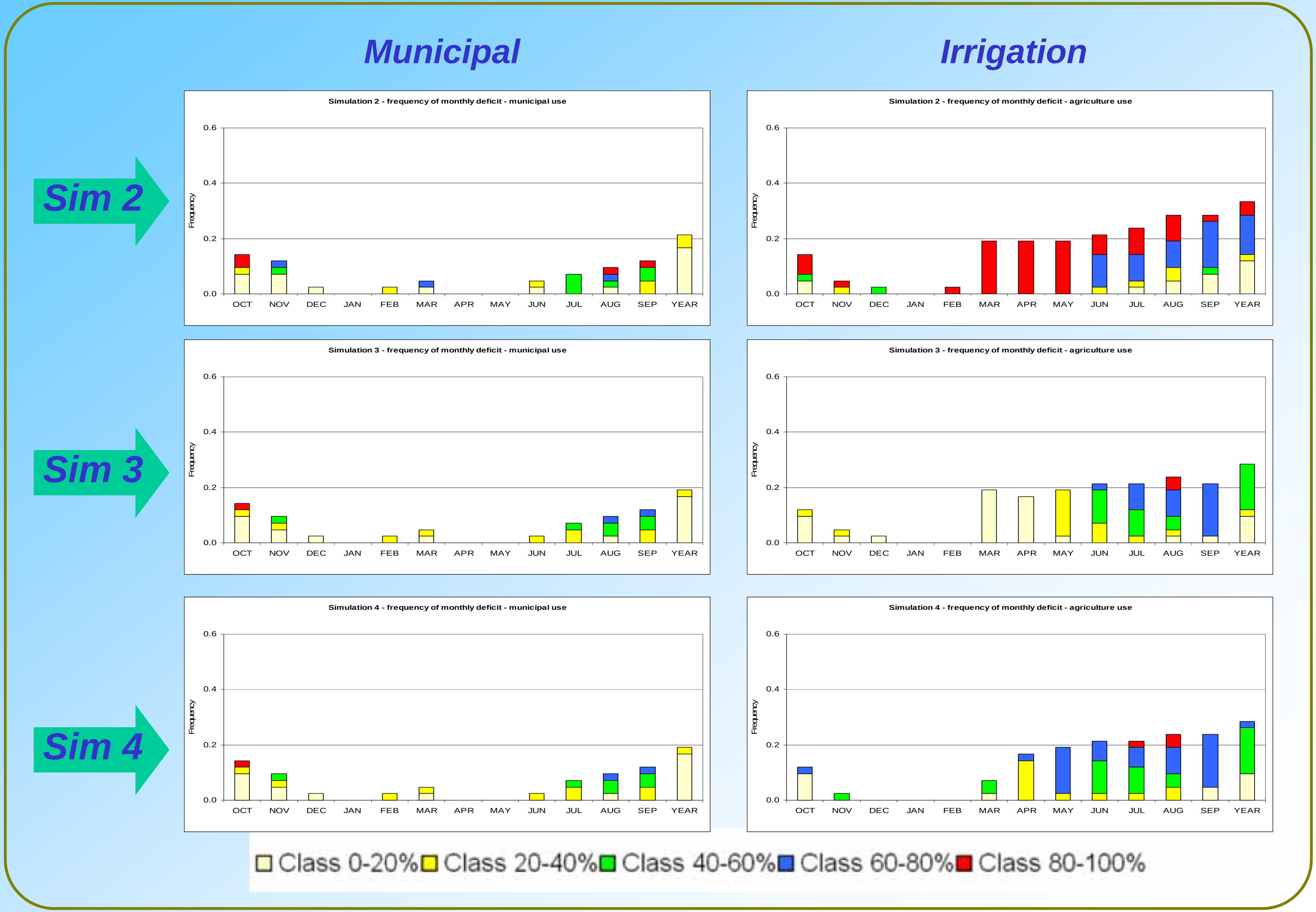
SHORT TERM

•Temporary re-allocation during drought conditions of water normally devoted to hydropower production in Cogliandrino reservoir

Probability of water shortages (1/2)



Probability of water shortages (2/2)



