Are vulnerability indices to drought useful tools in order to evaluate the status of a water supply system?

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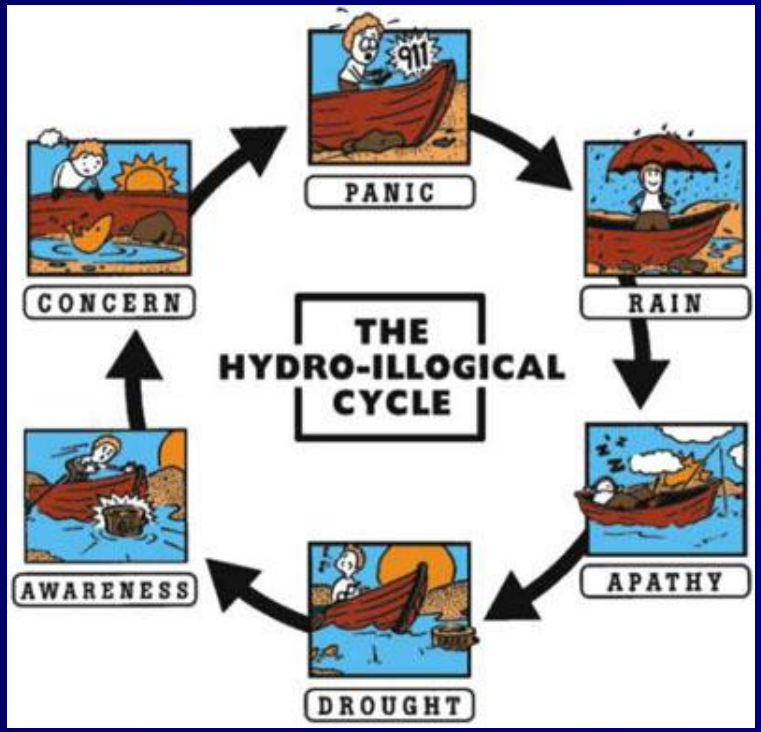
Water managers perception



from I.R. Tannehill, *Drought: Its Causes and Effects*, Princeton University Press, Princeton, New Jersey, 1947)

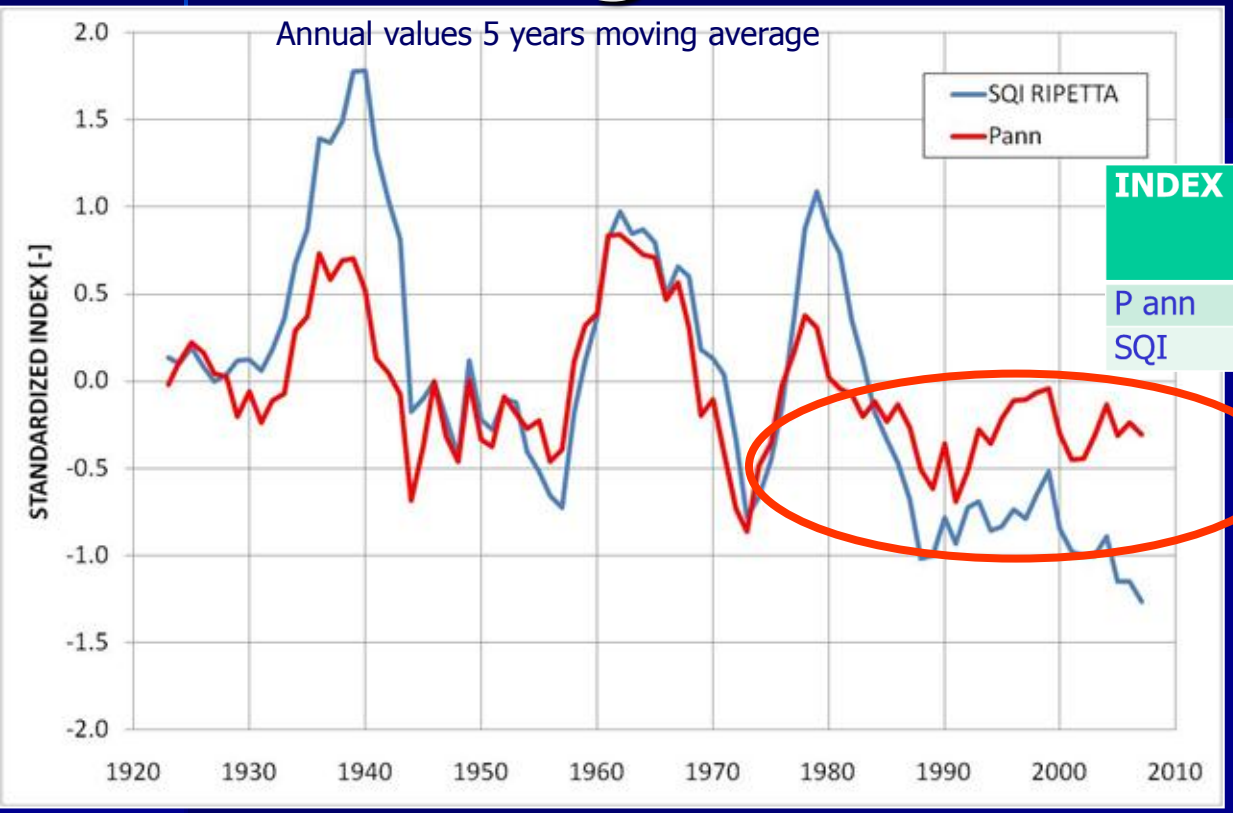
- "The future is no longer what it used to be"
- Water resources availability can fail in an unexpected manner
- SCENARIOS are needed in which severe drought conditions are expected for the assessment of water supply system vulnerability and evaluation of possible mitigation options
  - → Feasible (costs and timing)
  - → Acceptable from a socio-economic and environmental point of view

Research questions

- How to assess the vulnerability of a water supply system? Which nodes are most sensitive to droughts?
- How to evaluate the effects of the mitigation options?
- How to provide a comprehensive and easily understandable information to stakeholders/public?

