WUEMED Workshop

Roma, September 29-30, 2005

DROUGHT MONITORING AND ASSESSMENT OF WATER SHORTAGE MITIGATION MEASURES

Giuseppe Rossi

Department of Civil and Environmental Engineering
University of Catania, Italy

grossi@dica.unict.it

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Projects and main publications

- **INCO DC DSS** – A decision support system for mitigation of drought impacts in the Mediterranean Regions.

  Rossi G., Cancelliere A., Pereira L.S., Oweis T., Shatanawi M. and Zairi A. (2003).*Tools for Drought Mitigation in Mediterranean Regions*, Kluwer Academic Publishing, Dordrecht. 357 p.
- **Interreg IIC Drought – Interreg IIIB Sedemed**.

  Rossi G., Cancelliere A. (2002). Early warning of drought: development of a drought bulletting for Sicily. *2nd International Conference "New trends in water and environmental engineering for safety and life: eco-compatible solutions for aquatic environments*, Capri (Italy), June 24-28.
- **INCO-MED WAMME** – Water resources management under drought condiitons: criteria and tools for conjunctive use of conventional and marginal waters in Mediterranean regions.

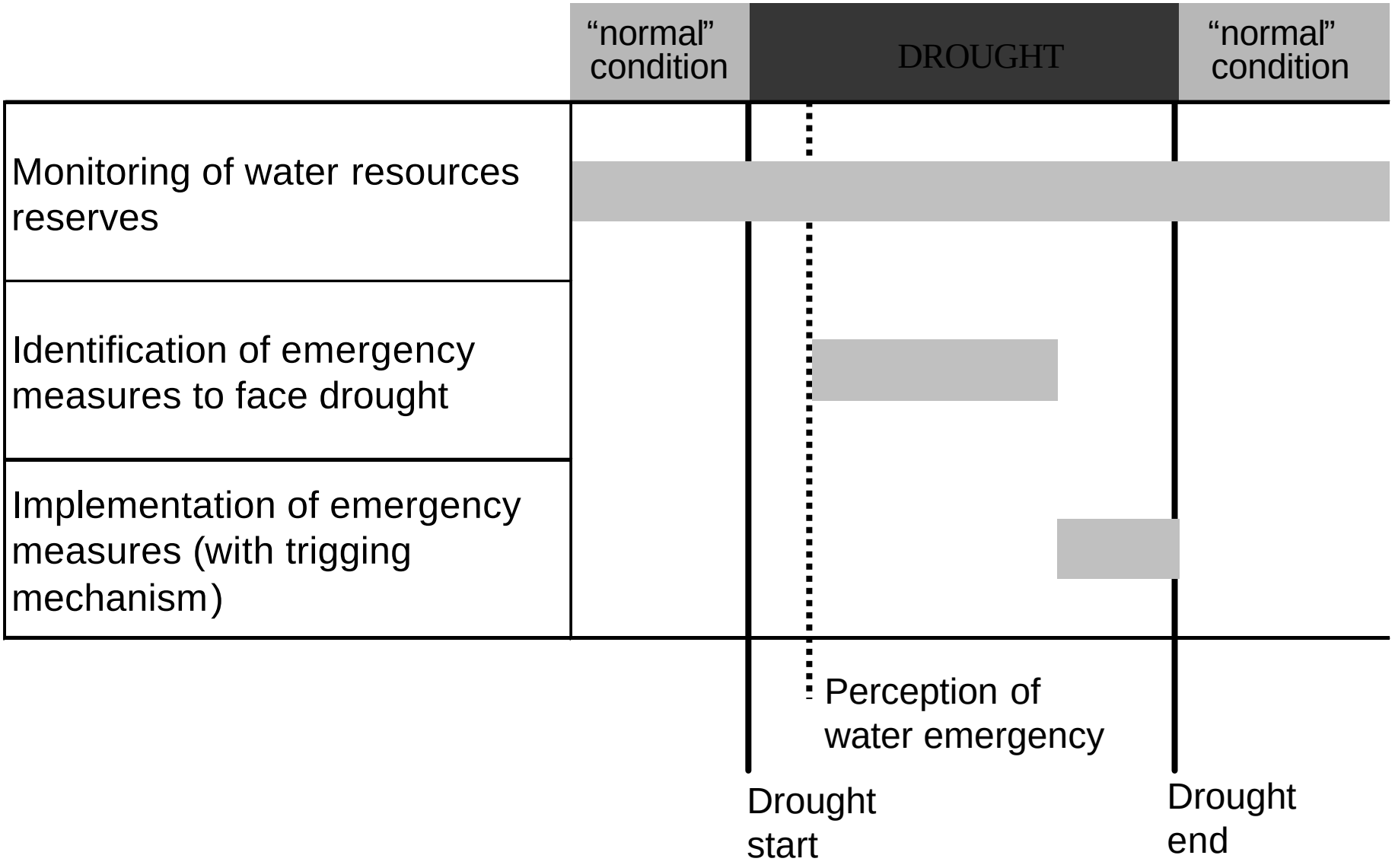
  Andreu J.A., Rossi G., Vela A., Vagliasindi F. (2005). *Drought management and planning for water resources*. CRC Press, Florida, USA.

Integrated approach for coping with drought

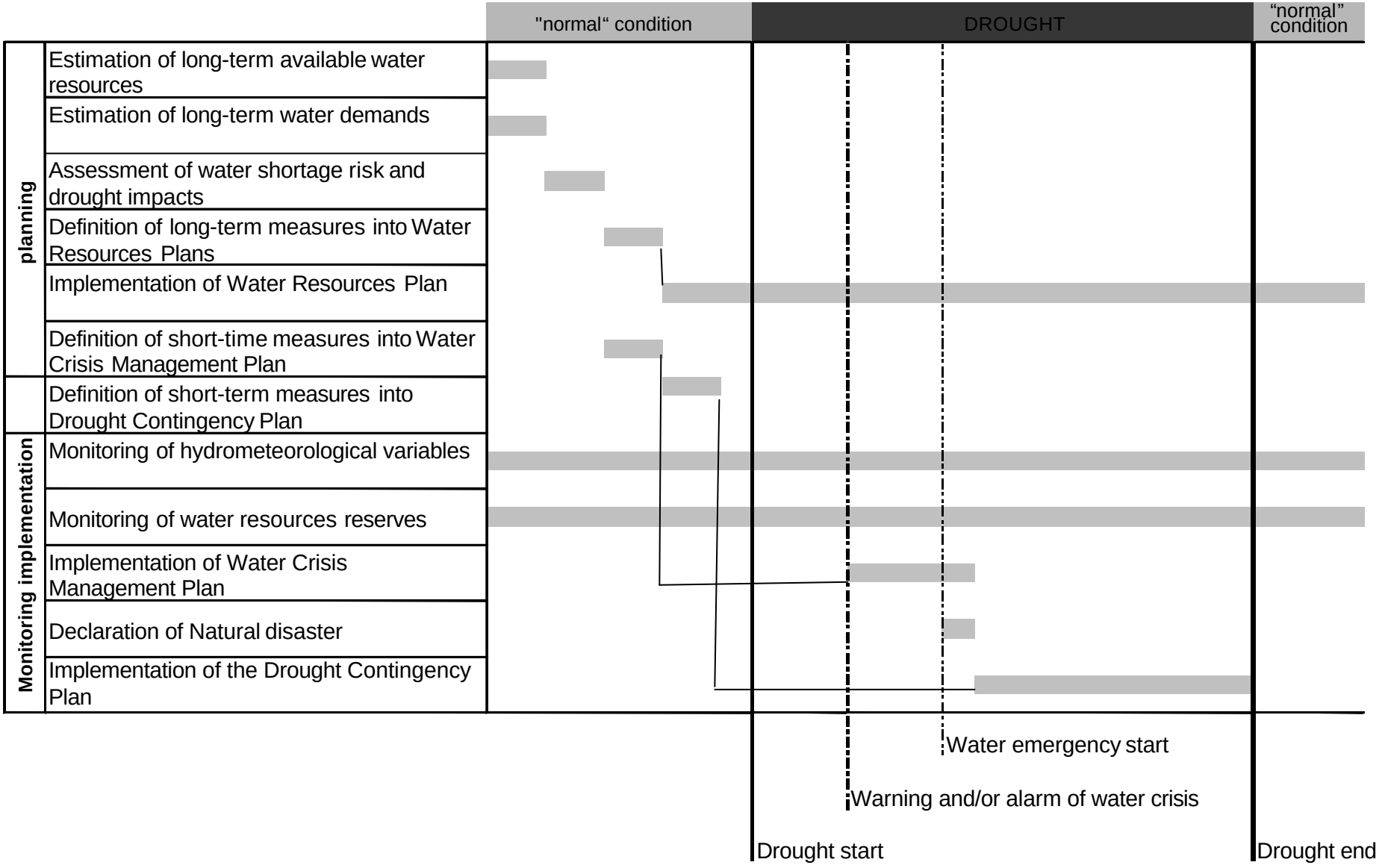
Basic principles

- Drought consists in a *significant* reduction of precipitation amount (and related hydrologic variables) 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, infrastructures features, operation rules, demand management, etc.
- To face such a risk, a shift from a reactive approach (emergency assistance) to a pro-active approach is necessary.

