net risk work

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA
Autorità di Bacino della Sardegna

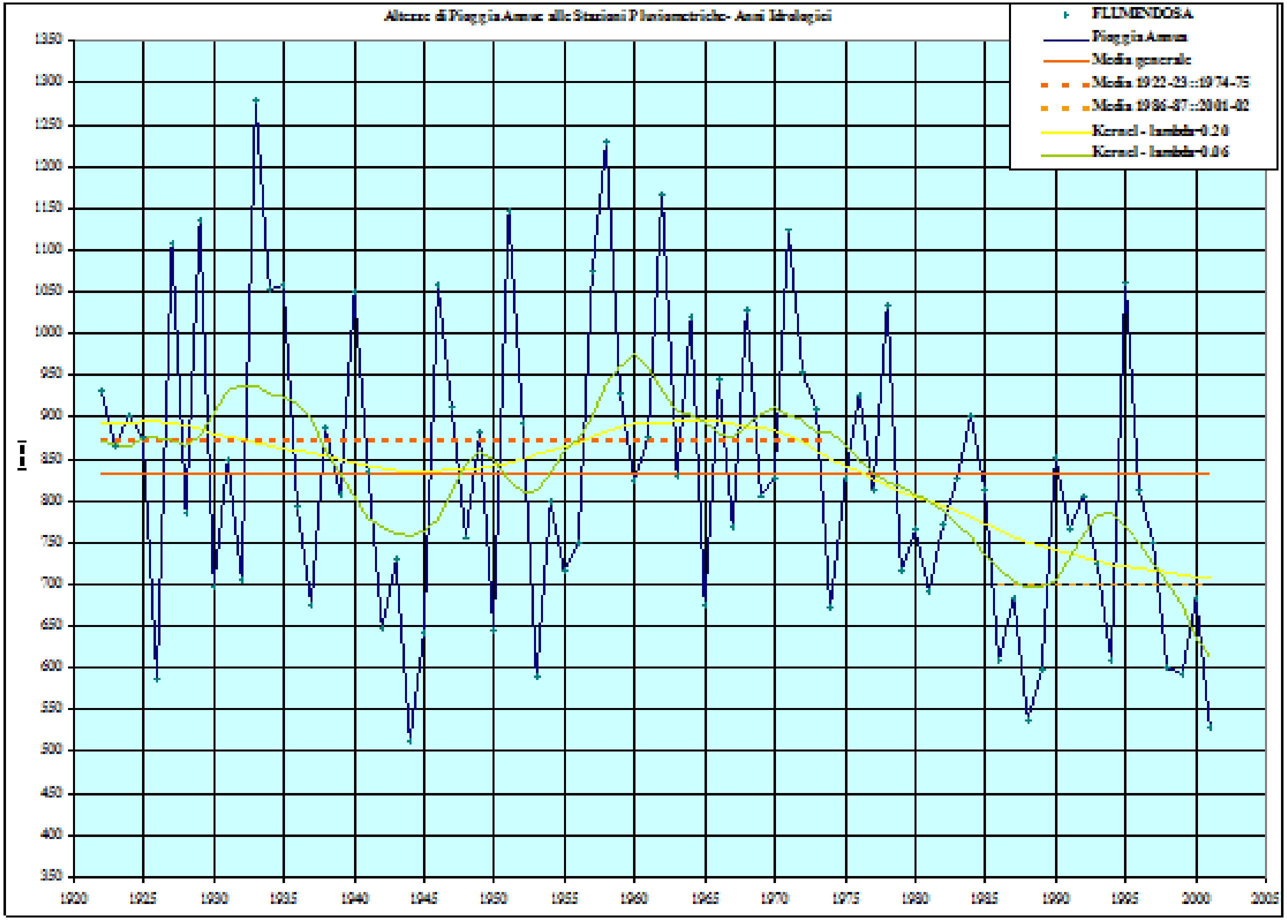
Direzione generale Agenzia regionale del distretto idrografico

Funded by
European Union
Humanitarian Aid
and Civil Protection

Drought Risk Reduction. Framework and practices in Sardinia

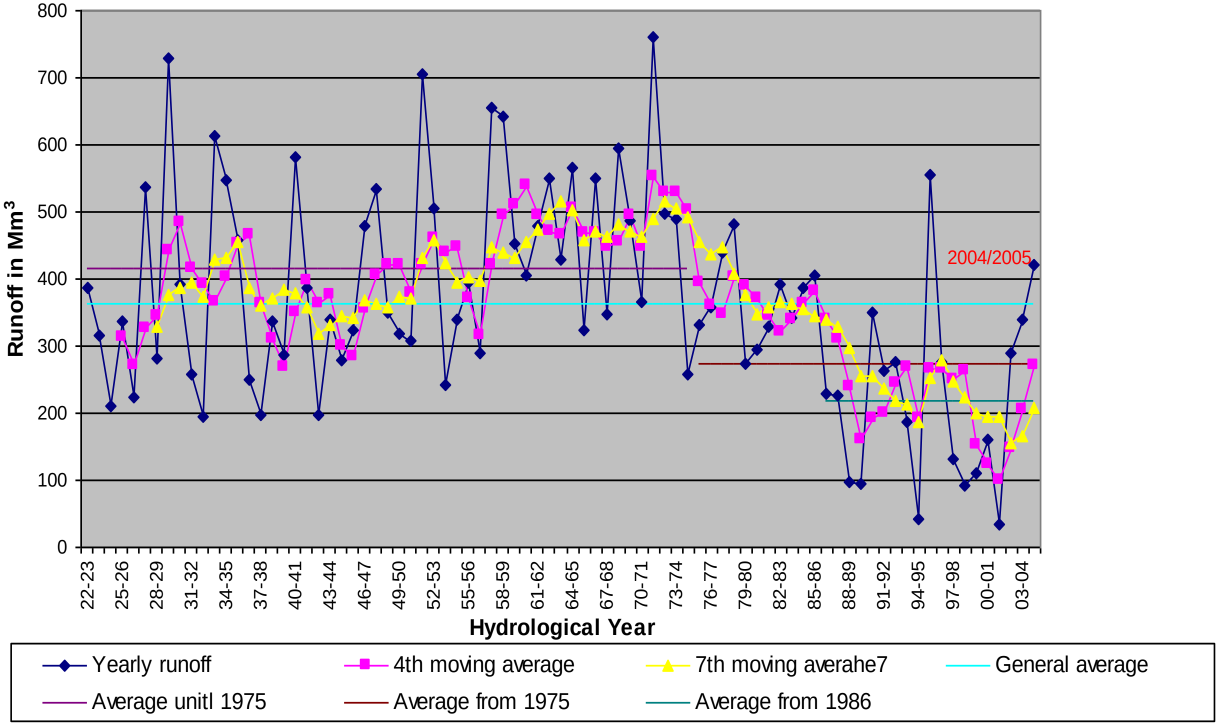
Paolo Botti - Regional Hydrographic Agency of Sardinia