This research was founded by the Tiber River basin Authority (SICCITA', 2006-2009)

Standardized precipitation and discharge in the Tiber basin

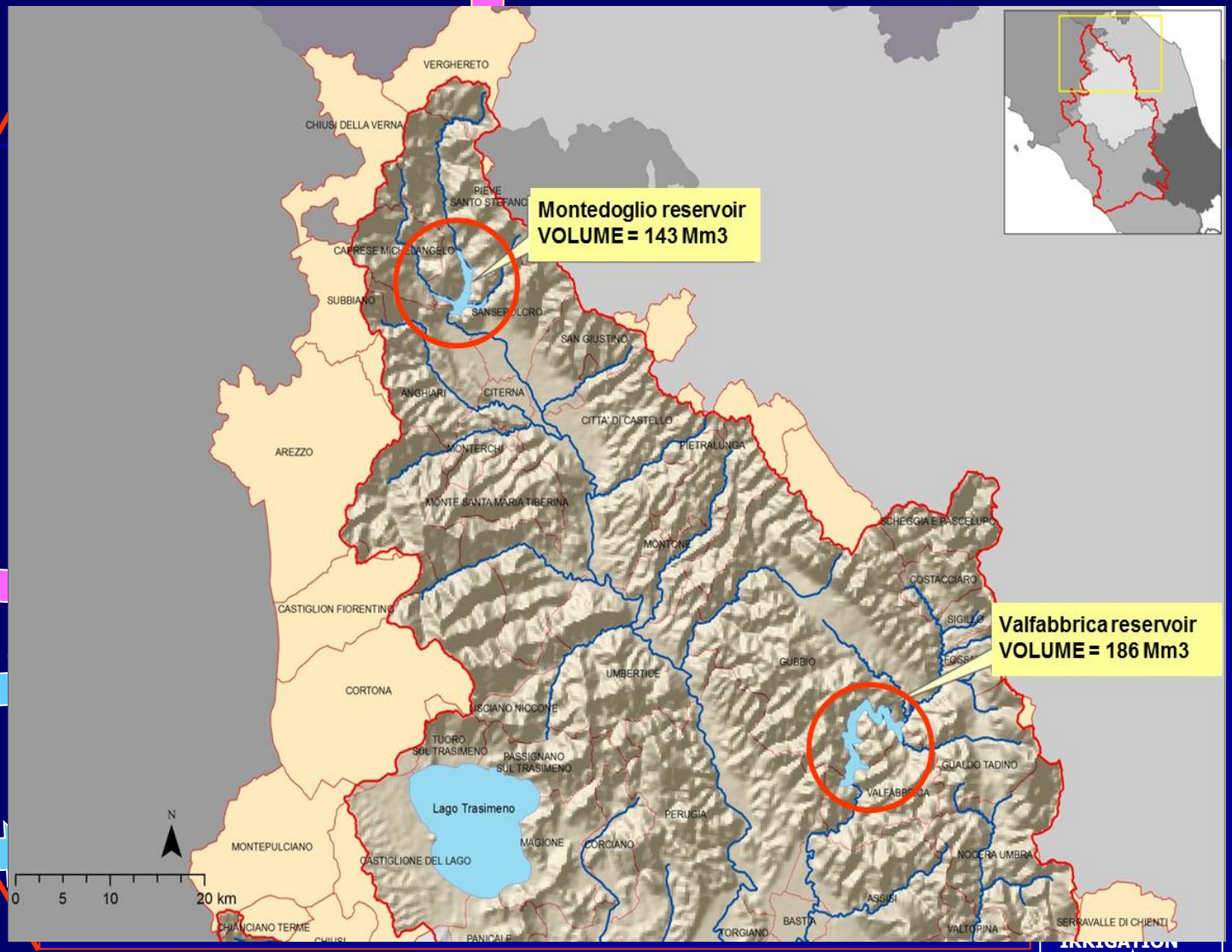


INDEX	VARIABLE	TREND 1952-2008 [%]	TREND 1922-2008 [%]
P ann	Rainfall	-8.4	-11.4
SQI	Discharge	-22.1	-37.6

- Good correlation (R^2 = 0.58) between the Tiber discharge index and P_{ann}.
- Decreasing trends result to be significant at the 95% of confidence
- Steeper trends for the period 1922-2010 than for the period 1952-2008 both for rainfall and discharge

(Romano et al. 2011)