Reactive approach



Pro-active approach



MAIN STEPS	TOOLS
1. Identification and characterization of droughts (meteorological, agricultural, hydrological)	*Analysis of stochastic processes*
2. Monitoring of drought and early warning of water shortages	*Drought watch system*
3. Assessment of economical, environmental and social impacts of droughts	*Economical analysis and study of ecological and social effects*
4. Definition of drought preparedness strategies and mitigation measures	*Mathematical models for the analysis of structural and non-structural projects*

MAIN STEPS	TOOLS
5. Comparison and ranking of long-term and short-term drought mitigation measures	*Multicriterion assessment of alternatives*
6. Development of Water Resources Plan and Drought Contingency Plan	*Institutional involvment and stakeholders-public partecipation*
7. Implementation of plans to face drought and water shortage risk	*Actions by government authorities and management agencies*

Drought watch systems

Objective:

early warning of drought conditions to implement mitigation measures, and to declare public disaster

Elements:

- automated network of gauges for monitoring hydrometeorological variables and water supply reserves (e.g. reservoir storage, groundwater level)
- center for collecting, storing and processing data for evaluating drought conditions through a set of indices and GIS (for space variability)
- tools for transferring information to decision-makers and public (with Internet as preferable solution)

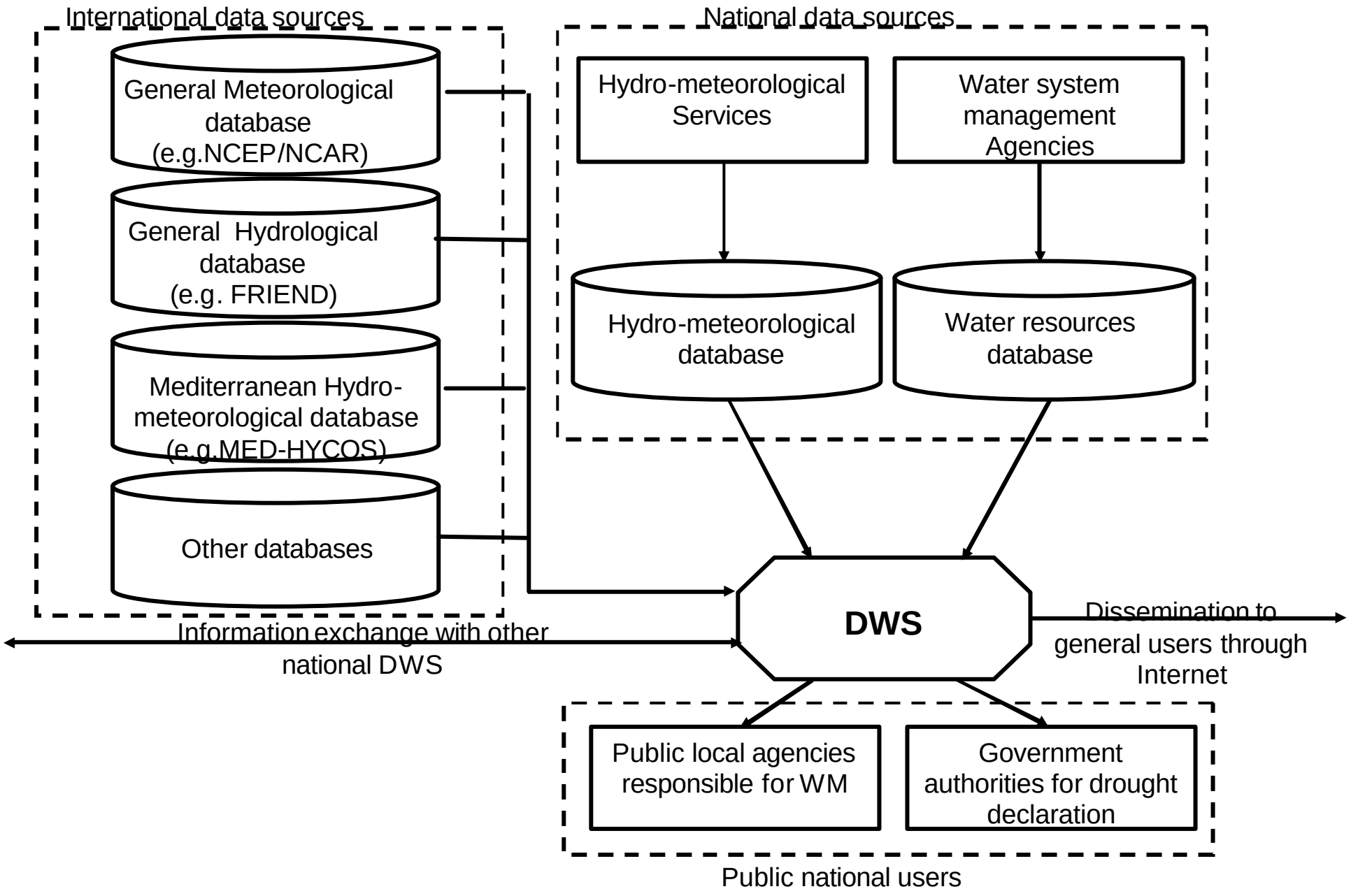
Main Drought Watch Systems in operation

Organization and web site	Available information
Bureau of Meteorology and Queensland Dept. of Natural Resources and Mines, Australia www.bom.gov.au/silo	Precipitation anomalies, temperature anomalies
National Drought Mitigation Center (NDMC) – University of Nebraska-Lincoln, USA www.ndmc.unl.edu	Percent of normal rainfall, SPI Palmer Index, Crop Moisture Index, Daily streamflow, Soil moisture anomaly, Vegetation Condition Index
Centre for Ecology and Hydrology Wallingford UK www.nerc-wallingford.ac.uk	Precipitation maps River flow maps Ground water level maps
Centre for Eastern and Southern Africa, Nairobi (Kenya) and Harare (Zimbabwe) www.africanews.org/environ	Precipitation amount by categories Drought severity index, Temperature anomalies, Precipitation anomalies, Normalised difference vegetation index Expected weather impacts on agriculture

Recent proposal of Drought monitoring systems

Research project and/or meeting	Coordinator	Proposal
EC-ENV ARIDE Assessment of the Regional Impact of Droughts in Europe	University of Freiburg, Germany Centre for Ecology and Hydrology, Wallingford, UK	European Drought Monitoring System (pilot system at CEH by using the UNESCO FRIEND project partners)
Meeting on Drought Early Warning Systems, Lisbon, September 2000	World Meteorological Organisation	Recommendations on the improvement of drought warning at European scale
EC-INCO DC DSS Drought FAO-EC Workshop, ICARDA Aleppo, May 2001	University of Catania	Establishment of a Network on Drought for Mediterranean European, North Africa and Middle East countries

Scheme of a Drought Watch System for Mediterranean countries



Main steps for developing a Drought Watch System

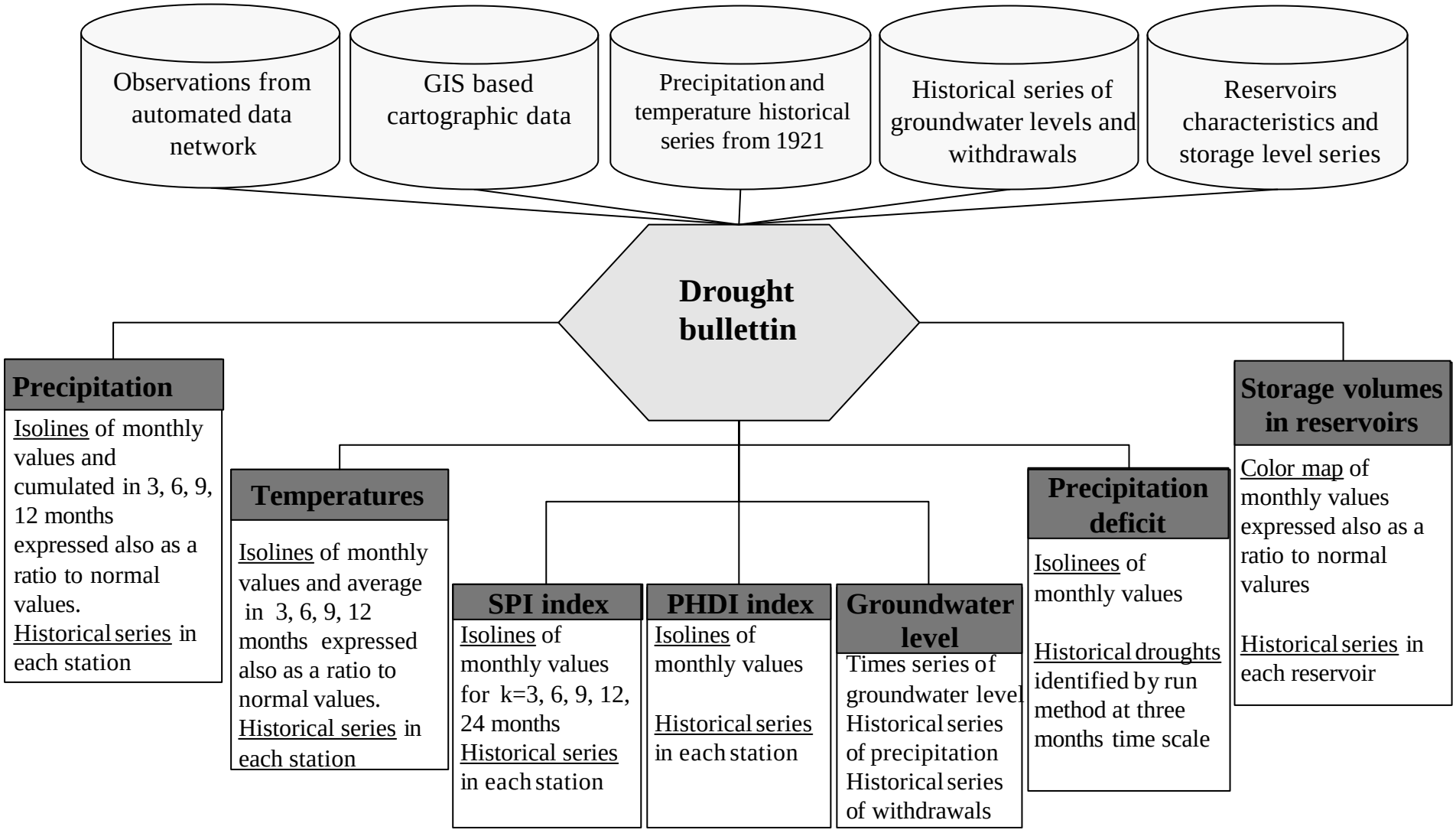
1. analysis of the institutional framework responsible for data acquisition
2. choice of the international sources of meteorological and hydrological data
3. choice of the national (regional) sources of meteorological and hydrologic data
4. choice of the national (regional) sources of water reserve status
5. development of architecture of the DWS
6. identification of ways for information dissemination
7. development of training programs for the personnel of DWS
8. a public campaign for making people aware of the importance of a drought monitoring service.