Middle Flumendosa basin – yearly rainfall historical series

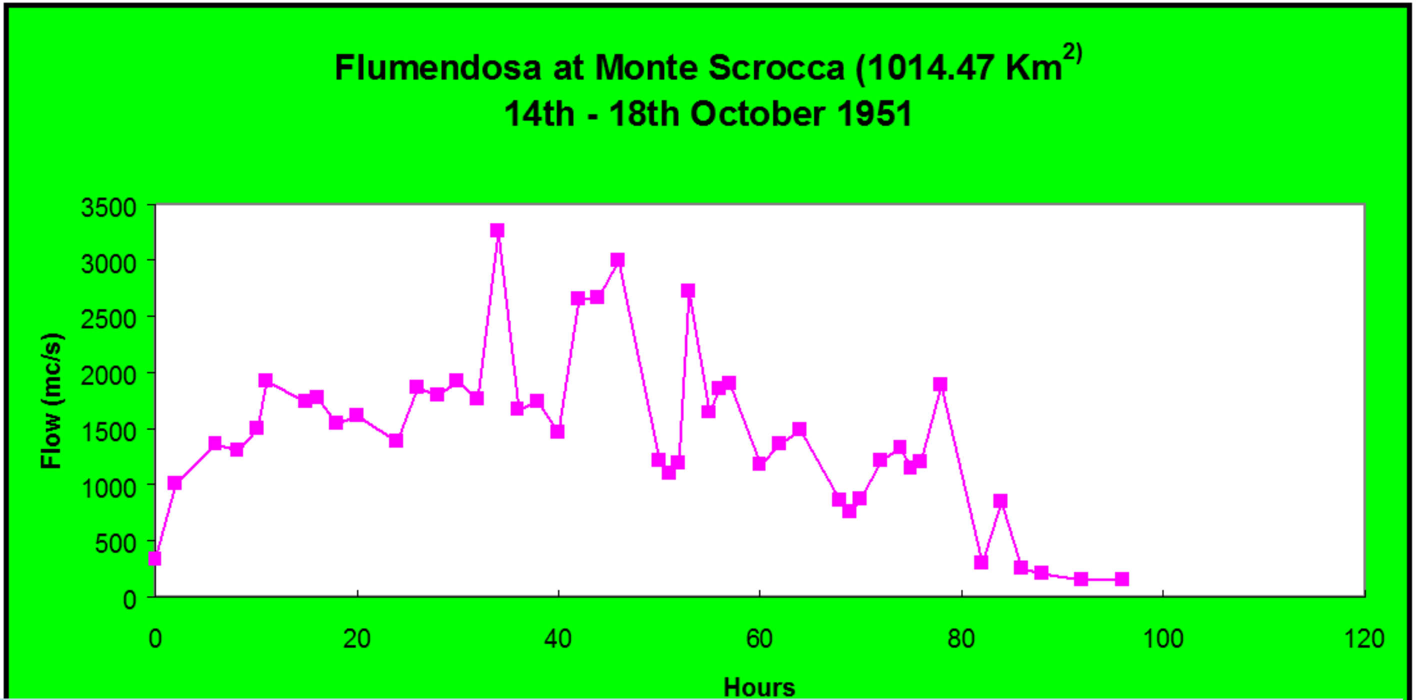


The rainfall distribution is characterized not only by a high variability within the year (wet semester and dry semester) but also by a high annual variability (rainy years and dry years)

Middle Flumendosa basin: runoff hystorical series
(Flumineddu + Flumendosa at N.ghe Arrubiu + Mulargia - Alto Flumendosa)



The characteristic of the rainfall distribution also affects the runoff which is not only almost zero in the four-month period June – September but also presents an even wider annual variability



Middle Flumendosa basin

Q_{av} = 11.5 m^3/s

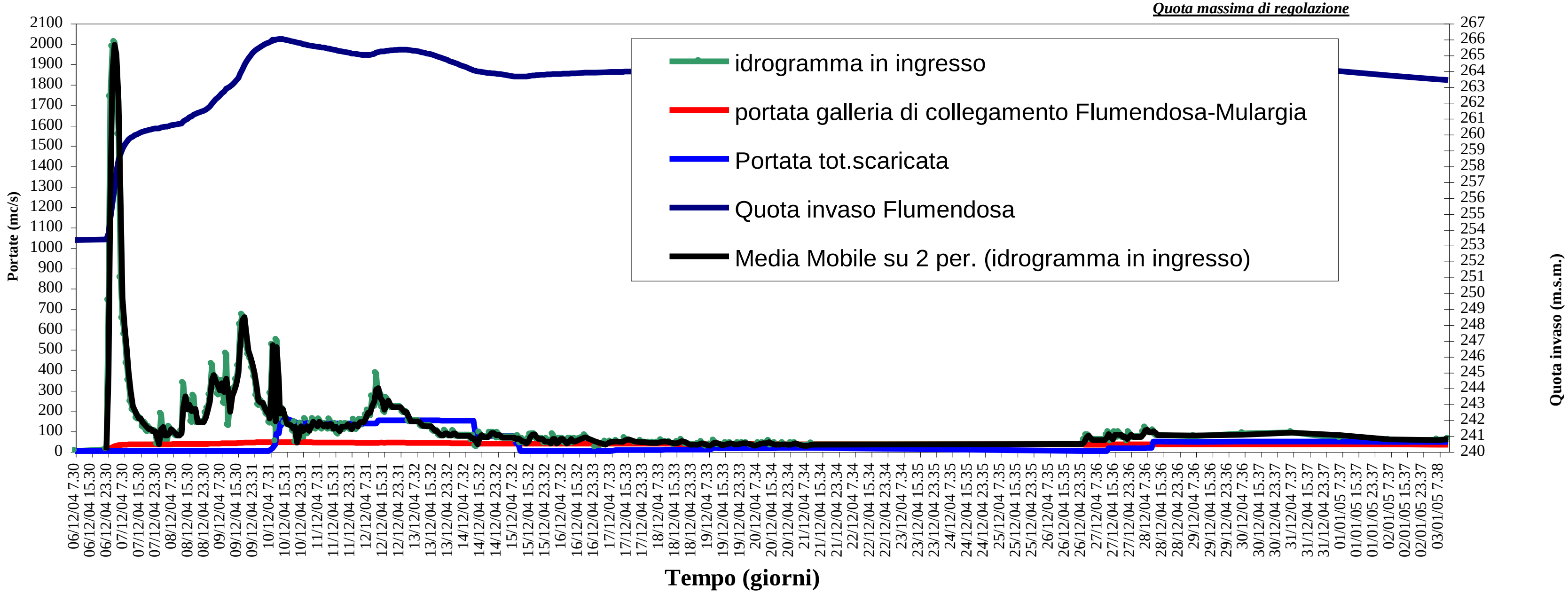
Q_{max}/ Q_{av} = 270 (Po river Q_{max}/ Q_{av} = 8 – Danube river Q_{max}/ Q_{av} = 3)

Runoff 14th - 17th October 51 650 Mm^3

Runoff 1998/99 – 2001/2002 400 Mm^3

Piena 7-10 Dicembre 2004

Idrogramma di piena (sino a Gennaio 2005)



Middle Flumendosa basin

$Q_{av} = 11.5\ m^3/s$

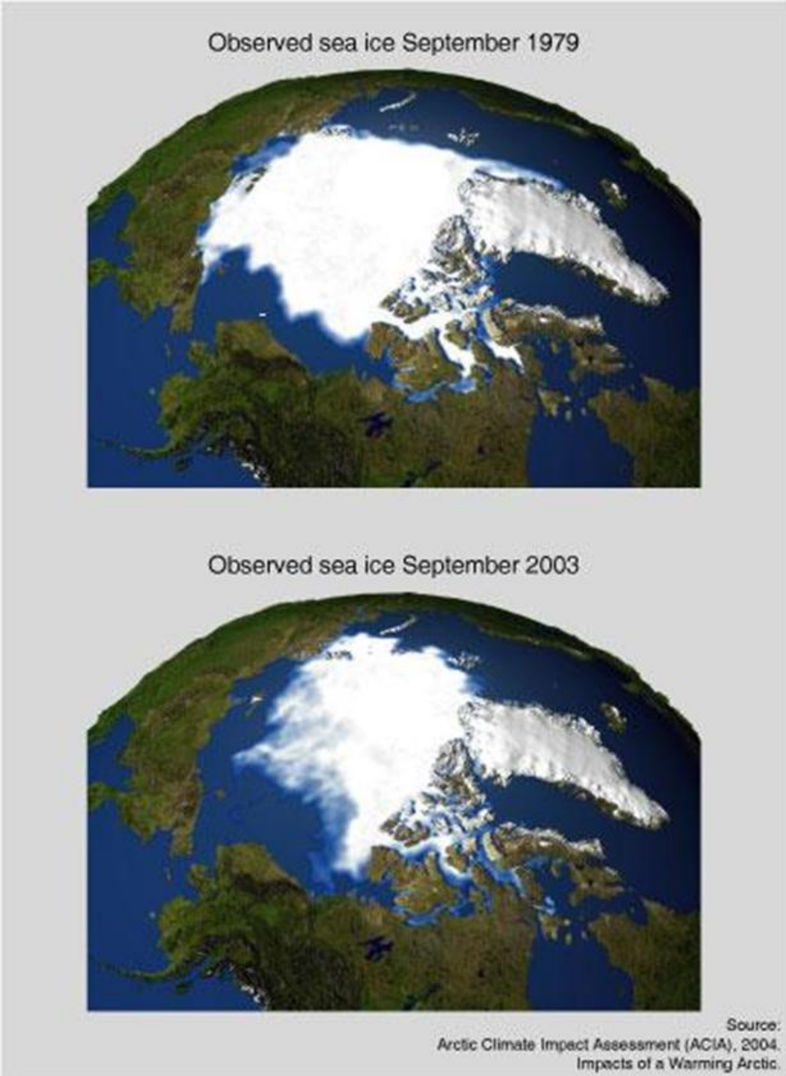
$Q_{max} / Q_{av} = 270$ (Po river $Q_{max} / Q_{av} = 8$ – Danube river $Q_{max} / Q_{av} = 3$)