Case study: the upper Tiber basin

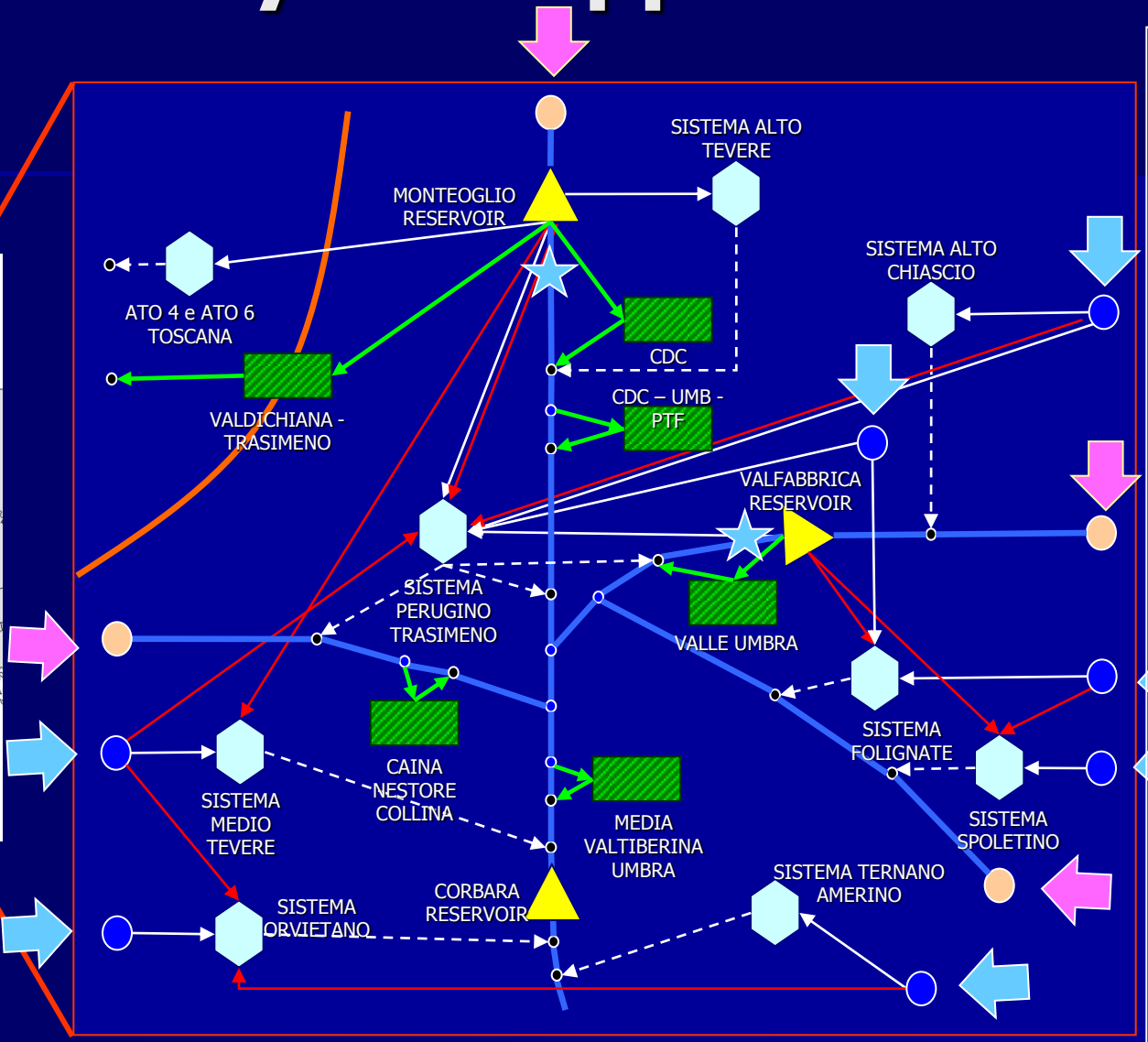


18 users nodes (9 civil use; 7 irrigation; 2 environmental)