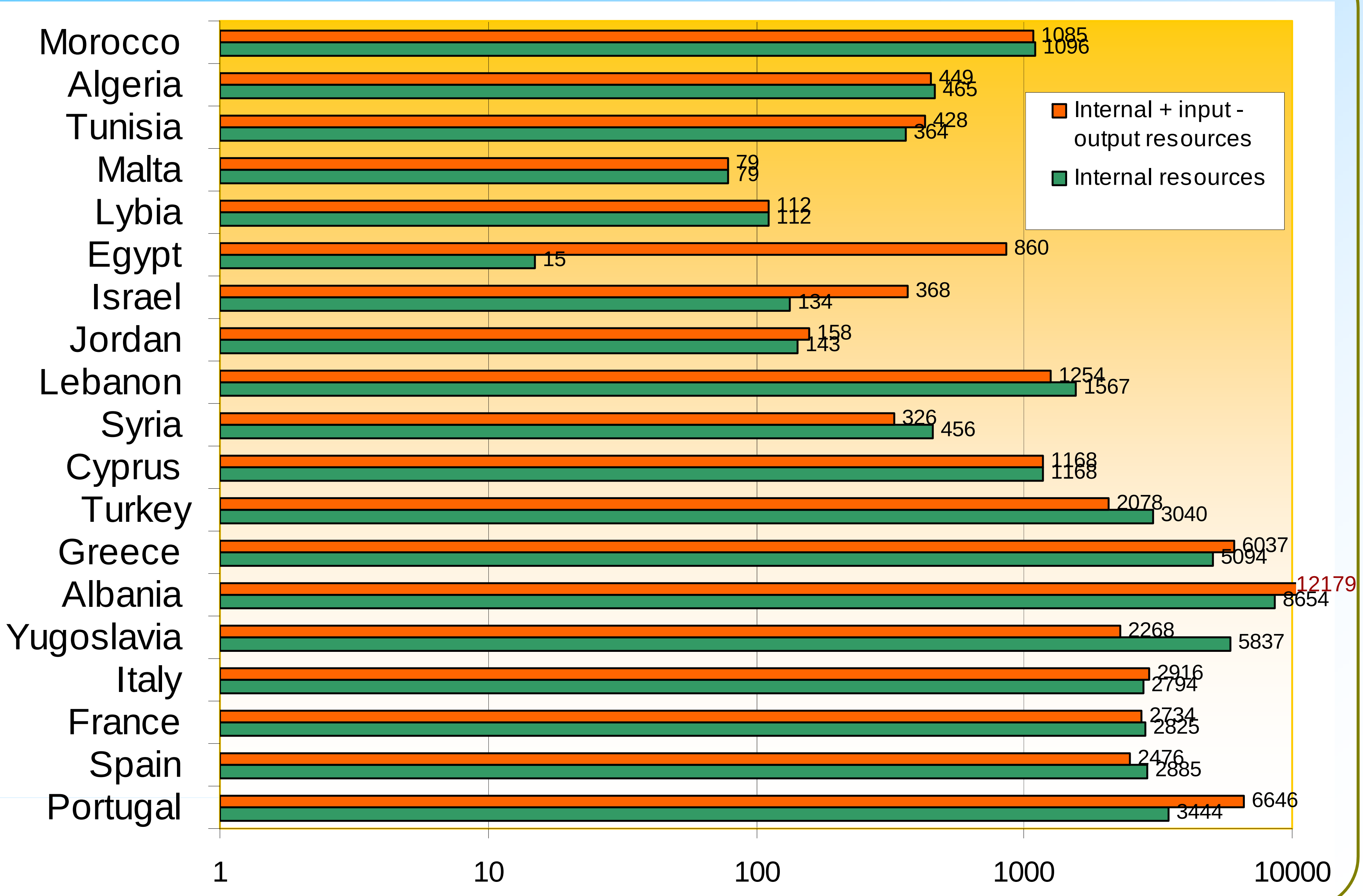
Conclusions

- Mediterranean countries suffer water problems due to water scarcity and droughts
- Such problems are expected to exhacerbate in the future, unless adequate preparedness and mitigation measures are put in effect, shifting from the current reactive approach toward a proactive approach
- Drought planning framework should be tailored to each country, on the basis of the particular legal, institutional and water management constraints
- The need of advanced simulation and/or optimization tools arises when planning for drought mitigation in complex water supply systems