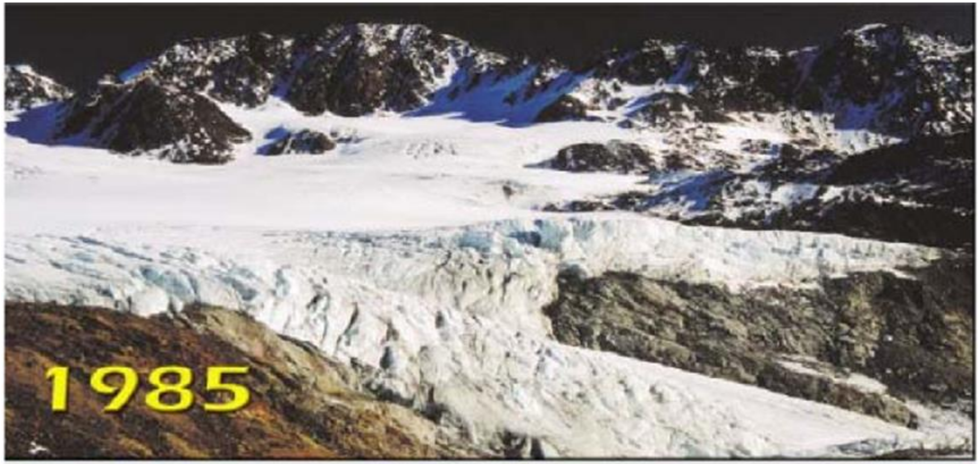
Runoff 7th December 2004 57.4 Mm^3

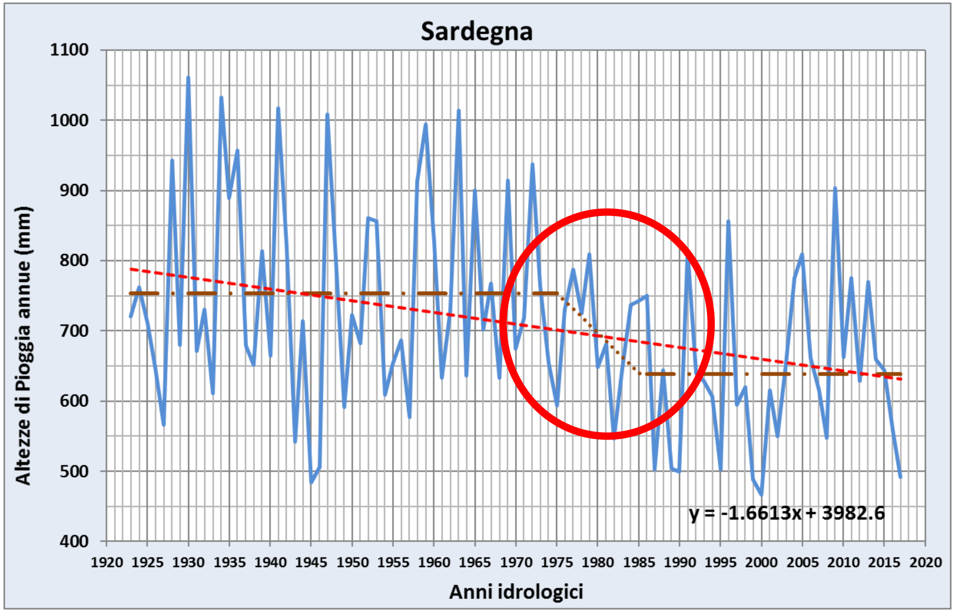
Runoff 2001/2002 34.8 Mm^3

Floods and drought – the two sides of the same coin

Climate changes ?







The analysis of the hydrological series for the last 94 years (1922/23 - 2016/17) shows that both the rainfall and the runoff are not stationary, as is clearly shown by the statistical tests. Rainfall decreases on average by about 1.66 mm/year.

Moreover, with regard to the Rainfall – runoff transformation, the runoff is very sensitive to any rainfall reduction