IRRIGATION USER

ENVIRON. USER

Case study: the upper Tiber basin



GROUND WATERS INPUT

SURFACE WATERS INPUT

RESERVOIR

RIVER NETWORK

CIVIL CONNECTION

EMERGENCY CONNECTION

CIVIL WASTEWATER SINK

IRRIGATION CONNECTION

IRRIGATION RETURN

CIVIL USER

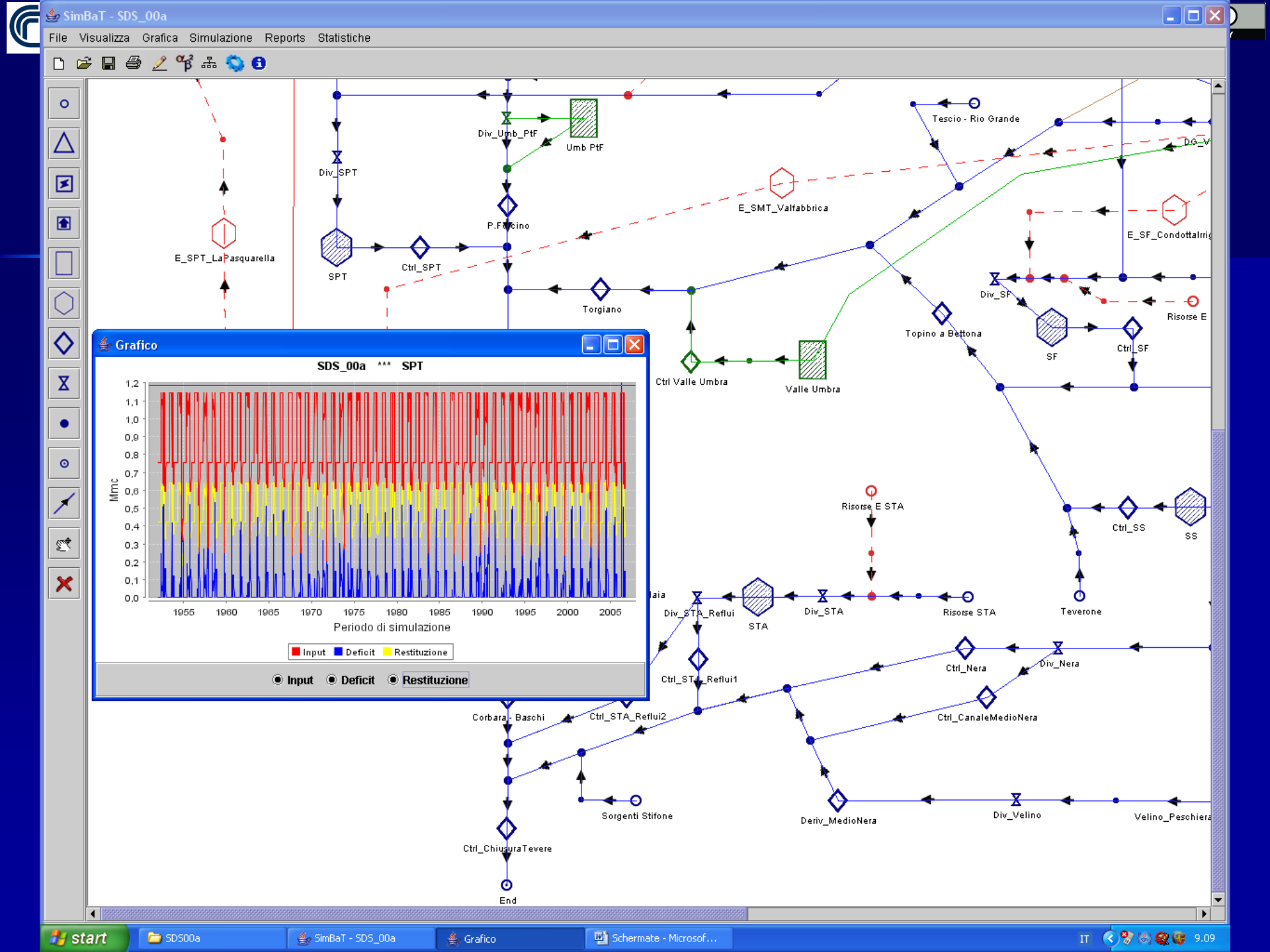
IRRIGATION USER

ENVIRON. USER

18 users nodes (9 civil use; 7 irrigation; 2 environmental)

Water balance model

- Simulation code: SimBaT (Pierleoni et al. 2007)
- The water supply system is conceptualized into a flow network in which water resources and water users (nodes) are connected through arcs (water courses, channels, pipelines). Storage is only possible in the reservoirs (i.e. storage capacity of the aquifers is not accounted for). Runoff time is not considered
- SimBaT solves a balance equation between the available resource and the water demand of the supplied nodes at the weekly time step
- The model is fed by the hydrological time series of all the input resources
- It provides information about the flow balance and possible deficit at each node of the network


SimBaT - SDS_00a
File Visualizza Grafica Simulazione Reports Statistiche
Grafico
SDS_00a *** SPT
Mmc
Periodo di simulazione
Input Deficit Restituzione
Input Deficit Restituzione
Div_Umb_PtF
Umb PtF
Div_SPT
P.Fiorcino
E_SPT_LaPasquarella
SPT
Ctrl_SPT
Torgiano
E_SMT_Valfabbrica
Tescio - Rio Grande
E_SF_Condottalrrig
Div_SF
Risorse E
SF
Ctrl_SF
Topino a Bettona
Ctrl Valle Umbra
Valle Umbra
Risorse E STA
Ctrl_SS
SS
Teverone
Div_STA_Reflui
STA
Div_STA
Risorse STA
Ctrl_STA_Reflui1
Ctrl_Nera
Div_Nera
Ctrl_STA_Reflui2
Ctrl_CanaleMedioNera
Corbara - Baschi
Sorgenti Stifone
Deriv_MedioNera
Div_Velino
Velino_Peschiera
Ctrl_ChiusuraTevere
End
start
SDS00a
SimBaT - SDS_00a
Grafico
Schermate - Microsof...
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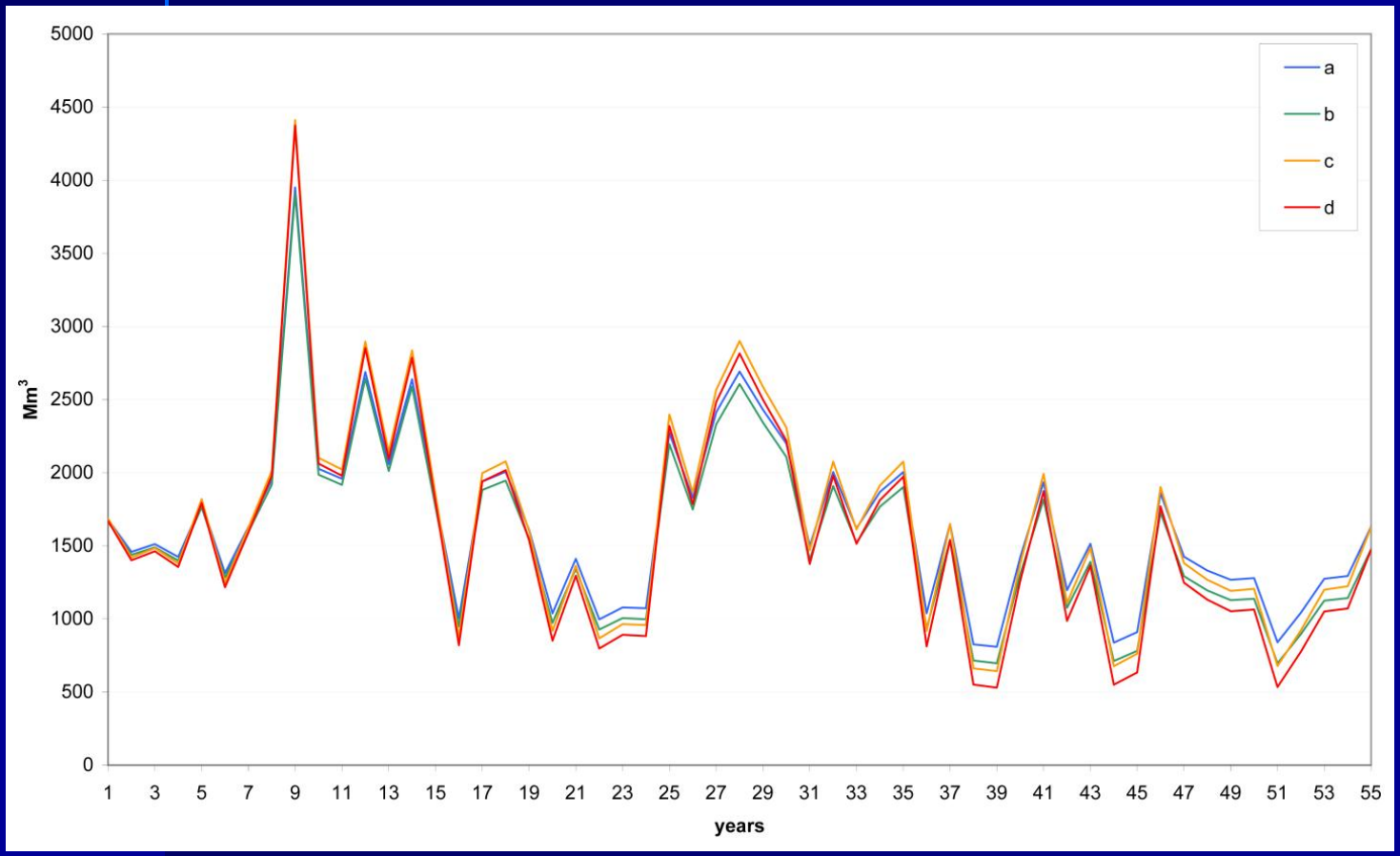
Water input to the model : hydrological time series at weekly time step