Water scarcity

- Average per capita available water is often used as a rough water scarcity indicator
- Commonly, 2000 m3/person/year is the threshold for water stress, 1000 for water scarcity
- Many countries experience less than 500 m3/person year of available water
- Such indicator can sometimes be misleading
  - Renewable vs. non conventional waters
  - Presence of irrigation
  - Large spatial variability

Per capita average available water resources in Mediterranean countries (m^3/yr)



Coping with drought and water shortage risk

- *WHY A REACTIVE APPROACH HAS TO SHIFT INTO A PROACTIVE APPROACH?*
  - Because emergency actions are costly and not adequate, while a proactive approach helps to select in advance the measures to be adopted, which are implemented according to the information provided by a drought monitoring system.
- *WHERE IS IT PARTICULARLY NECESSARY?*
  - Priority to the planning and operation of water supply systems (single or multipurpose).
- *HOW IS IT POSSIBLE TO IMPLEMENT IT?*
  - Through an integrated approach to coping with drought and its impacts

Incresing drought occurrences in Mediterranean

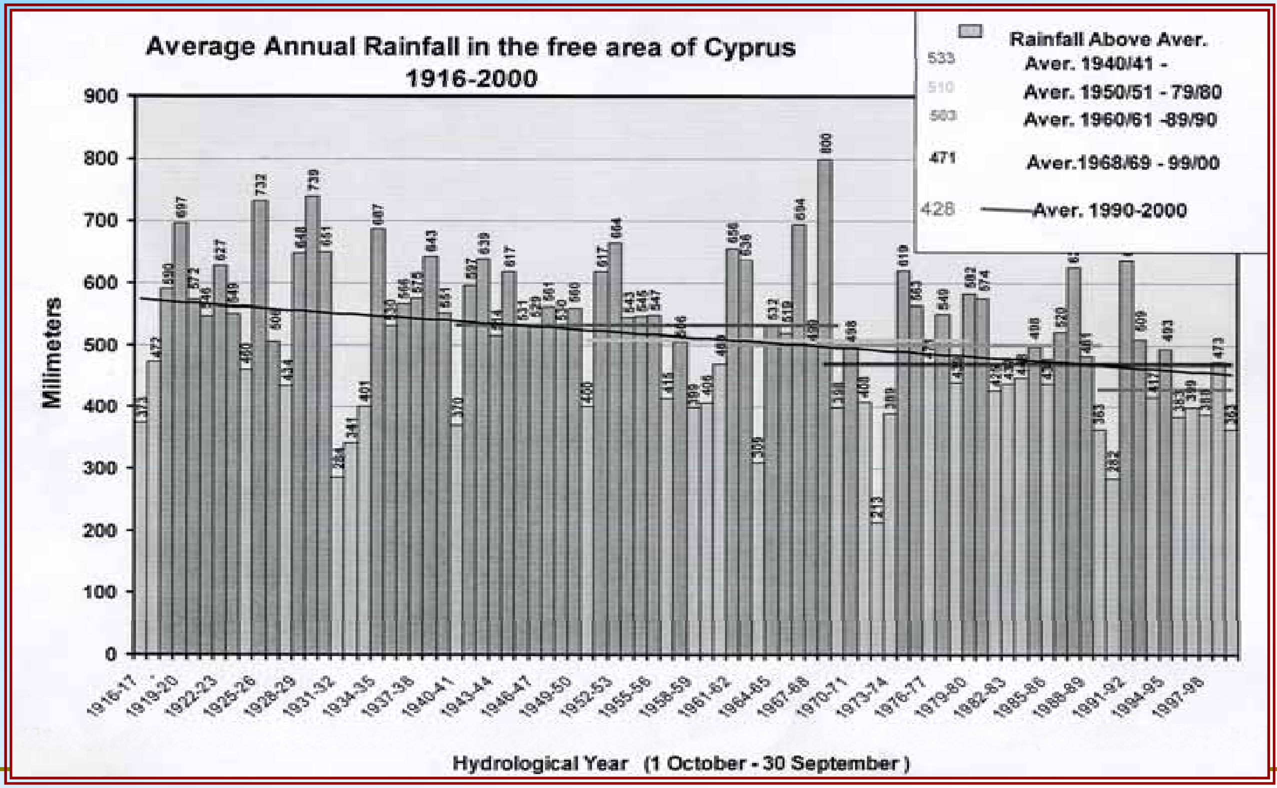
Among the most severe droughts affecting European countries in last years:

-1988-91 and 2003-04 Italy (shortage in municipal and agricultural supply)

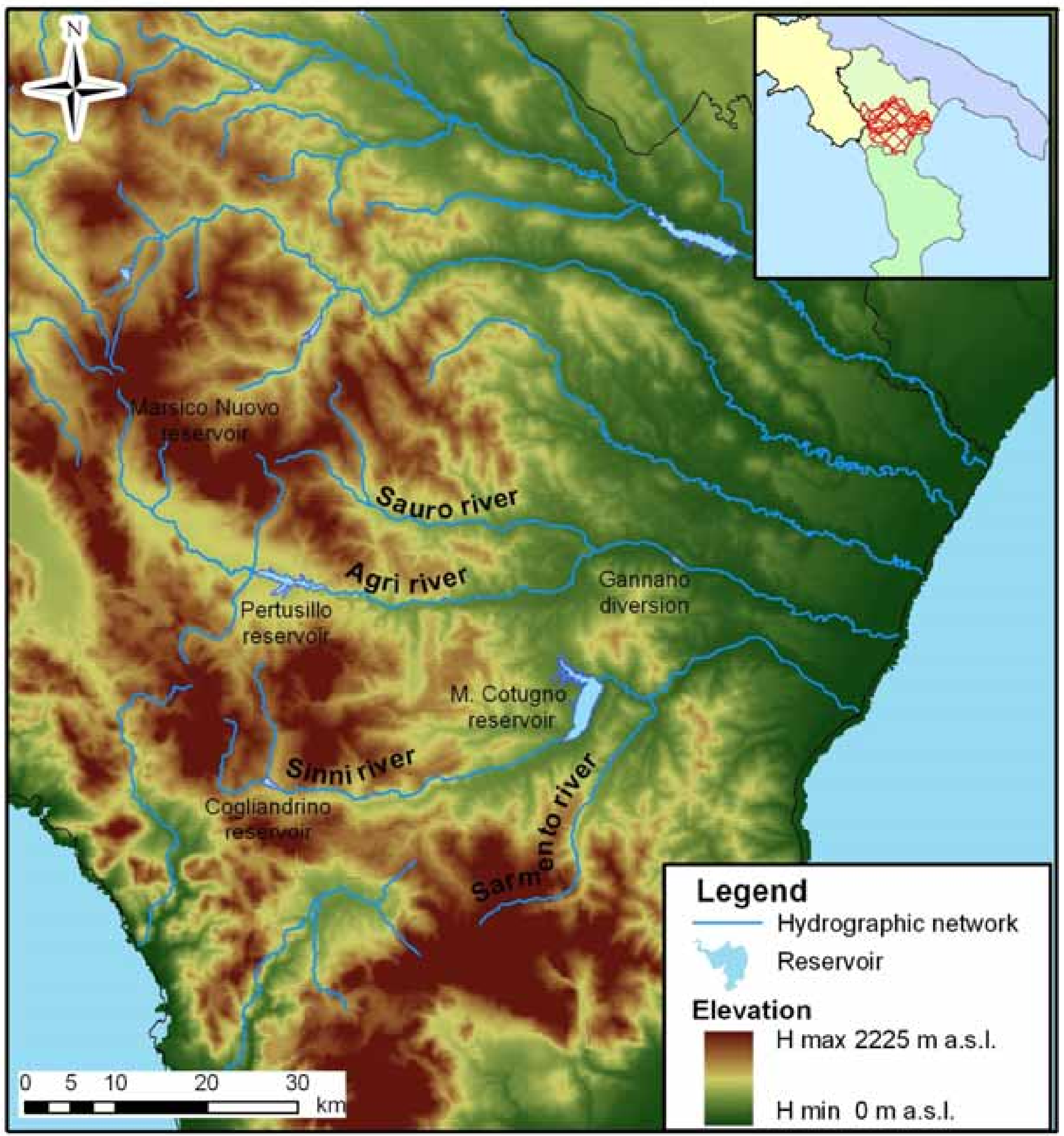
-1989-95 emergency in water supply of Athens