Mean water balance 1922-1975

Rainfall 755 mm - Runoff 230 mm

Mean water balance 1985-2017

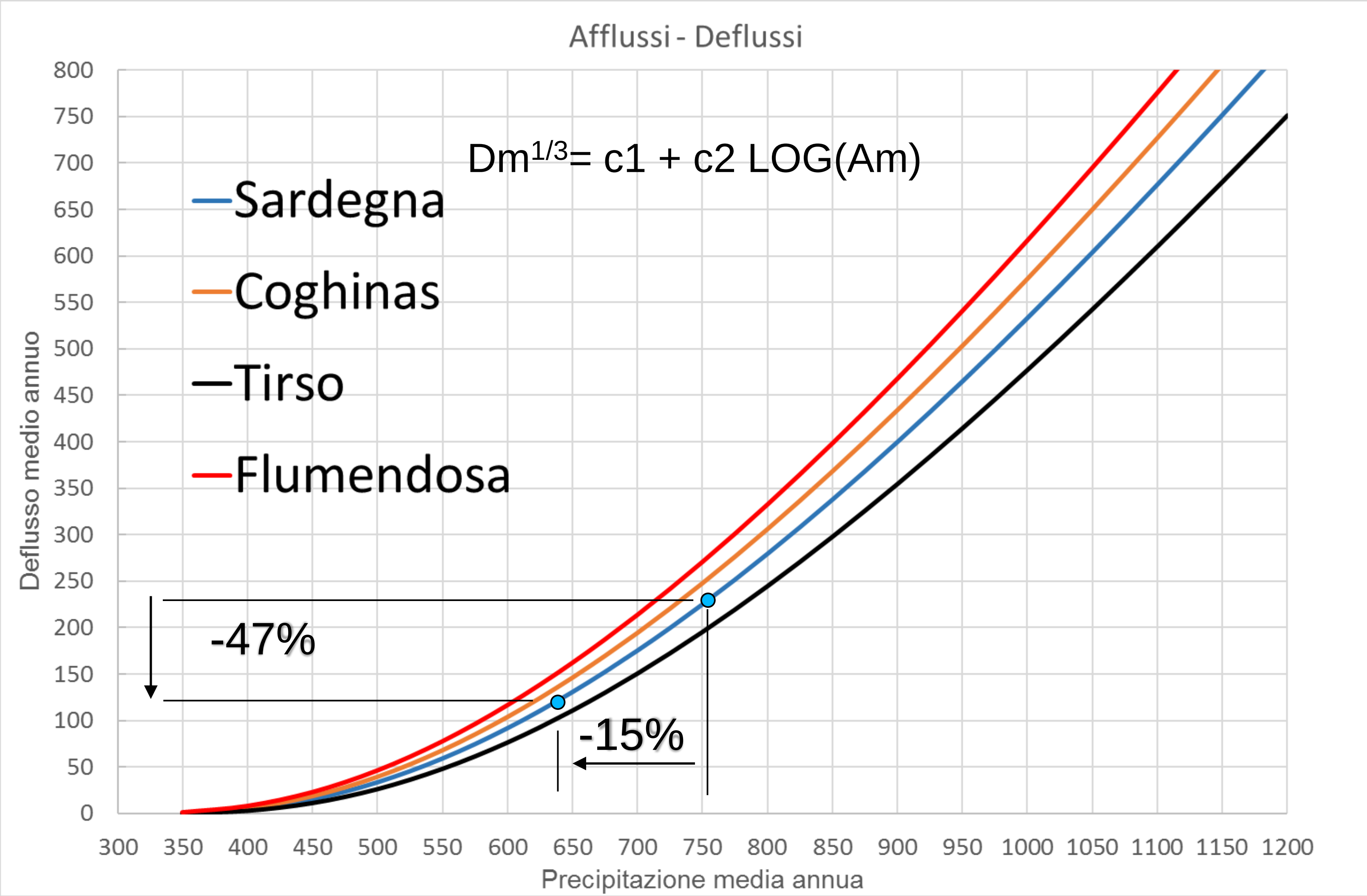
Rainfall reduction: 15%

Rainfall 639 mm - Runoff 122 mm

RUNOFF REDUCTION: 47%

Climatic changes ?

Heavy consequences in the different water use


Afflussi - Deflussi
$Dm^{1/3}$= c1 + c2 LOG(Am)
Sardegna
Coghinas
Tirso
Flumendosa
-47%
-15%
Deflusso medio annuo
Precipitazione media annua
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200

The Sardinian water supply system is mainly based on reservoirs due to the lack of significant underground resources.

Total number: 34
Total capacity: 2.289,7 m^3
Allowed capacity : 1.764,8 Mm^3

Total volume stored at 12th April 2018

1295,7 Mm^3 (71%)

With regard to the common criteria used to evaluate complex hydraulic systems, Sardinian system is characterized by:

LOW RELIABILITY: the probability of being in a satisfactory situation

HIGH VULNERABILITY: the extent of maximum damage in critical situations

LOW RESILIENCE: return speed to a satisfactory state; average probability of recovery

The Multi-Sectoral Regional Water System - SIMR

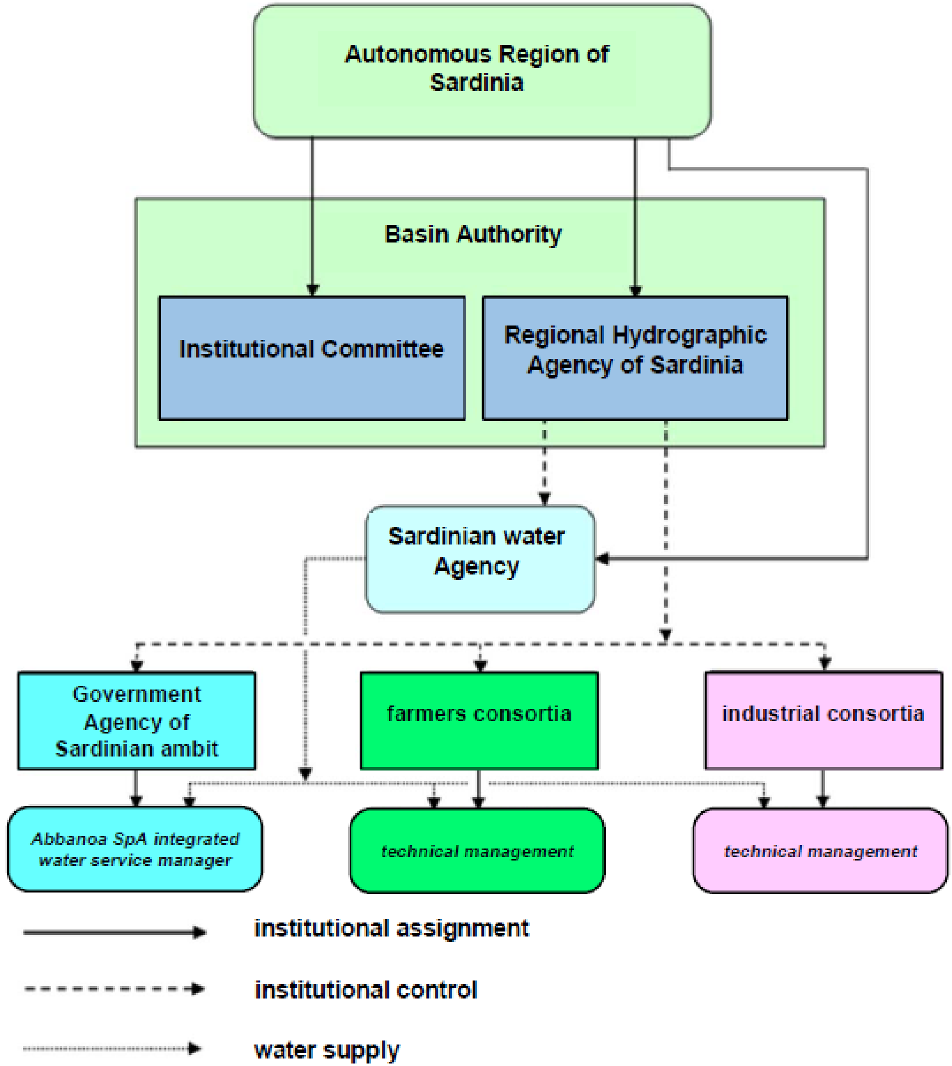
Main normative references :

- EU Directive 2000/60/CE - Water Framework Directive

- Decreto legislativo 152/2006 – Norme in materia ambientale

- L.R. n. 19/2006 - Disposizioni in materia di risorse idriche e bacini idrografici

- L.R. n. 6/2008 (Legge - quadro in materia di consorzi di bonifica)



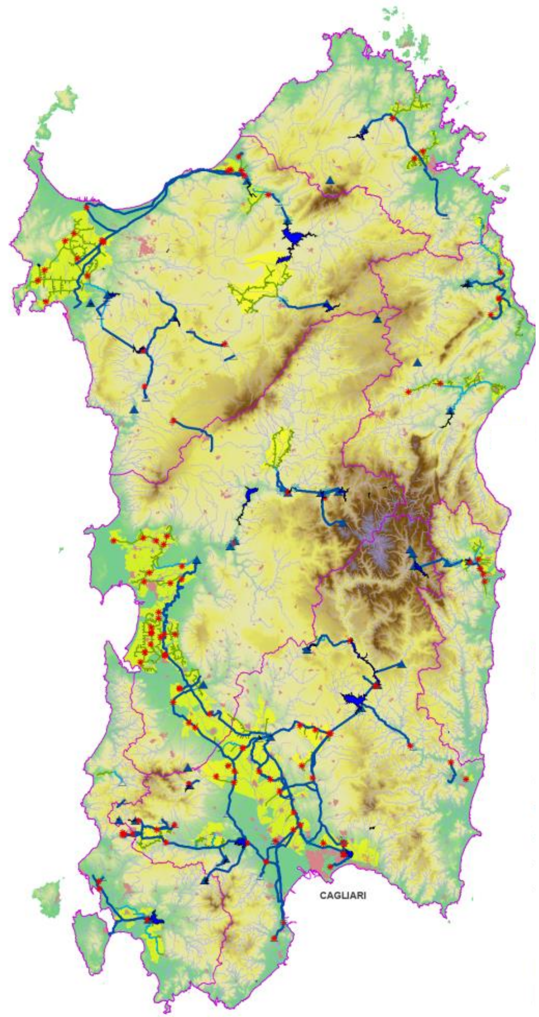
The Multi-Sectoral Regional Water System - SIMR

Water volumes provided by SIMR - 2017

Drinking use	218 Mm^3
Agricultural use	472 Mm^3
Industrial use	22 Mm^3
TOTAL	712 Mm^3

ESTIMATE of water volumes not belonging to the SIMR (wells, springs, surface waters) provided annually