- **River discharge**: 1952-2007 natural discharge at measuring sites and its regionalisation at the input nodes
- **Spring discharge**: probabilistic model based on recession curve following the SPI (see POSTER Romano et al. Session HS4.4 Wednesday hall A 17:30-19.00 for details)
- **Withdrawals from wells**: variable during the year but CONSTANT throughout the simulation

SCENARIOS: water input to the model in different climatic hypothesis (55 years)

a) ORDINARY : same availability as in the past (1952-2007)
b) NEGATIVE TREND (-8% in 55 years) applied to the hystorical time series
c) STATIONARY MEAN BUT INCREASED STANDARD DEVIATION (20%)
d) Combination of NEGATIVE TREND + INCREASED STANDARD DEVIATION

Input to the model : 55 years synthetic time series at weekly time step



a = «ordinary scenario»

b =negative trend -8%

c = std. dev. +20% of annual values of SPI

d =negative trend + std. dev.

Vulnerability index

Vulnerability: water deficit normalized by the demand (Jinno et al. 1995)

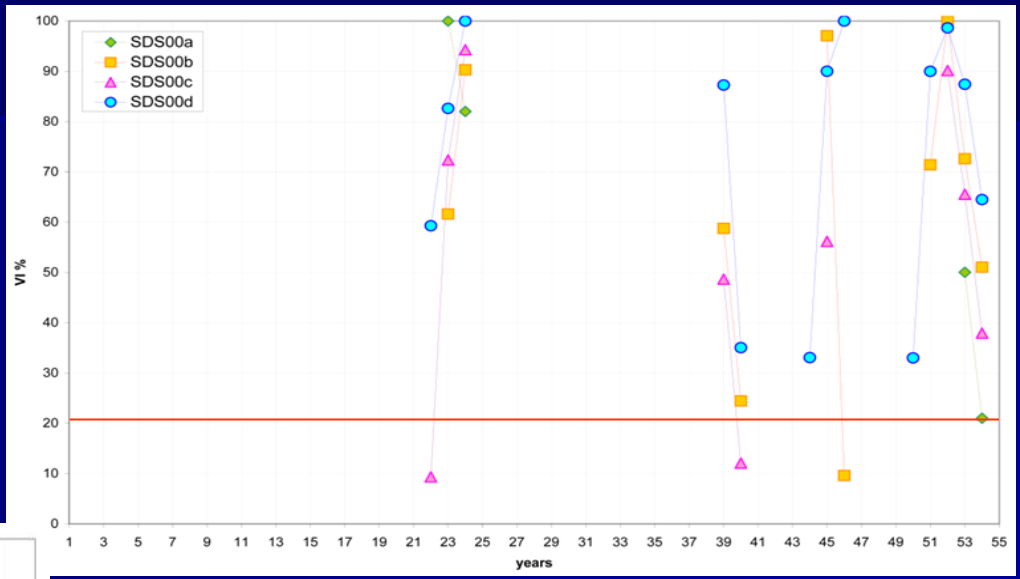
$$VI_j^i = \frac{100}{N_j^i} \cdot \sum_{k=1}^{N_j^i} \frac{DF_j^k}{DM_j^k}$$