-1990-95, 1998-2003 emergency in several cities and agriculture in Spain

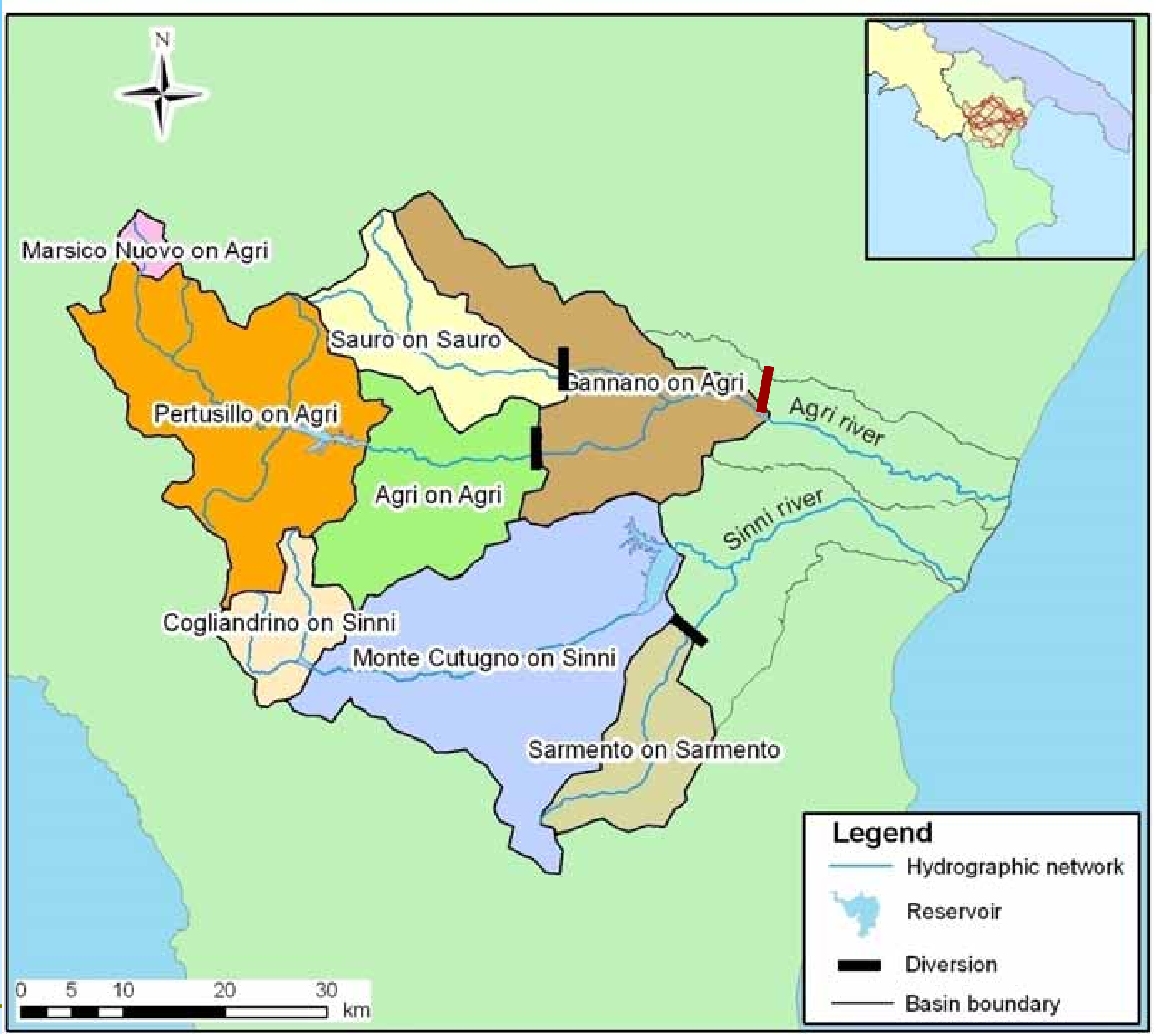
- several multi-year drought in Cyprus : for 2006-08 drought the E.C gave a grant of 7,6 million of euros for costs of emergency measures (transport of water from Greece)



DEM of the area of interest



River basins upstream reservoir and diversion of the Agri-Sinni system



Water plants

Pertusillo Reservoir

Monte Cotugno Reservoir

SIMDRO model operating rules and constraints

- **Priority on link simulation**

  Establishing the order of simulation and the corresponding order of demands fulfillment