Prototype of a Drought bullettin for Sicily

- developed by DICA, University of Catania for Regional Hydrographic Service of Sicily, funded through INTERREG programs
- based on the Regional Hydrographic Service network
- using a set of drought indices describing hydrometeorological conditions and water reserve status
- oriented to transfer information through Internet

www.uirsicilia.it

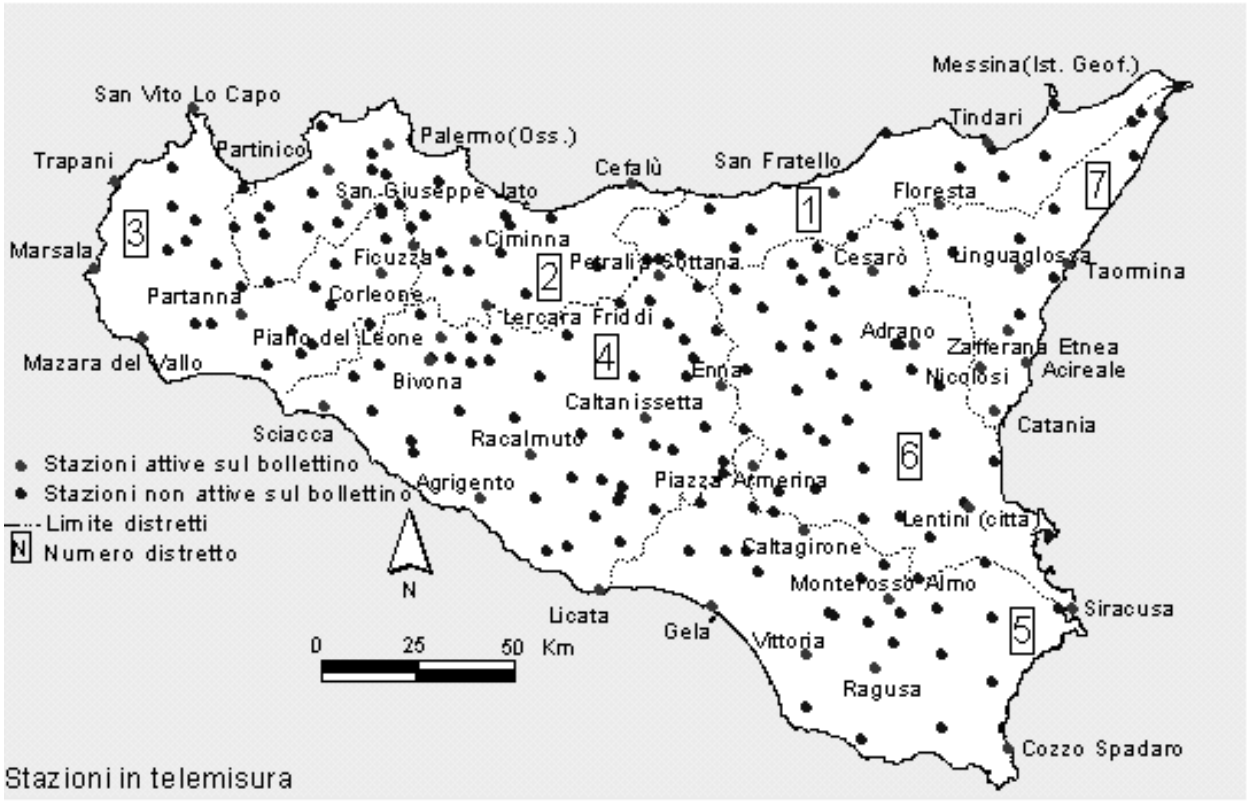
Structure of the Drought Bullettin for Sicily