DM_j^k = water deficit (demand-availability) for the node *j* in the week *k*

DF_j^k = water demand for the node *j* in the week *k*

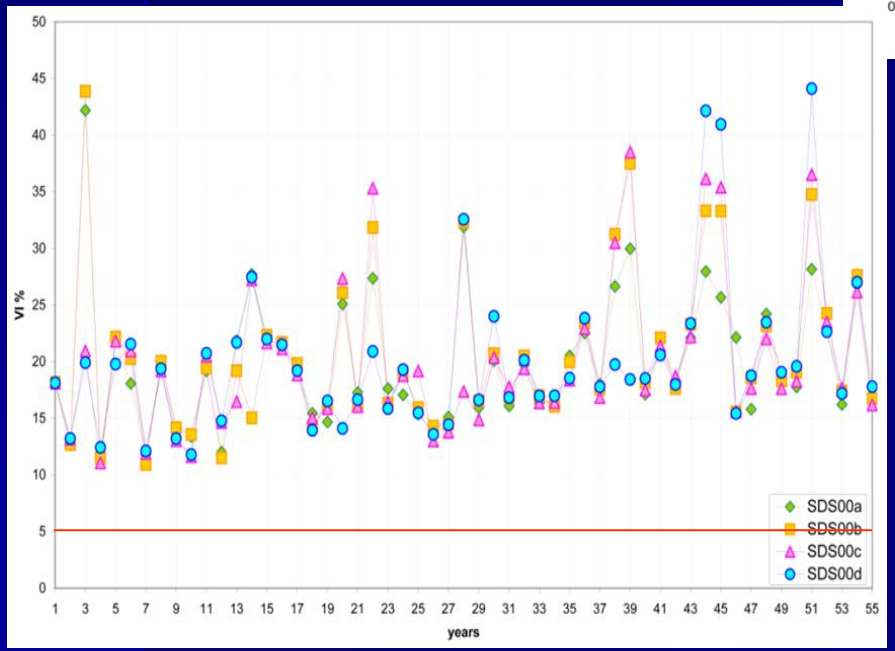
N_j^i = number of failure weeks during the i_{th} failure period

Vulnerability of the most severe failures



Irrigation node CdC

Civil node SPT



Risk assessment: criteria

Severe risk as established by local stakeholders:

→ at least 20% of the simulation years (11 out of 55) OR 2 years consecutively show failures as:

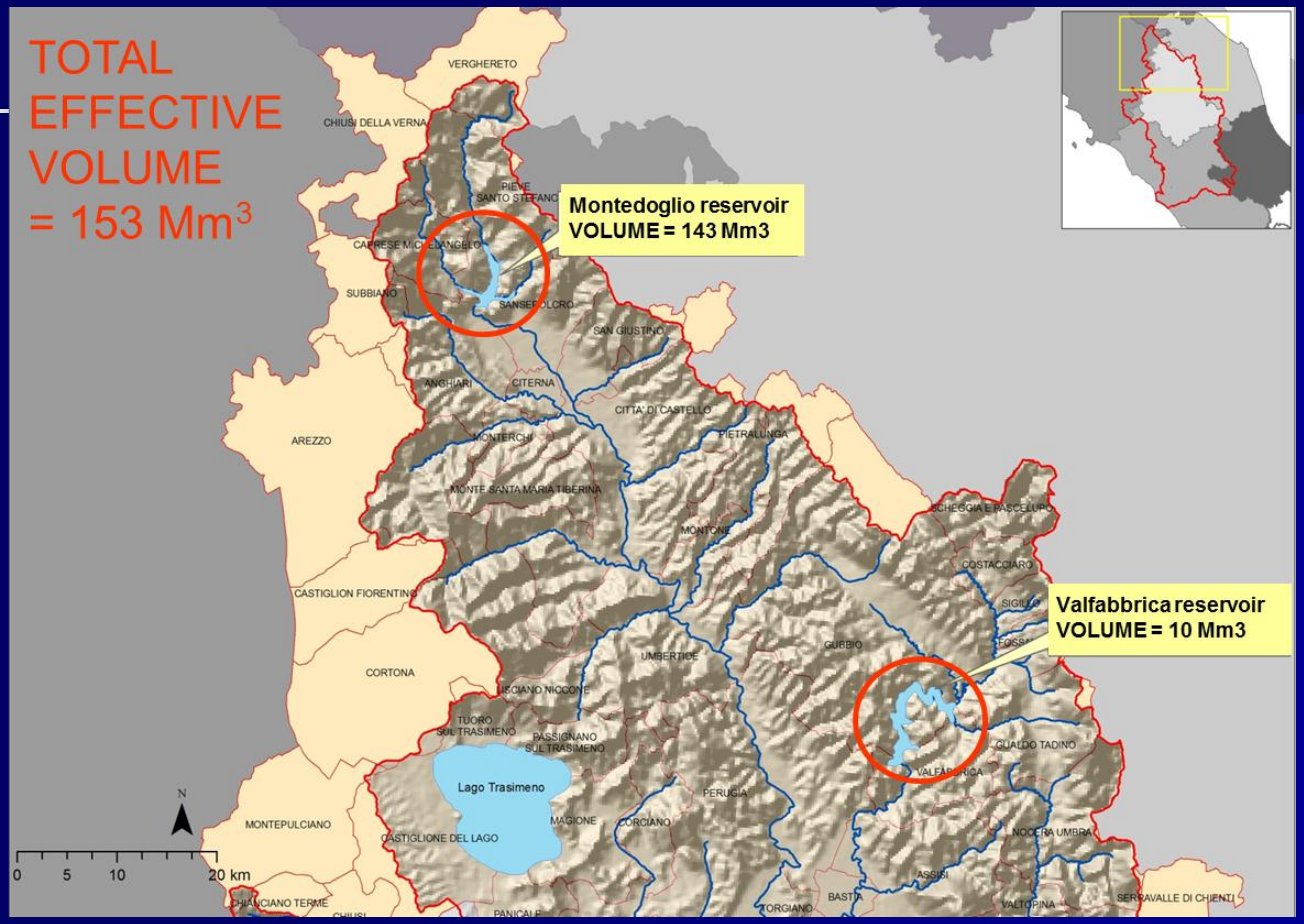
a) failure duration ≥ 4 weeks

WITH

b) VI ≥ 5% (civil) or ≥ 20% (irrigation)