- **Target storages**

  Monthly volumes to be stored in reservoirs to guarantee high priority uses

- **Three system states:**

  normal (no drought), **alert** (possible incoming drought)**,** **alarm** (ongoing drought)

- **Triggers:**

  to activate links tied to volumes stored in one or more reservoirs of the system

- **Ecological constraints**

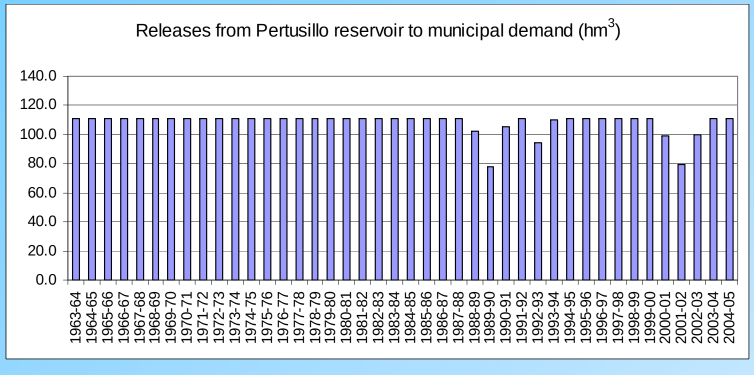
  Simulated as minimum volume to flow in a particular link and characterized by high priority