REGIONE SICILIANA

Ufficio Idrografico Regionale

Bollettino per il monitoraggio della siccità

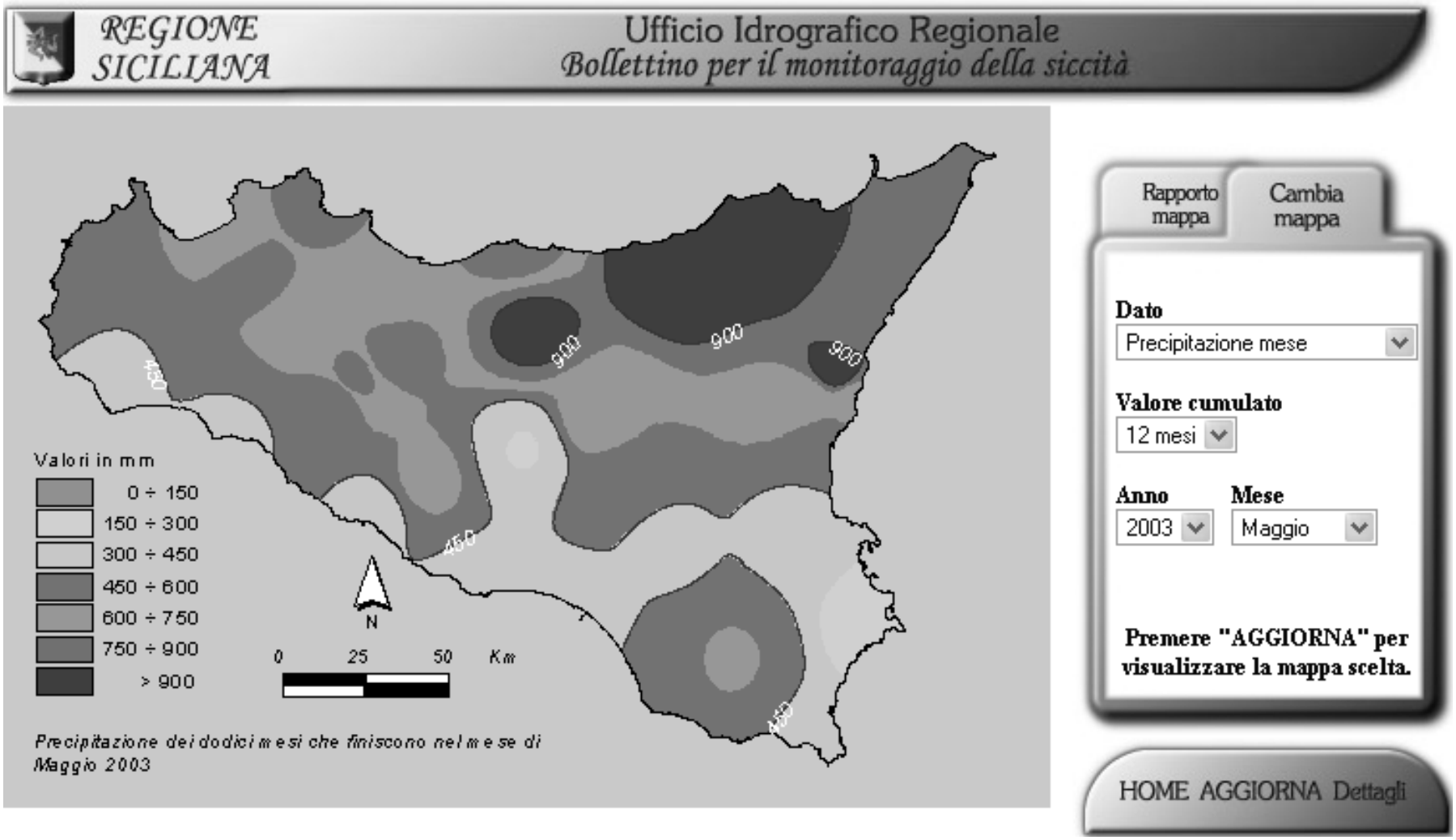


Stazioni in telemisura

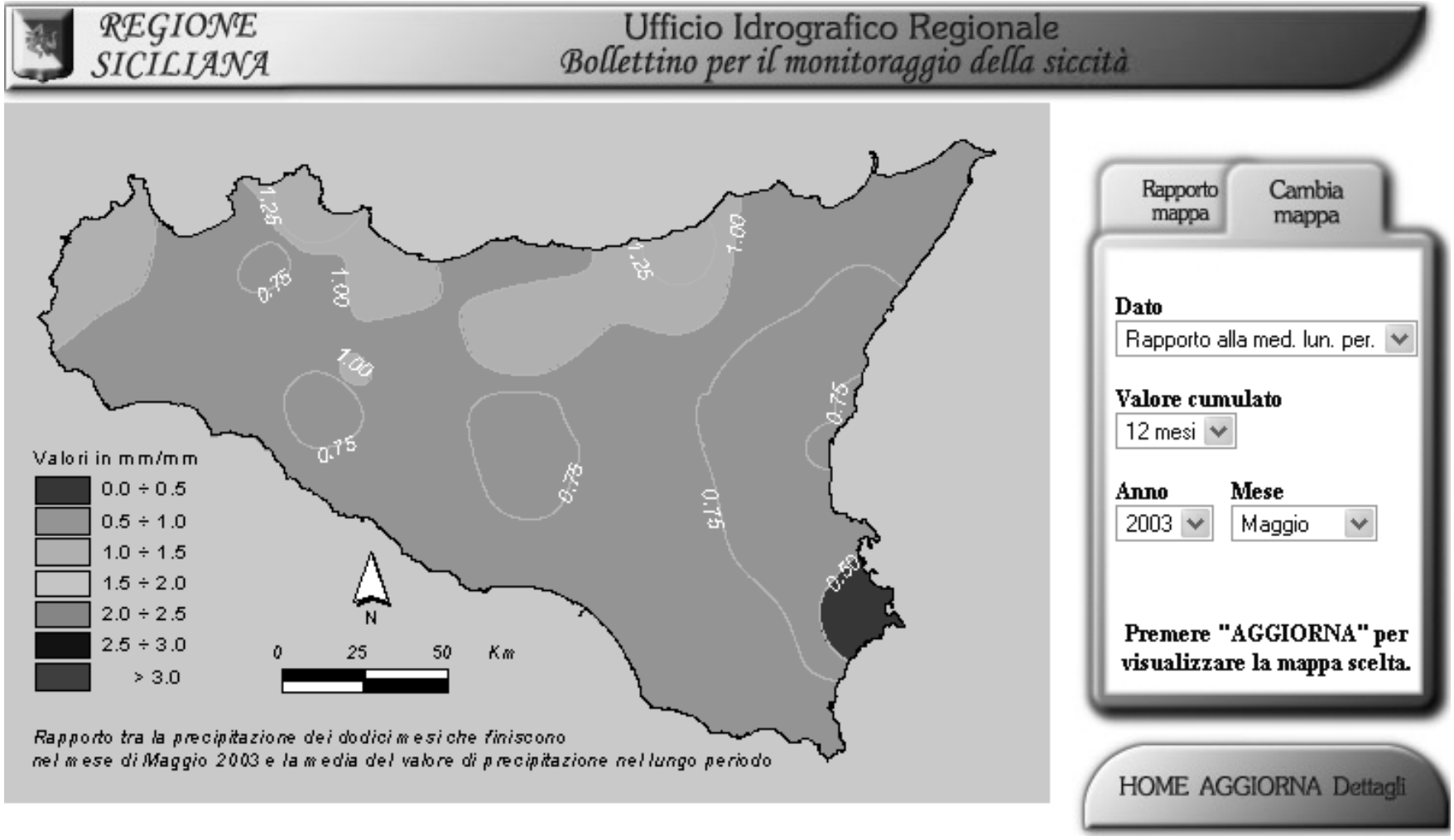
STAZIONE:	Zafferana E...
UBICAZIONE:	Uff. Municipio
COMUNE:	Zafferana Etnea (C1
LATITUDINE:	37° 41' 43"
LONGITUDINE:	15° 06' 23"
QUOTA:	590 m s.m.
VERSANTE:	est
DISTRETTO:	7. est-settentrionale

SENSORI ISTALLATI	
Pluviometro	Termometro

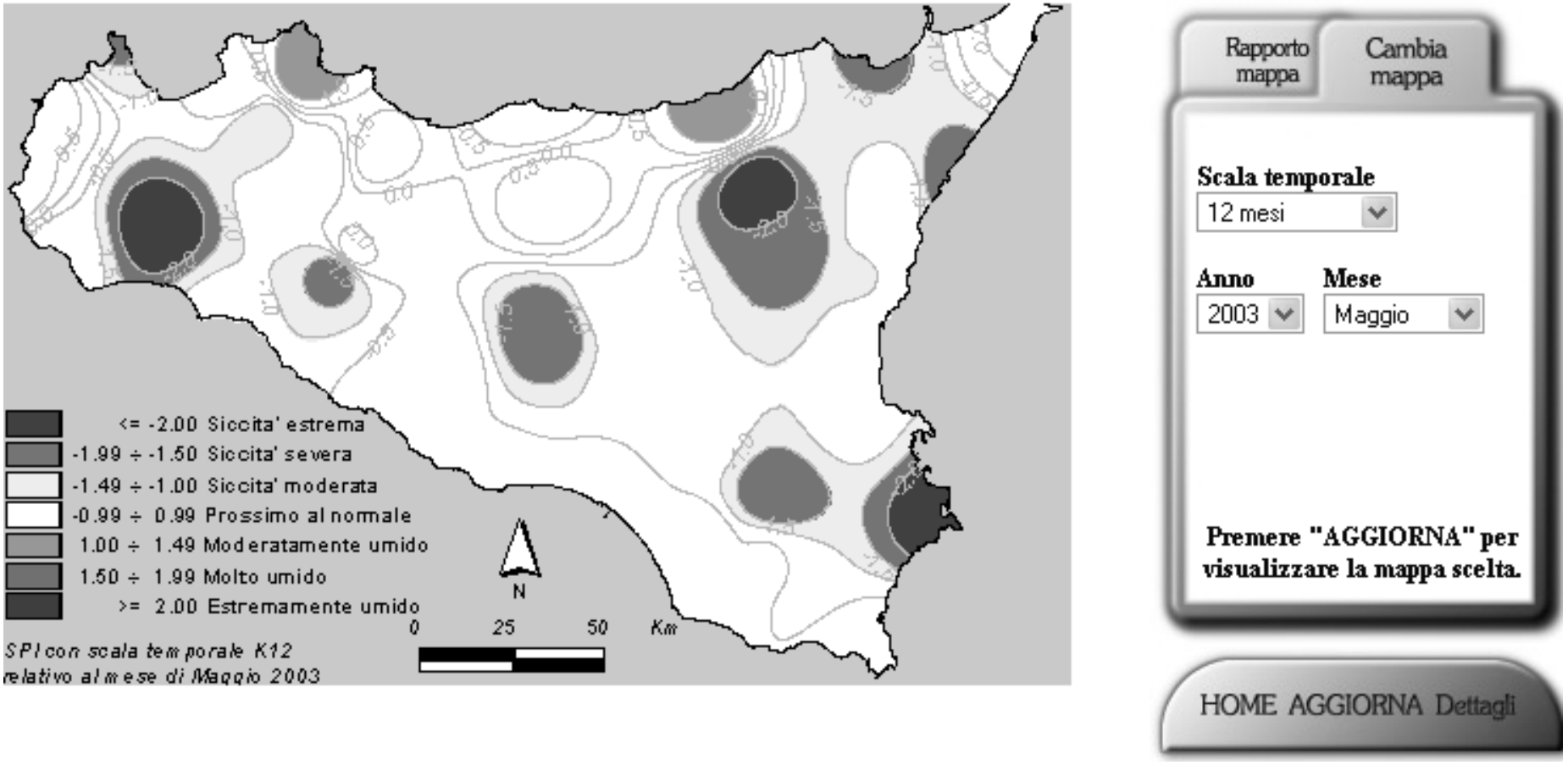
HOME Documenti



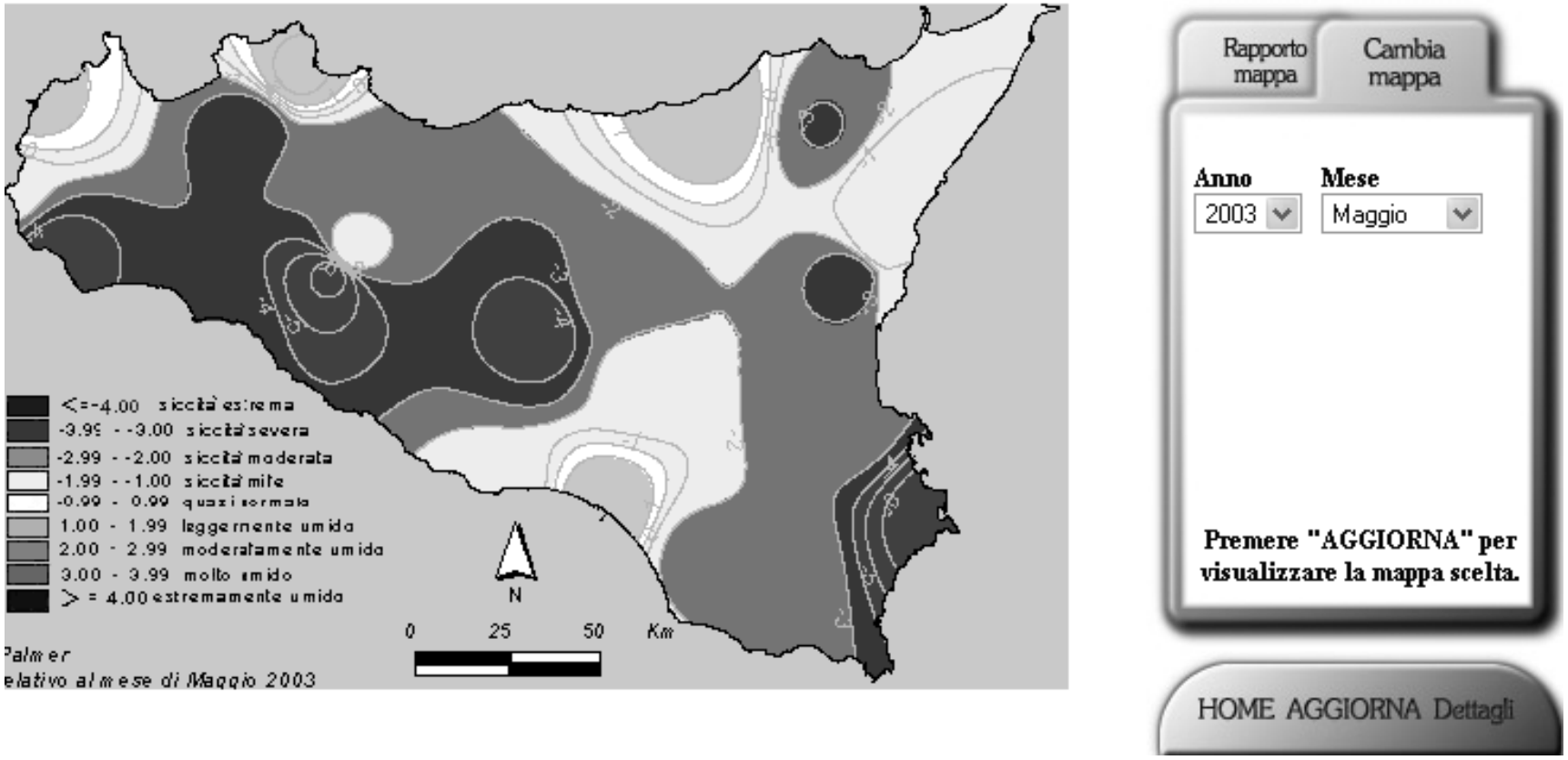
Precipitazione cumulata dei 12 mesi con fine a maggio 2003