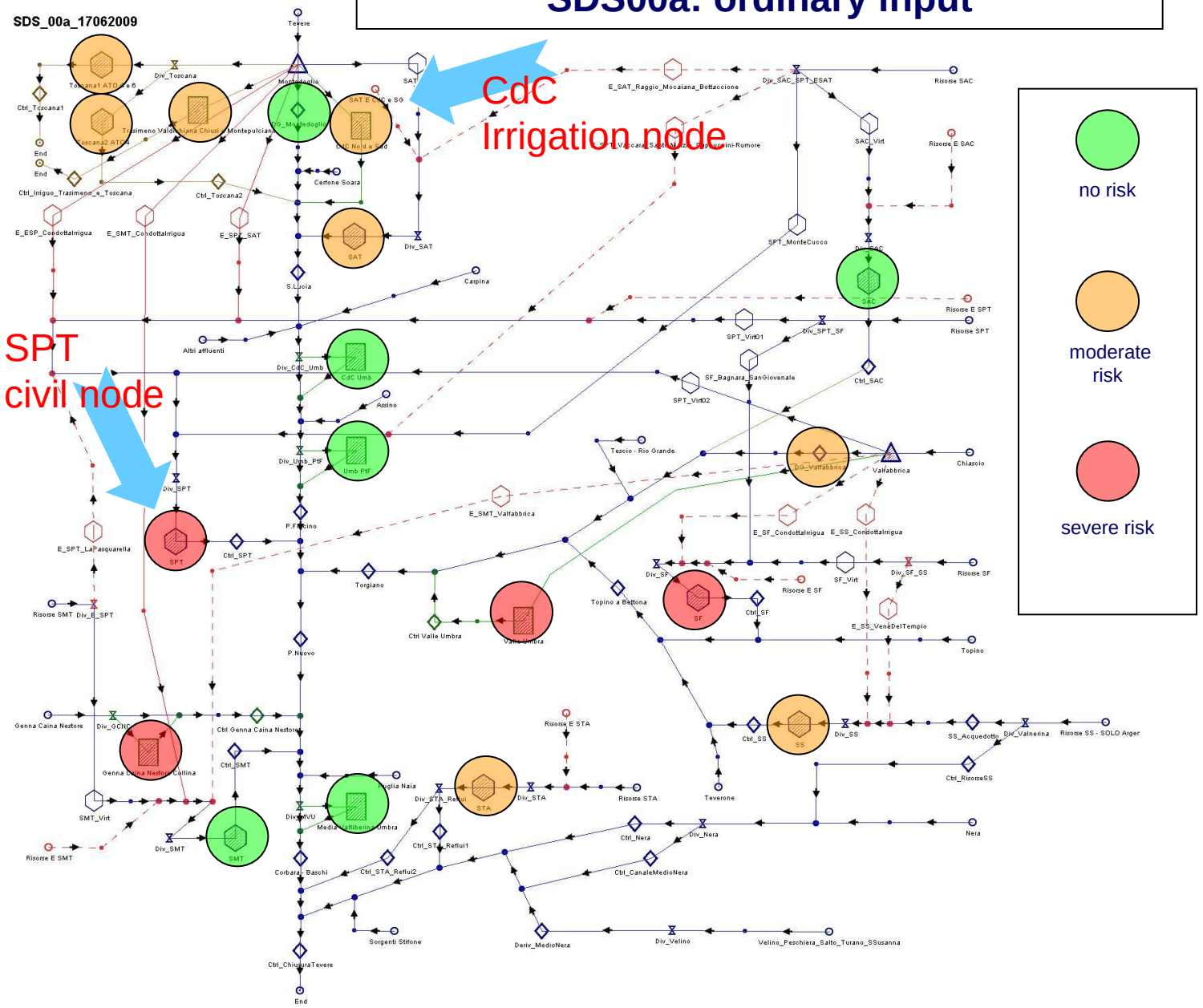
Moderate risk: all other failures

CURRENT SITUATION

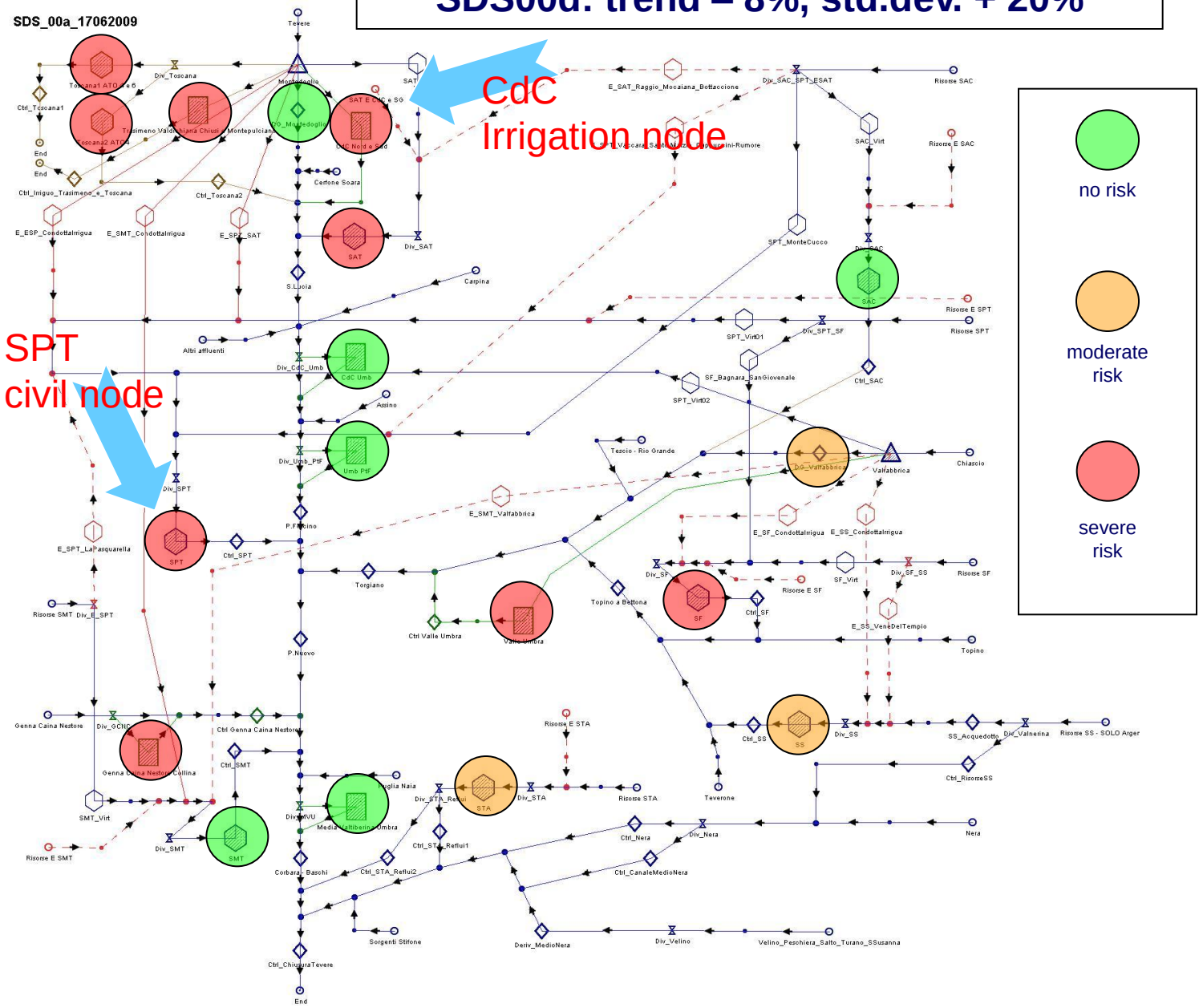