Drinking use	70 Mm^3
Agricultural use	300 Mm^3
Industrial use	5 Mm^3
TOTAL	375 Mm^3



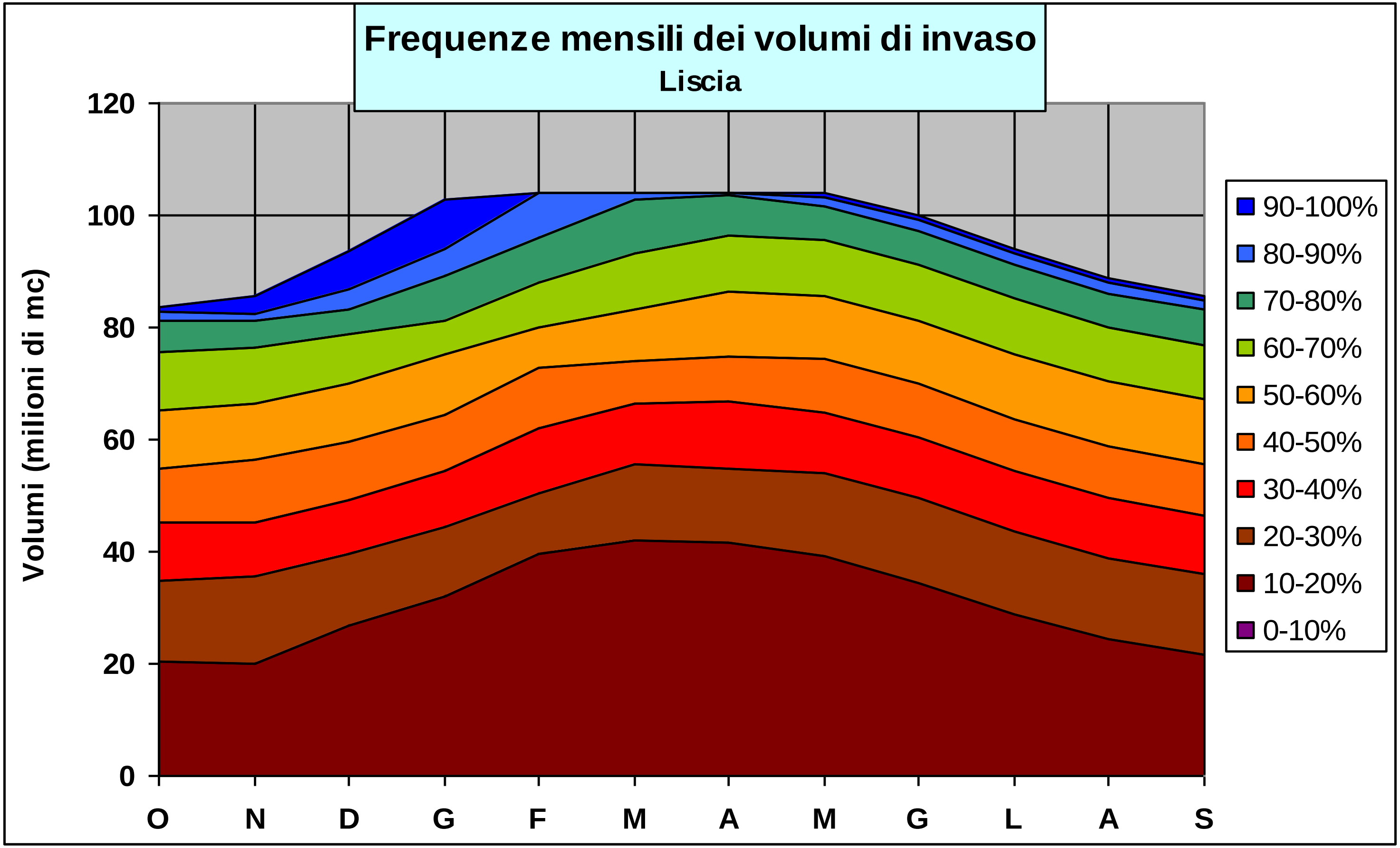
The Island has been divided in seven hydrographic zones called “Sistemi”

Sistema 1 – SULCIS, 1.646 km^2;
Sistema 2 – TIRSO, 5.372 km^2;
Sistema 3 – NORD OCCIDENTALE, 5.402 km^2;
Sistema 4 – LISCIA, 2.253 km^2;
Sistema 5 – POSADA-CEDRINO, 2.423 km^2;
Sistema 6 – SUD ORIENTALE, 1.035 km^2;
Sistema 7 – FLUMENDOSA-CAMPIDANO-CIXERRI, 5.960 km^2.

METHODOLOGY FOR THE ANALYSIS AND TUNING OF A SYSTEM OF INDICATORS FOR MONITORING AND PRE-ALARM OF DROUGHT

1. **Implementation of a monthly time step simulation model of the entire regional system.**
2. **Definition of the input hydrological series to the sections of interest.**
3. **Definition of the volumes that can be delivered by each system and sub-system with the simulation model, optimizing the management rules and establishing a minimum stock in the reservoirs equal to at least one year of the drinking request.**
4. **Generation of synthetic series to the 58 sections of interest, of 500 years duration, that respect the imposed parameters: averages, deviations and spatial correlation matrix.**
5. **Simulation of the regional multisectoral water system, with the runoff synthetic series as input variables and with the water supply and status variables as outputs of the simulation: among these, the synthetic series of monthly stored volumes in the 34 reservoirs, extended for 500 years, is of particular interest.**
6. **Calculation of the stored volumes not exceeding frequencies in each reservoir (or of the sum of the stored volumes in the interconnected reservoirs) for each month of the year: STATUS INDICATOR.**

RESULTS - CONSTRUCTION OF INDICATORS



http://www.sardegnacedoc.it/invasi

ALERT POINTS IN ACCORDANCE WITH THE RESERVOIRS STATUS INDICATORS

ORDINARY REGIMEN (normal situation) I = 0,5 – 1	**management according to the general planning guidelines**
WATCHFULNESS LEVEL (pre alert) I = 0,3 - 0,5	**it is necessary to monitor the climatic parameters to promptly estimate the trigger of any fluctuations; at the same time, consumption should be controlled, with a first level of reduction that produces very limited disadvantages to the users**
DANGER LEVEL (alert) I = 0,15 - 0,3	**the supply must be reduced on average, according to the priority categories of uses, in order to proactively manage any persistence of the dry period; at the same time the planned mitigation measures must be activated**
EMERGENCY LEVEL I = 0 - 0,15	**in this field should not be entered, as a result of the supply reduction of the previous points. It is necessary, however, to activate further supply restrictions; if emergency levels occur and, previously, the planned measures have been observed, this could mean that the statistical parameters of the series have been further modified and, consequently, the average eligible supply under ordinary regime must be reassessed.**