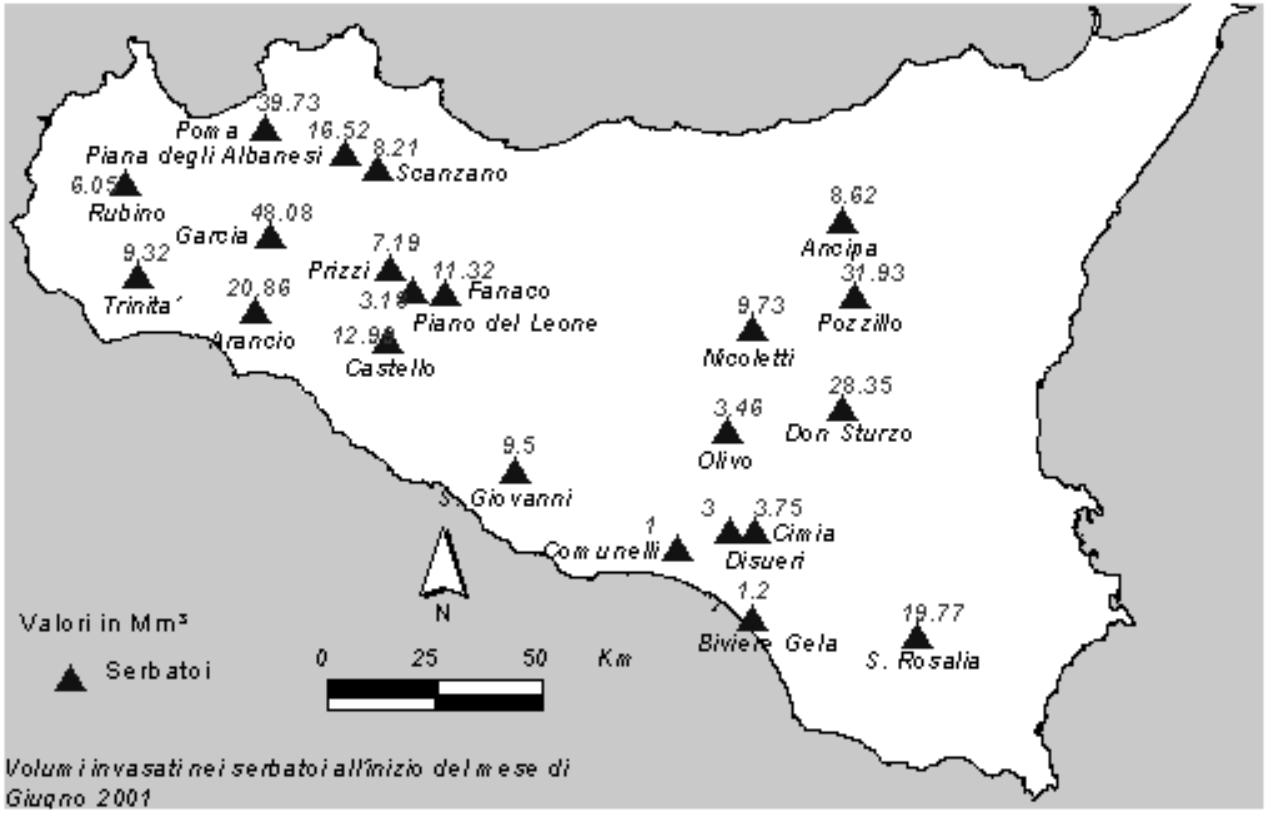
Rapporto sulle precipitazioni di lungo periodo



SPI di maggio 2003 (k=12 mesi)



Indice di Palmer di maggio 2003



Rapporto mappa | Cambia mappa

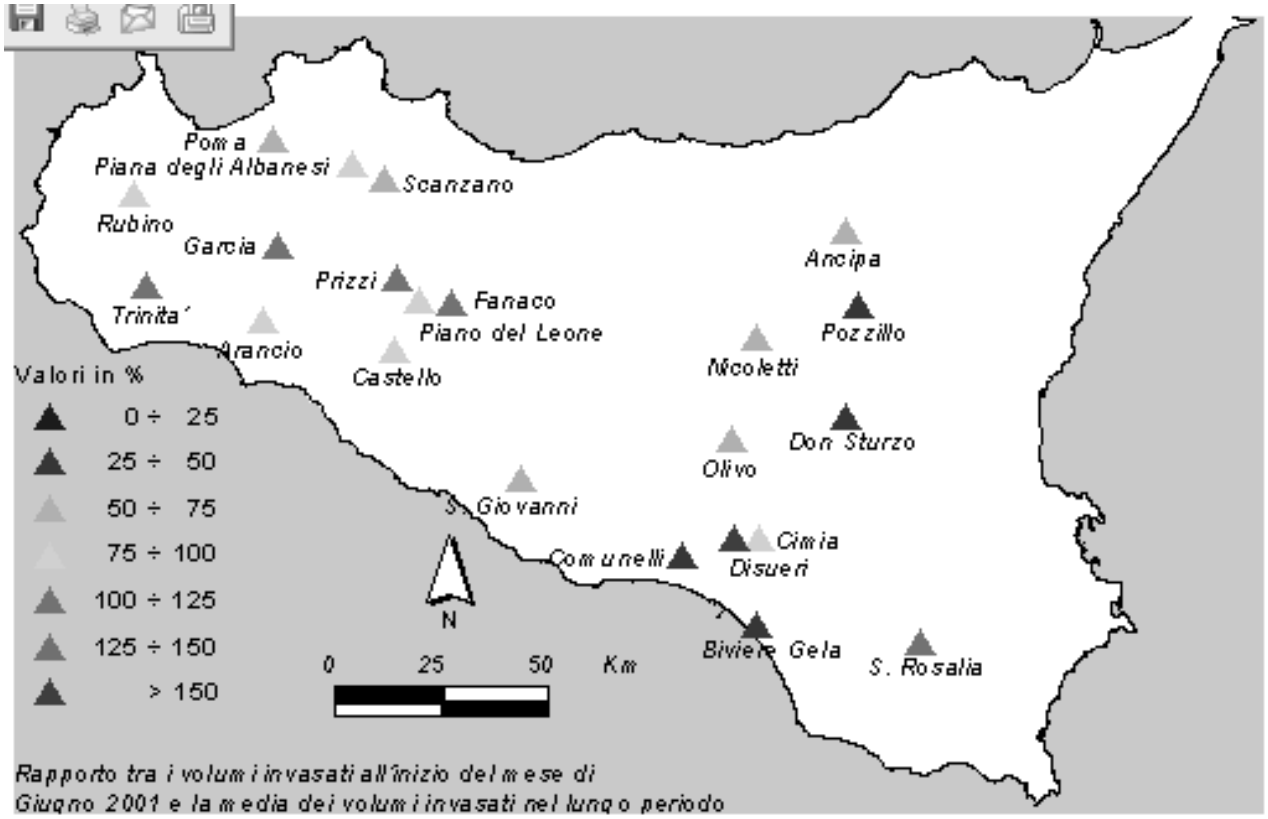
Dato

Volume invasato

Anno 2001 **Mese** Giugno

Premere "AGGIORNA" per visualizzare la mappa scelta.

HOME AGGIORNA Dettagli



Rapporto mappa | Cambia mappa

Dato

Rapporto alla med. lun. per.