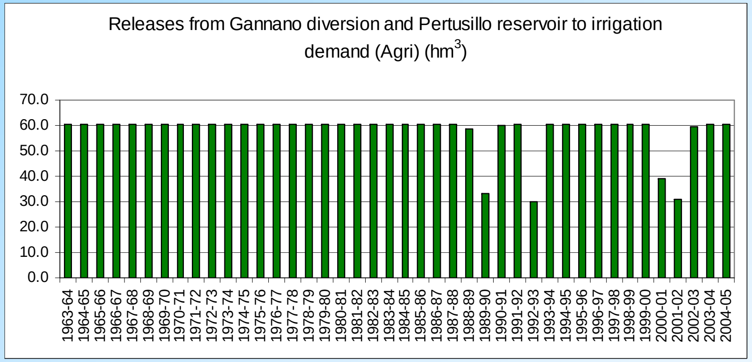
Releases from Agri subsystem

Municipal

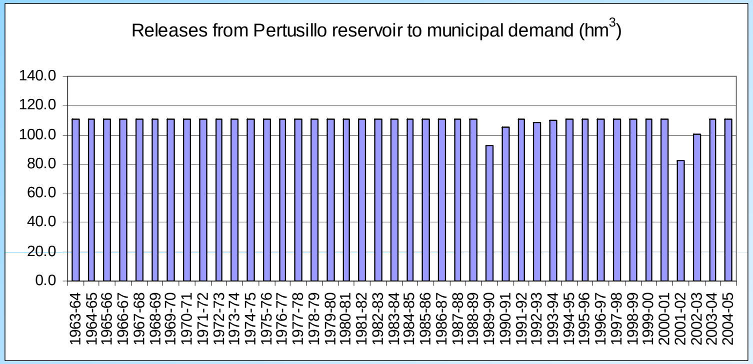
Irrigation

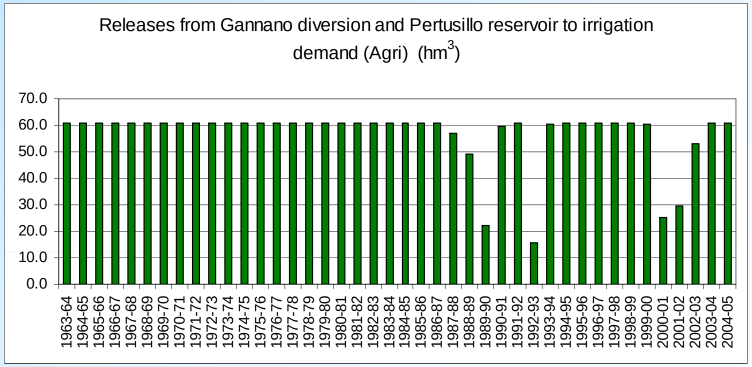
Sim 0



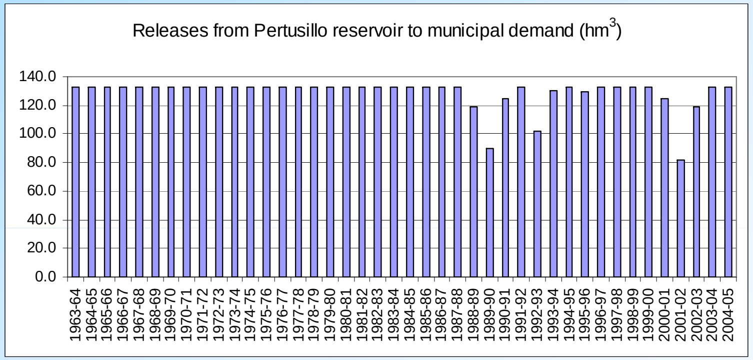


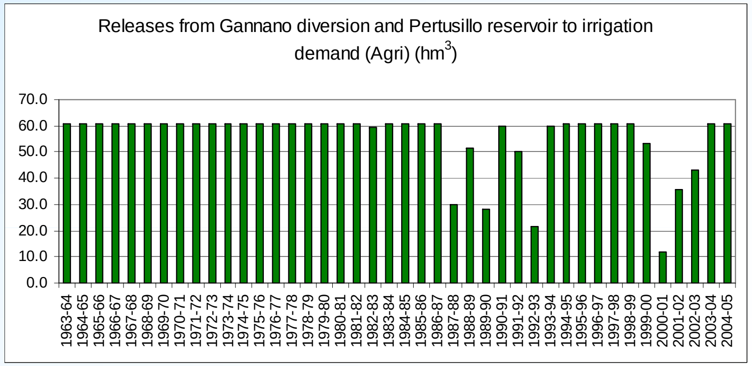
Sim 1





Sim 2





Comparisons of results

Simulation 0.

		Release F=80% [hm^3]	Release F=80% [%]	Volume based reliability	Time based reliability D_{tot}	Time based reliability D_{red} *threshold*	Time based reliability D_{red}	Def_{max}/D [%]
Municipal	Agri	110.59	99.9%	0.975	0.810	*0.90*	0.905	29.7%
	Sinni	122.23	91.6%	0.935	0.690	*0.90*	0.833	47.6%
Irrigation	Agri	60.62	99.9%	0.955	0.619	*0.65*	0.905	50.4%
	Sinni	162.85	91.0%	0.888	0.643	*0.65*	0.833	75.1%
Industrial	Sinni	11.53	91.5%	0.921	0.690	*0.90*	0.833	58.1%

Simulation 1.

		Release F=80% [hm^3]	Release F=80% [%]	Volume based reliability	Time based reliability D_{tot}	Time based reliability D_{red} *threshold*	Time based reliability D_{red}	Def_{max}/D [%]
Municipal	Agri	110.68	100.0%	0.986	0.857	*0.90*	0.952	25.4%
	Sinni	126.41	94.7%	0.975	0.738	*0.90*	0.905	27.2%
Irrigation	Agri	60.26	99.3%	0.932	0.595	*0.65*	0.905	74.4%
	Sinni	153.34	85.7%	0.855	0.595	*0.65*	0.833	94.0%
Industrial	Sinni	11.57	91.8%	0.953	0.738	*0.90*	0.857	42.2%

Simulation 2.

		Release F=80% [hm^3]	Release F=80% [%]	Volume based reliability	Time based reliability D_{tot}	Time based reliability D_{red} *threshold*	Time based reliability D_{red}	Def_{max}/D [%]
Municipal	Agri	130.59	98.3%	0.969	0.786	*0.90*	0.881	38.6%
	Sinni	157.79	98.5%	0.976	0.762	*0.90*	0.929	31.6%
Irrigation	Agri	53.01	87.4%	0.912	0.548	*0.65*	0.881	80.7%
	Sinni	159.41	89.1%	0.864	0.667	*0.65*	0.833	95.1%
Industrial	Sinni	11.58	91.8%	0.956	0.762	*0.90*	0.881	49.9%

WSUDC DSS – SIMDRO model

WSUDC is prototype of DSS developed at the University of Catania by the DICA group

SIMDRO is the module to simulate water supply systems

- Specifically oriented for simulating the implementation of drought mitigation measures
- Node-Link framework respecting mass-balance and continuity principles
- SIMDRO can simulate
  - Node without storage
  - Node with storage
  - Pipes and channels
  - Consumptive demands with different monthly patterns