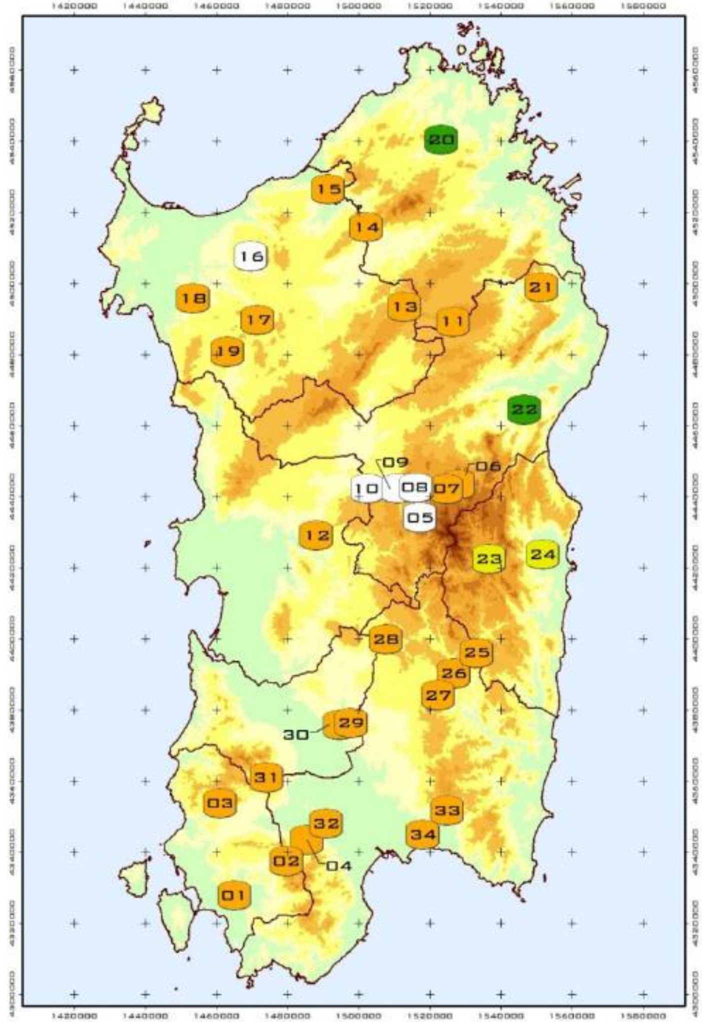
Situation al 31st March 2018

http://www.sardegnacedoc.it/invasi/

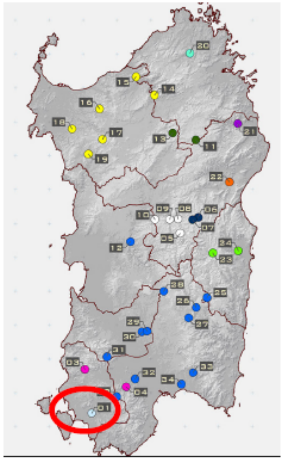
SITUAZIONE ATTUALE DEGLI SCHEMI IDRICI DEL SISTEMA MULTISETTORIALE REGIONALE
INDICATORI DI STATO PER IL MONITORAGGIO DELLA SICCITA'

Volumi [Mm^3]

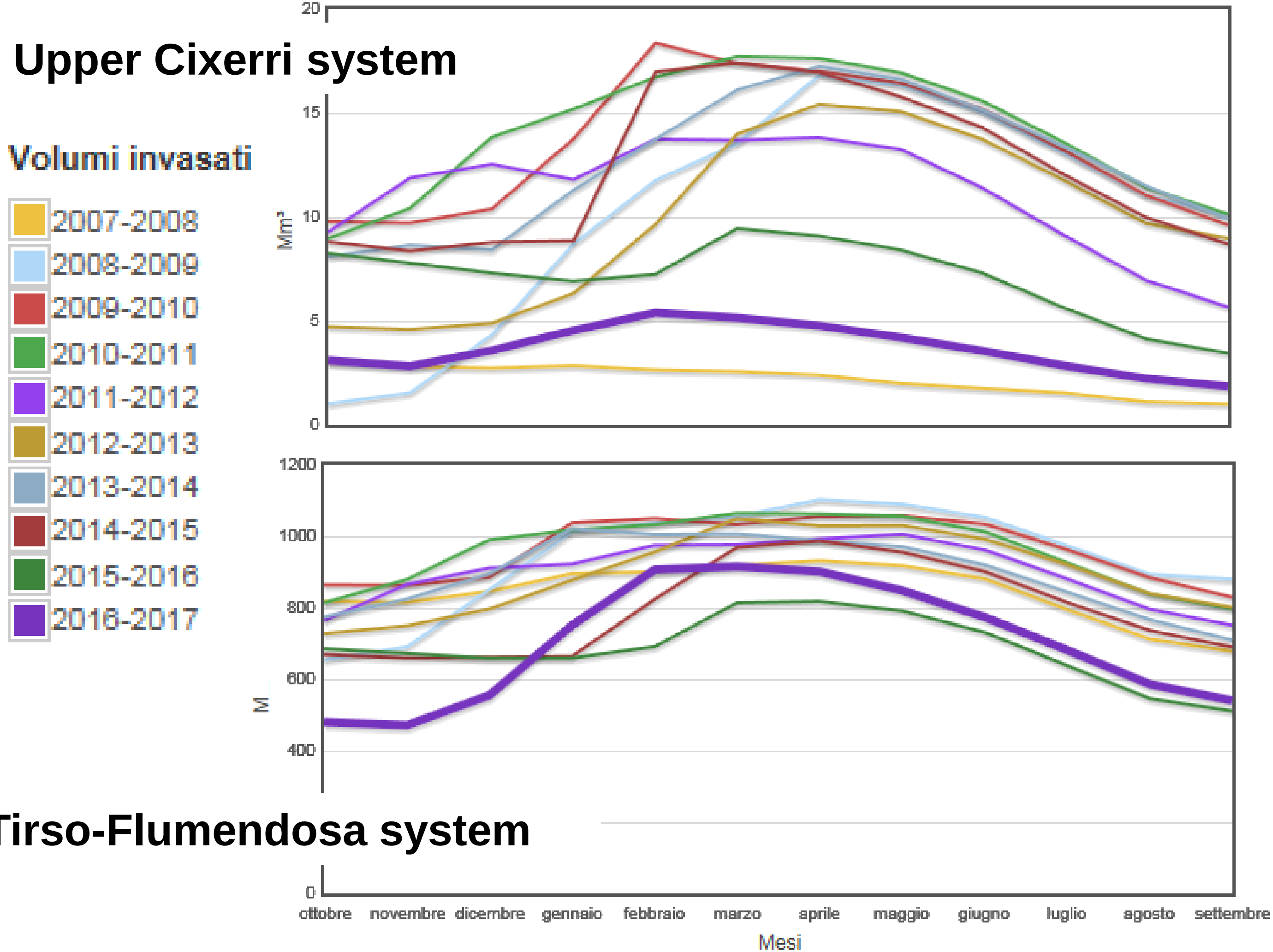
Sistema Idrico	Cod	INVASO	Volume di regolazione autorizzato	Situazione attuale 31 marzo 2018			Volume di regolazione da modello di simulazione
				Volume invasato	%	Indicatore di stato simulato	
Basso Sulcis	1	MONTE PRANU	49.30	20.89	42.37	0.18	49.30
Alto Cixerri	3	P.TA GENNARTA	18.30	5.69	31.09	0.16	19.40
	4	MEDAU ZIRIMILIS					
Alto Taloro	6	OLAI	9.59	6.71	69.94	0.19	19.26
	7	GOVOSSAI					
Alto Coghinas	13	MONTE LERNO (PATTADA)	37.98	30.01	79.02	0.24	75.42
	11	SOS CANALES					
Nord Occidentale	14	MUZZONE (COGHINAS)	328.79	252.01	76.65	0.28	323.85
	15	CASTELDORIA					
	16	BUNNARI ALTA					
	17	BIDIGHINZU					
	18	CUGA					
	19	M. LEONE ROCCADORIA (TEMO)					
Gallura	20	CALAMAIU (LISCIA)	104.00	81.63	78.49	0.58	104.00
Posada	21	MACCHERONIS (POSADA)	22.00	22.33	101.50	0.30	25.00
Cedrino	22	PEDRA E OTHONI (CEDRINO)	16.03	15.63	97.50	0.84	16.05
Ogliastra	23	BAU MUGGERIS (Flumendosa)	61.25	54.94	89.70	0.37	61.47
	24	SANTA LUCIA					
Tirso -Flumendosa	2	BAU PRESSIU	1040.88	692.47	66.53	0.24	1138.48
	25	CAPANNA SILICHERI (Flumineddu)					
	26	NURAGHE ARRUBIU (Flumendosa)					
	27	MONTE SU REI (Rio Mulargia)					
	28	IS BARROCUS (Fluminimannu CA)					
	29	SA FORADA DE S'ACQUA					
	30	CASA FIUME					
	31	MONTE ARBUS (Rio Leni)					
	32	GENNA IS ABIS (Rio Cixerri)					
	33	CORONGIU 3					
	34	SIMBIRIZZI					
	12	OMODEO (Tirso a Cantoniera)					
Sardegna		Tutti i serbatoi	1764.80	1245.93	70.60	0.25	1907.63