Anno 2001 **Mese** Giugno

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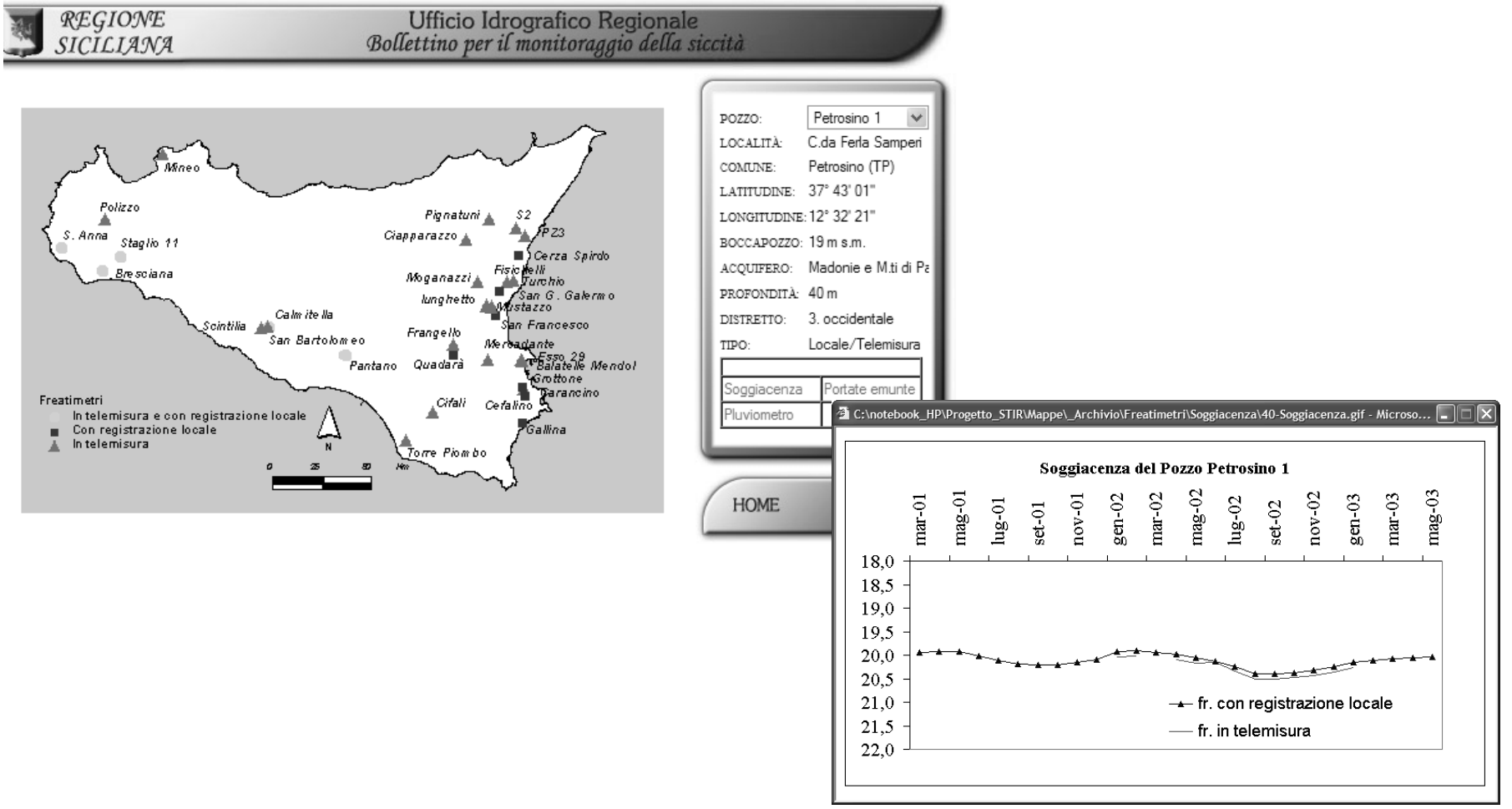
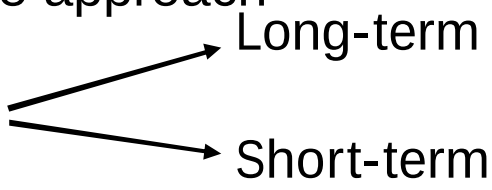
Freatimetria



Drought mitigation measures

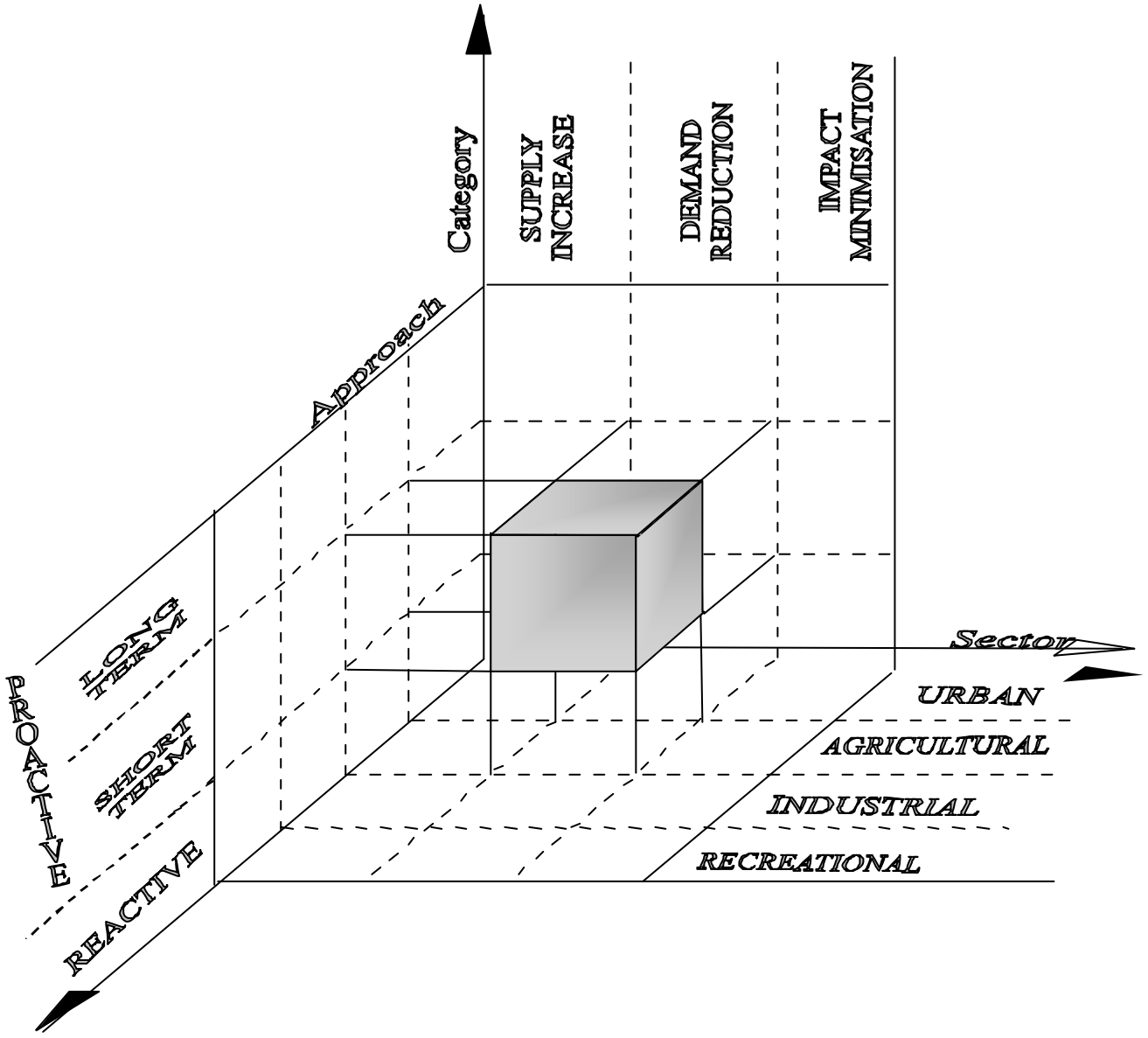
Classification

- according to the approach
  - Reactive
  - Proactive



- According to the aim:
  - Supply increase
  - Demand reduction
  - Impact minimization

- according to the affected sector
  - Urban
  - Agricultural
  - Industrial
  - Recreational


Category
SUPPLY INCREASE
DEMAND REDUCTION
IMPACT MINIMISATION
Approach
PROACTIVE
LONG TERM
SHORT TERM
REACTIVE
Sector
URBAN
AGRICULTURAL
INDUSTRIAL
RECREATIONAL

	Long-term measures	Short-term measures
Supply increase	- New storage facilities - Water transfers and use exchange - Non-conventional resources (wastewater, desalination)	- Use of marginal water sources - Relaxing environmental constraints - Improvement of efficiency
Demand reduction	- Dual municipal distribution networks - Water recycle in industries - Reduction of irrigation consumption (new crops and irrigation techniques)	- Restriction on municipal uses - Restriction on annual crops - Water saving campaign - Mandatory rationing
Impact minimisation	- Early warning system and drought contingency plan - Quality-based reallocation of water resources - Insurance and economic policies	- Temporary reallocation of resources - Public aid and tax relief - Rehabilitation programs

Multicriterion analysis (MCA) for the assessment of drought mitigation measures Why is MCA necessary?

- Evaluation of different courses of actions requires to consider several categories of objectives; e.g.:
  - Economic
  - Environmental
  - Social (equity among different groups and different generations)
- Decision-ranking in this framework requires a compromise solution that takes into account conflicting interests by different stakeholders
- Assessment of alternatives has to consider a variety of criteria both quantitative and qualitative

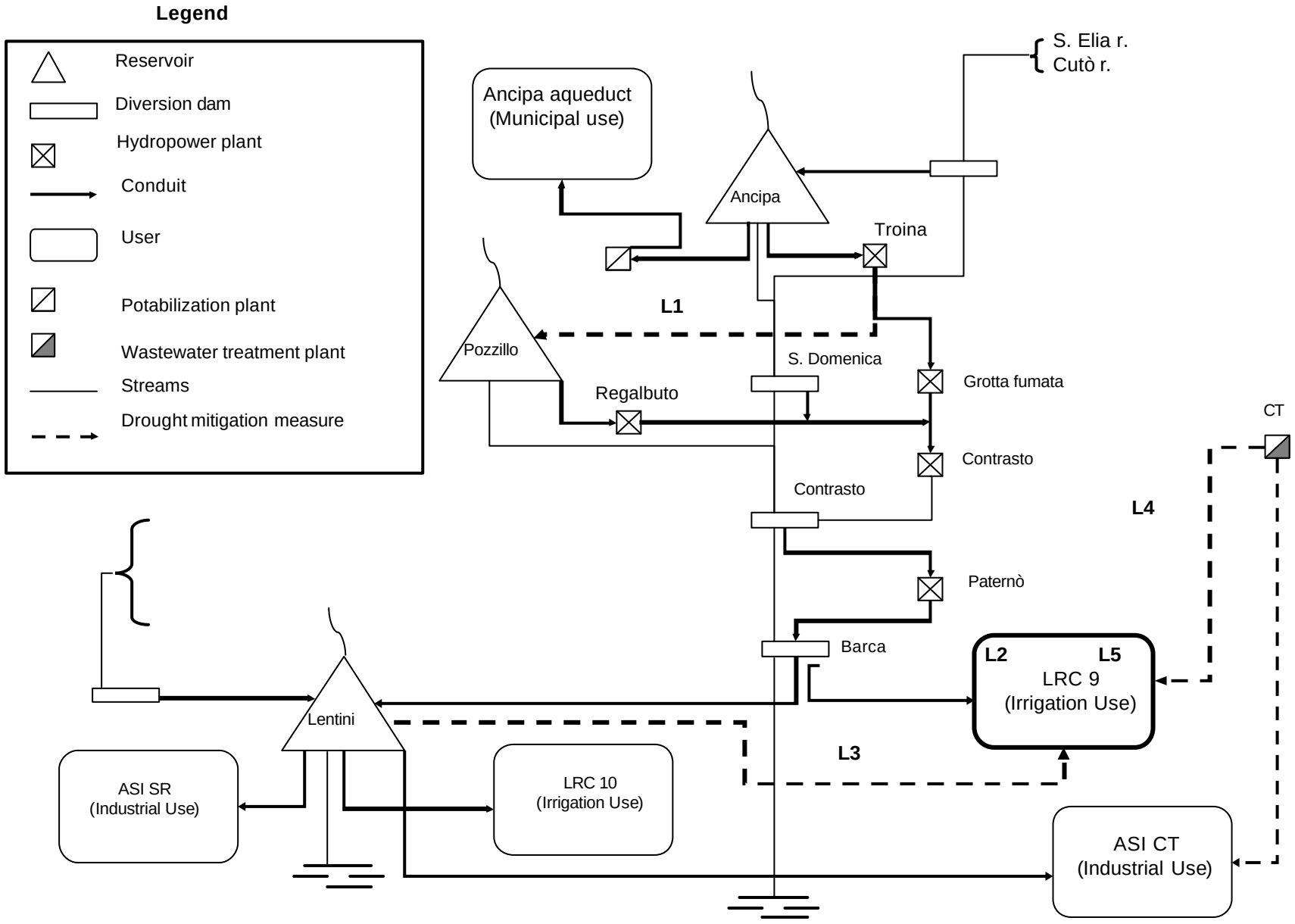
Multicriterion method NAIADE

NAIADE (Novel Approach to Imprecise Assessment and Decision Environment), (Munda, 1995) is a multicriterion method oriented to evaluate alternatives for resources management and environmental protection

It includes:

- ranking of alternatives based on a impact matrix whose criteria can be either crisp, stochastic or fuzzy
- analysis of the coalition formation process among different groups of interest

Scheme of the system (with long-term measures)



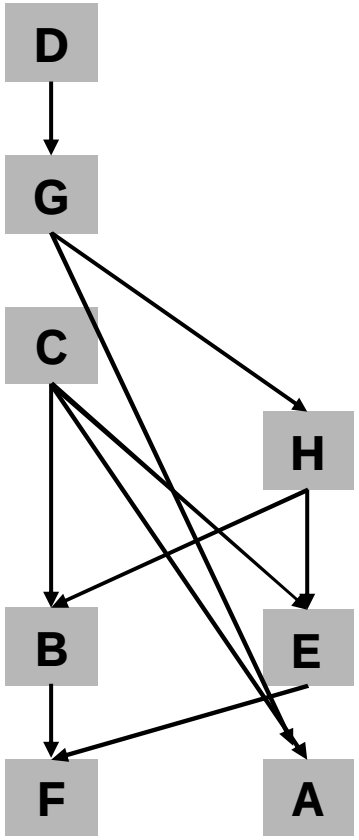
Alternatives for drought mitigation

	ALTERNATIVES							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
LONG-TERM MEASURES								
L0 System in the current configuration	x							
L1 Water transfer from Ancipa res. to Pozzillo res.		x					x	x
L2 Modernization of the irrigation network			x					
L3 Release for irrigation from Lentini reservoir.				x			x	
L4 Treated wastewater reuse from Catania plant.					x			x
L5 Construction of small reservoirs by farmers.						x		
SHORT-TERM MEASURES								
S1 Supplementary resources from groundwater and ponds	x	x	x	x	x	x	x	x
S2 Management criteria to face water scarcity	x	x	x	x	x	x	x	x
S3 Natural calamity aids	x	x	x	x	x	x	x	x

Criteria for assessment of alternatives

	Economic criteria	Units
1.a	Construction costs of infrastructures (long-term)	Euro
1.b	Operation and maintenance cost of infrastructures	Euro
1.c	Cost of short-term measures	Euro
1.d	Damages to perennial crops	No. years with deficit >25% demand
	Environmental criteria	**Units**
2.a	Failure to meet minimum storage in Pozzillo	% months
2.b	Failure to meet minimum storage in Ancipa	% months
2.c	Sustainability of the measure (groundwater and wastewater reuse)	Qualitative
2.d	Reversibility of the measure	Qualitative
	Social criteria	**Units**
3.a	Vulnerability of the system to drought	Sum of squared deficits
3.b	Temporal reliability	% of years
3.c	Realization time of the measure	Qualitative
3.d	Employment increase	Qualitative

Ranking of alternatives

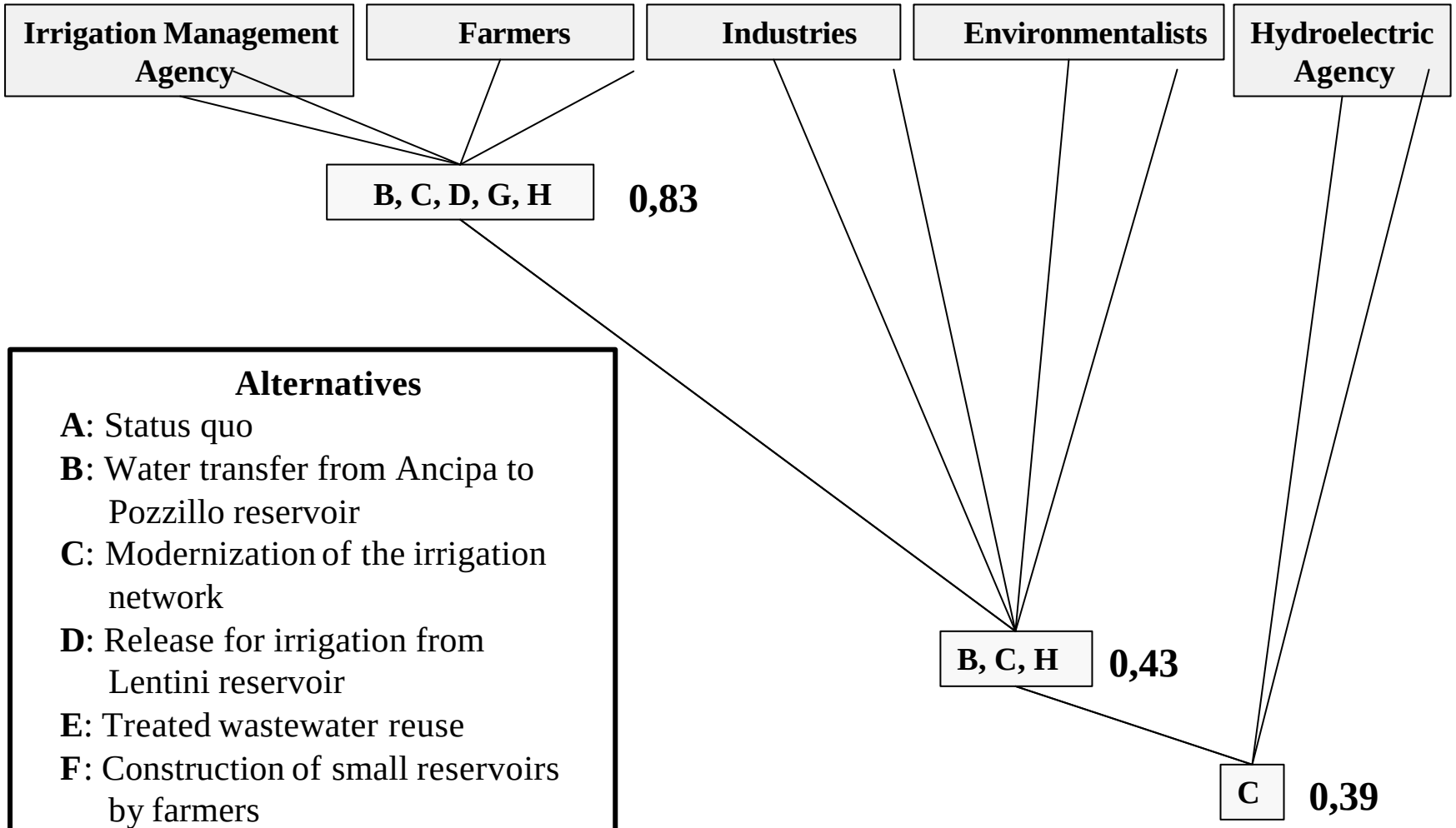


Alternatives

D: Release for irrigation from Lentini reservoir
G: Water transfer from Ancipa to Pozzillo reservoir
+ Release for irrigation from Lentini reservoir
C: Modernization of the irrigation network
H: Water transfer from Ancipa to Pozzillo reservoir
+ Treated wastewater reuse

On the basis of the preference matrix of the stakeholders some alternative have to be excluded

Coalition formation process



Alternatives

A: Status quo
B: Water transfer from Ancipa to Pozzillo reservoir
C: Modernization of the irrigation network
D: Release for irrigation from Lentini reservoir
E: Treated wastewater reuse
F: Construction of small reservoirs by farmers
G: **B+D**
H: **B+E**

C preferable alternative

Preference matrix

STAKEHOLDERS	ALTERNATIVES							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
G1 - Irrigation Management Agency	VB	G	VG	G	MLG	MLG	P	VG
G2 - Farmers of Catania Plain district	EB	G	P	G	MLG	MLG	P	VG
G3 - Hydroelectric Power Agency	P	EB	VG	G	G	G	EB	EB
G4 - Industries	M	VG	VG	M	VB	G	G	EB
G5 - Environmentalists	M	MLG	VG	B	P	VB	VB	VG