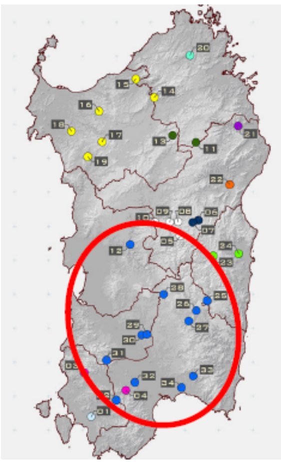


Historical analysis of the status indicators



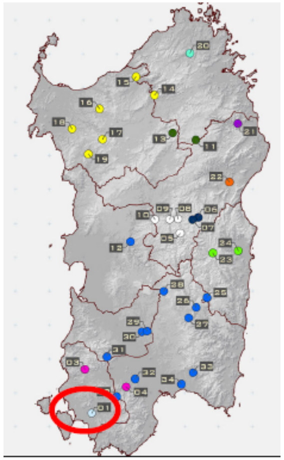
Upper Cixerri system

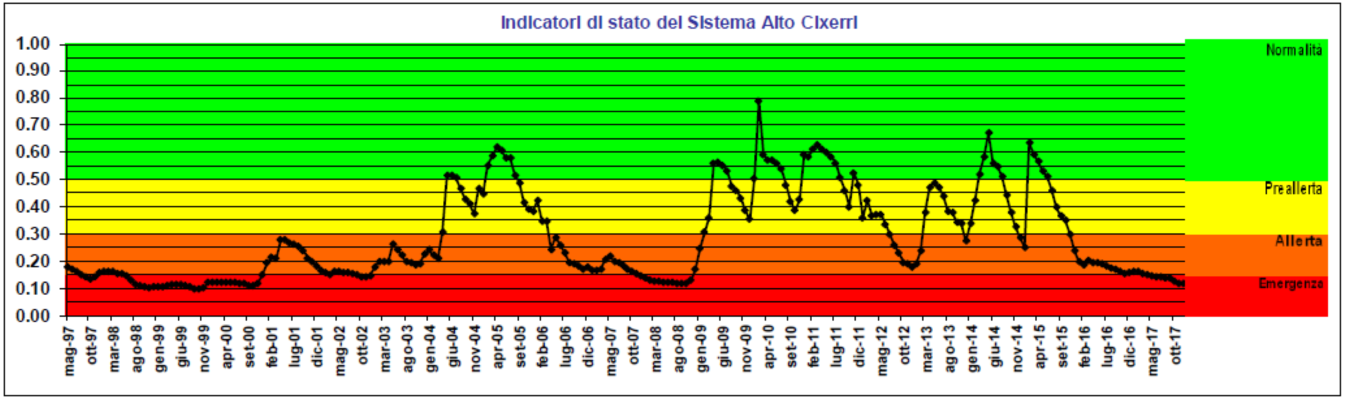


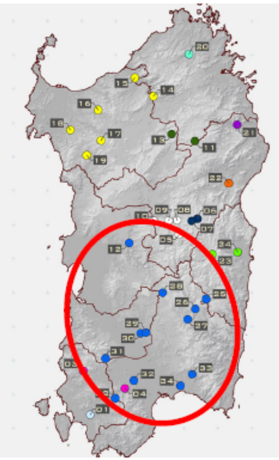


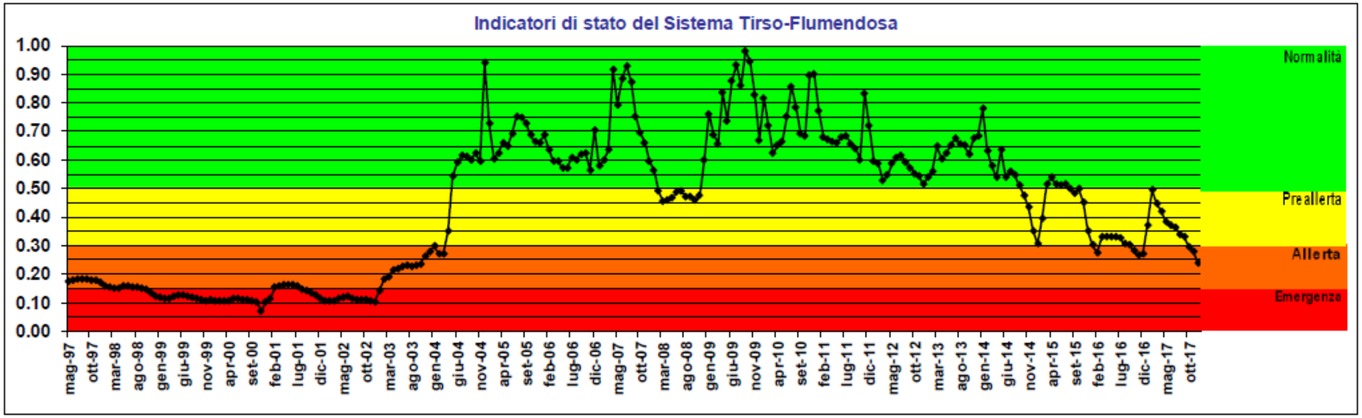
Tirso-Flumendosa system

Historical analysis of the status indicators

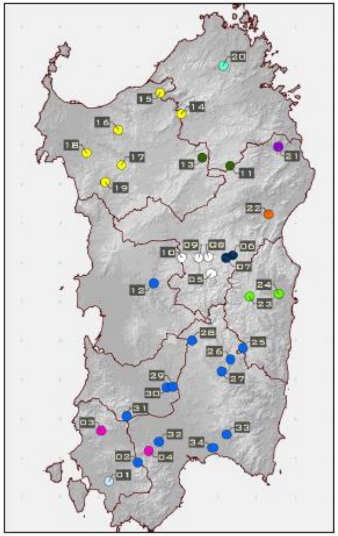


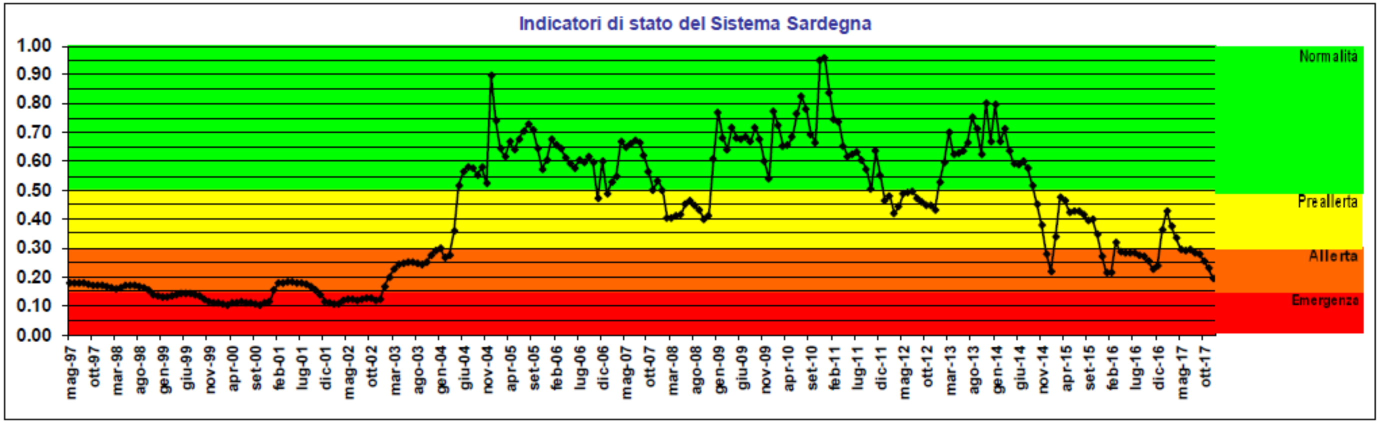


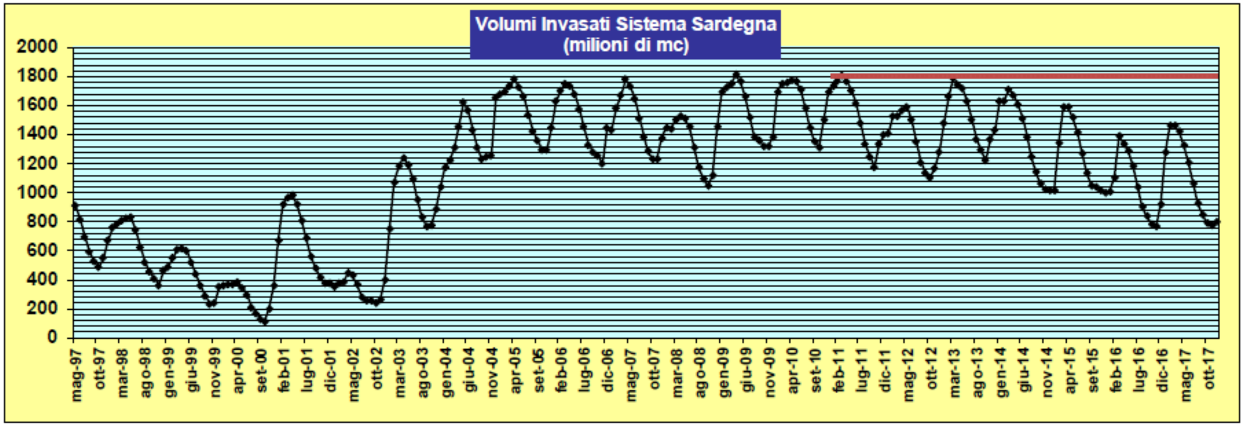




Historical analysis of the status indicators - Sardinia



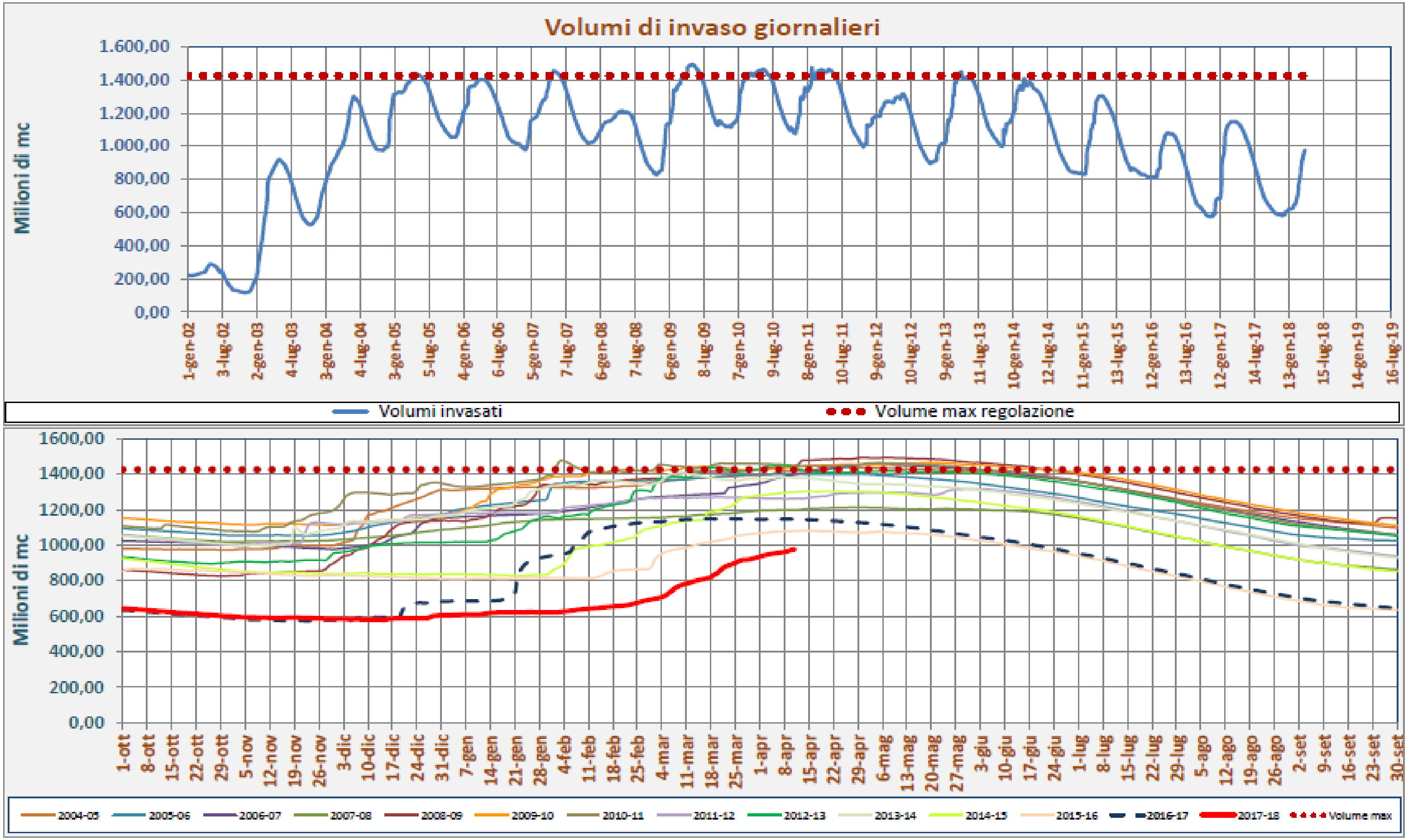




Water stored in the SIMR system reservoirs

Situazione delle riserve idriche - Serbatoi artificiali ENAS

INVASI SIMR



BALANCE Resources-Needings for different hydrological scenarios

The results show that if we still had the historical hydrology 1922-1975 the balance between resources and current potential needs (population, areas equipped for irrigation, industrial areas) would not only be in equilibrium but would allow further development of irrigated areas. In the most recent hydrological scenario, on the other hand, there is an average annual deficit of about 220 million m^3 which almost exclusively penalizes agriculture, considering that the exclusive hydroelectric use is practically zeroed.

This requires specific attention in setting the management rules, since the possibility of supplying is lower than the potential demand (from which conflicts between uses arise) and the recording of possible climatic fluctuations requires the use of several indicators that, in real time, allow the whole system to be monitored.

Another aspect to underline is that between the two scenarios the average regional utilization coefficient goes from 42% to 63%. Such a high value demonstrates the importance of defining reliable operating rules, indicating, however, a high vulnerability and a low resilience of the regional water supply system.

Conclusions

The application of the methodology summarized above for the Sardinia Multi-sector Water System has given good results over the last decade and through this tool it has been possible to identify, from time to time, the areas of crisis and the mitigation measures to apply.

- It is preferable to anticipate resource deficits, especially where costs are not a linear function of the deficit; therefore it is preferable to have several years with a moderate shortage rather than a single year with a high deficit.

- The duration of the water crisis may be in the order of months or even years. At the time of planning, in such circumstances, it is always very difficult to assess the volumes for the different uses and thanks to hydrological studies and forecasting models it is possible to identify the most suitable choices.

The measures to tackle a water crisis are typically a combination of structural and non-structural interventions, including, for example

- Use of alternative resources
- Construction of emergency infrastructures
- Implementation of the levels of supply established in the Crisis Management Plan (restrictions, reductions)
- Combined use of superficial and underground resources
- Integration of the emergency plan with other mitigation measures (eg socio-economic measures)
- Measures of Civil Protection in situations of particular emergency

Thank you for your kind attention

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

Sardinian Basin Authority

Regional Hydrographic Agency of Sardinia

pres.ab.distrettoidrografico@regione.sardegna.it
pres.ab.distrettoidrografico@pec.regione.sardegna.it