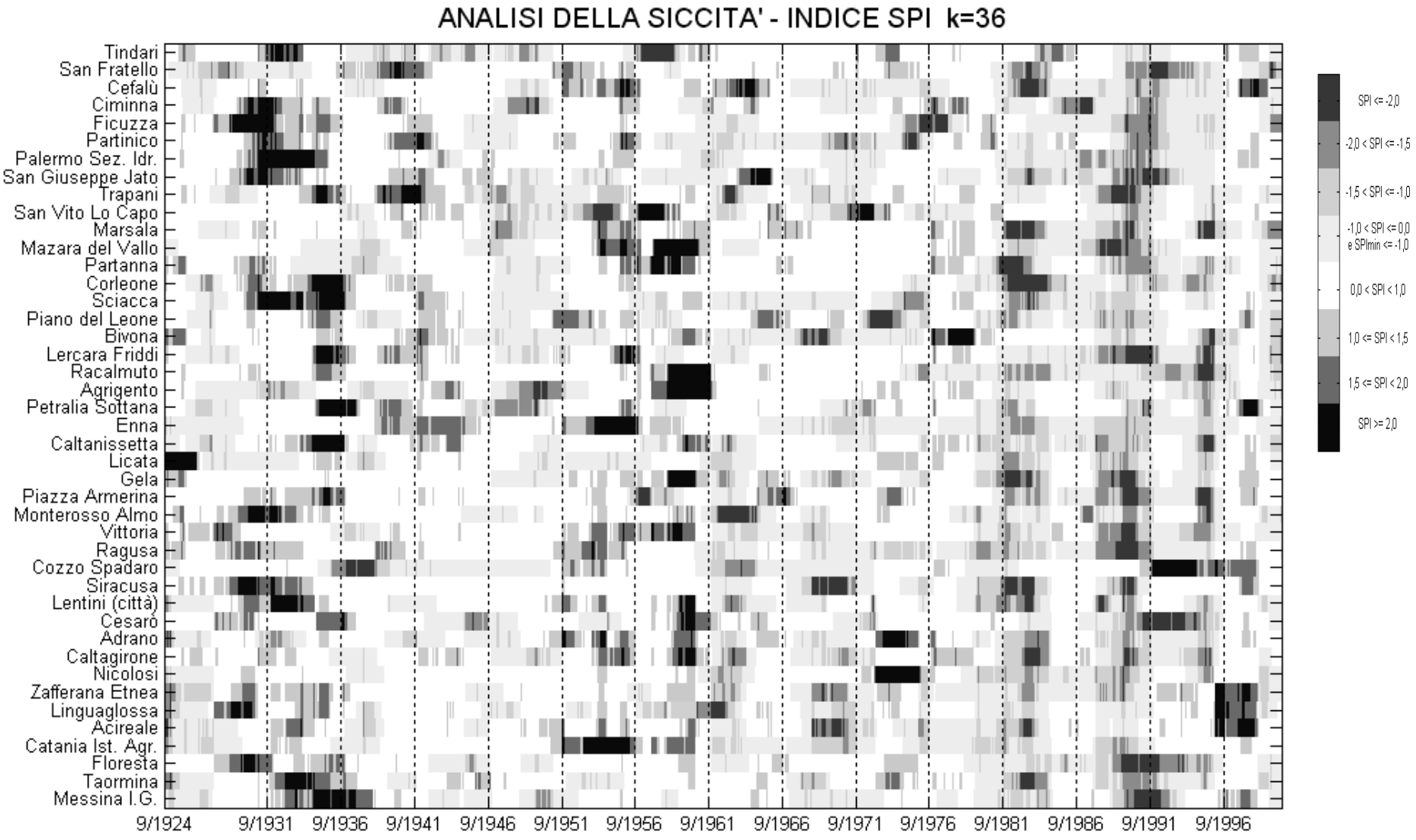
Where: EB=Extremely Bad, VB=Very Bad, B=Bad, MLB=More or Less Bad, M=Moderate, MLG=More or Less Good, G=Good, VG=Very Good, P=Perfect.

Alternatives

A: Status quo
B: Water transfer from Ancipa to Pozzillo reservoir
C: Modernization of the irrigation network
D: Release for irrigation from Lentini reservoir
E: Treated wastewater reuse
F: Construction of small reservoirs by farmers
G: **B+D**
H: **B+E**

Conclusion

- For coping with drought is necessary to shift from emergency management to a pro-active approach.
- The experience gained in the development of a web drought bullettin for Sicily shows that a drought watch system could represent an effective tool for implementing such a pro-active approach.
- Also the lessons drawn from the use of multicriterion analysis for comparing and ranking a mix of long-term and short-term drought mitigation measures in a water supply system confirm that the method is able to describe multiple society's viewpoints and stakeholders interests so to foster the decision making process.


ANALISI DELLA SICCITA' - INDICE SPI k=36
Tindari
San Fratello
Cefalù
Ciminna
Ficuzza
Partinico
Palermo Sez. Idr.
San Giuseppe Jato
Trapani
San Vito Lo Capo
Marsala
Mazara del Vallo
Partanna
Corleone
Sciacca
Piano del Leone
Bivona
Lercara Friddi
Racalmuto
Agrigento
Petralia Sottana
Enna
Caltanissetta
Licata
Gela
Piazza Armerina
Monterosso Almo
Vittoria
Ragusa
Cozzo Spadaro
Siracusa
Lentini (città)
Cesarò
Adrano
Caltagirone
Nicolosi
Zafferana Etnea
Linguaglossa
Acireale
Catania Ist. Agr.
Floresta
Taormina
Messina I.G.
9/1924
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SPI <= -2,0
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-1,0 < SPI <= 0,0 e SPImin <= -1,0
0,0 < SPI < 1,0
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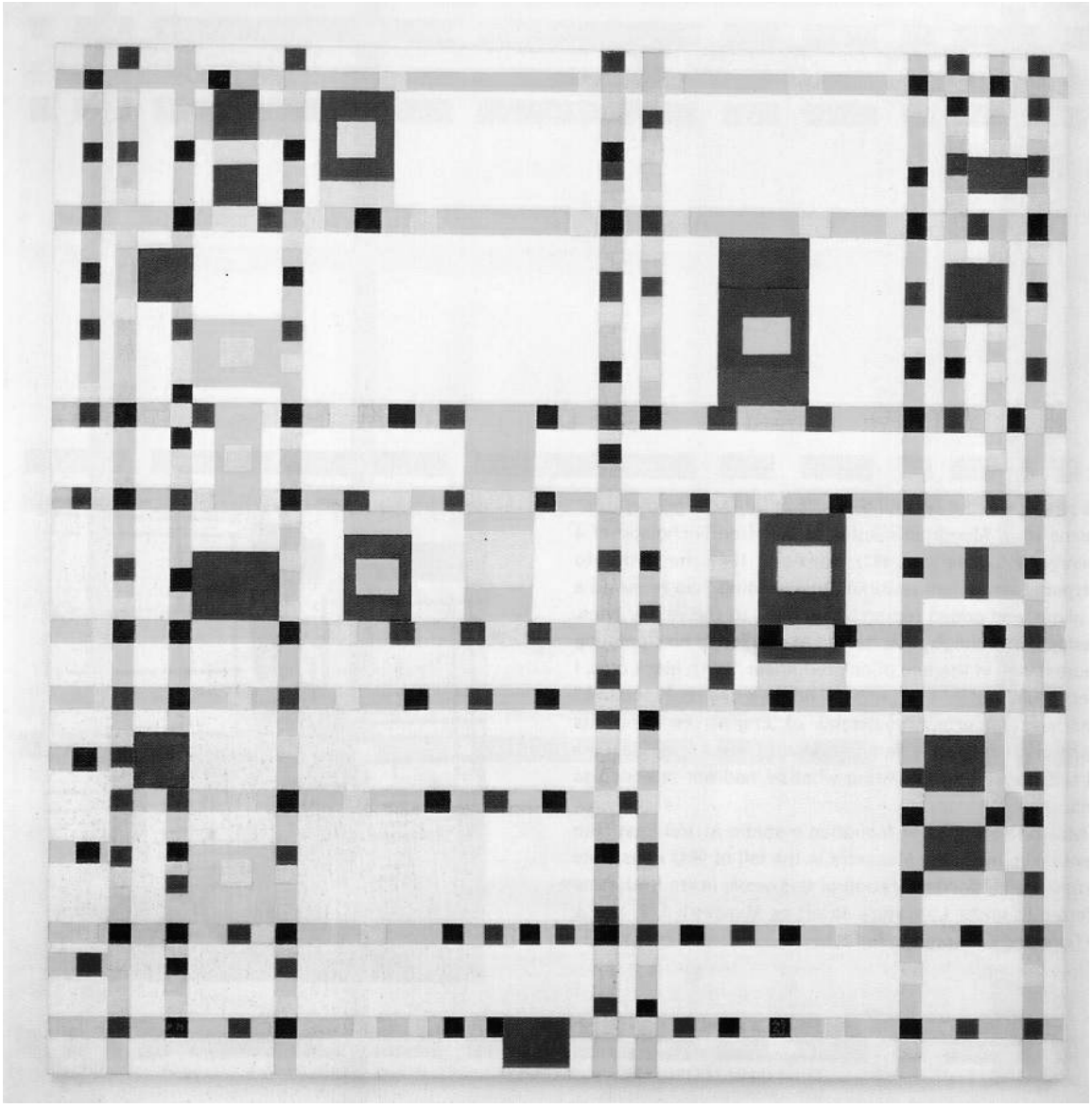
1,5 <= SPI < 2,0
SPI >= 2,0



Piet Mondrian, *Broadway Boogie-Woogie*. 1942-43