Water demand, management rules and network: forecast for 2015
Reservoir effective volume : current situation
Water availability: 4 scenarios

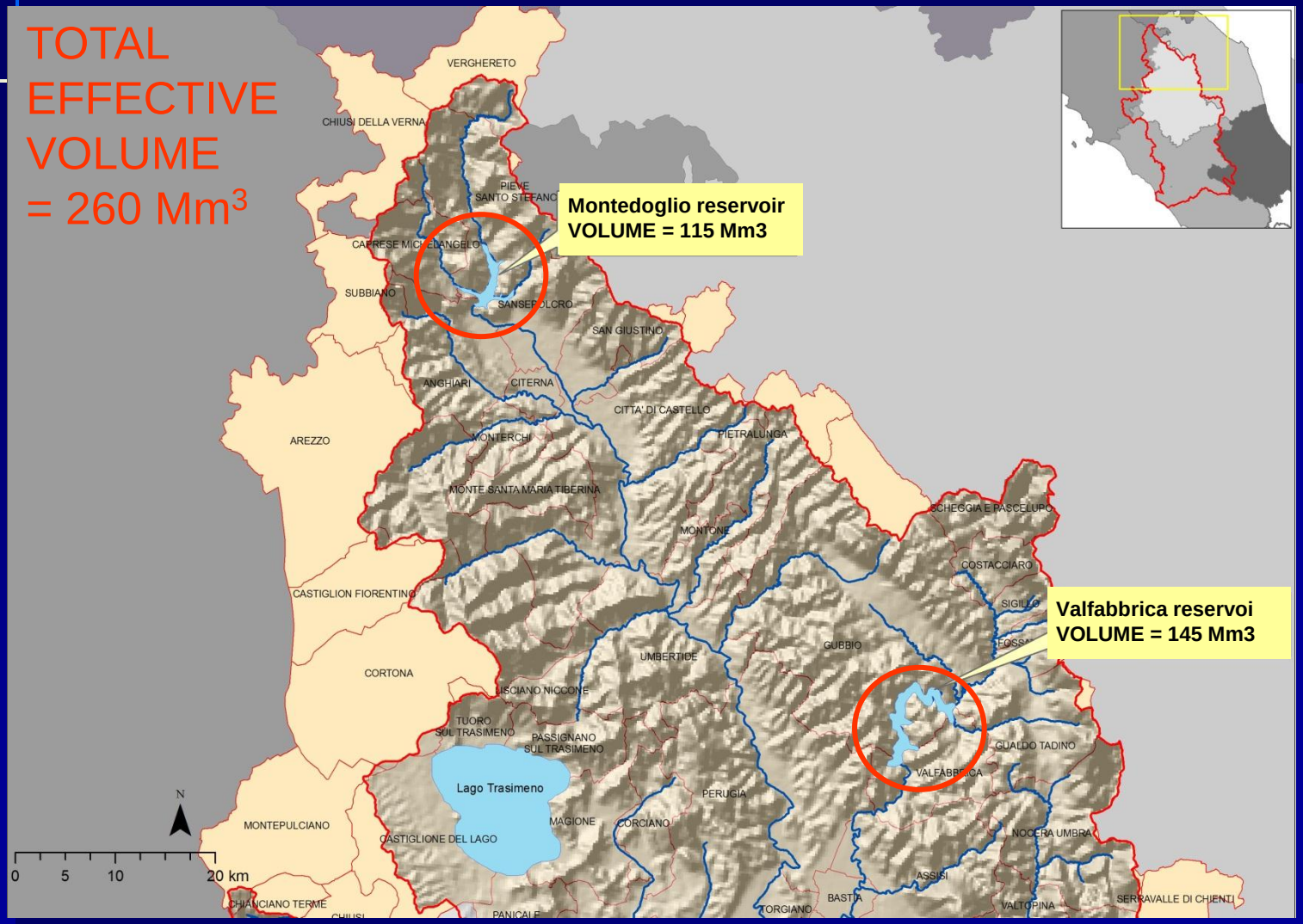
SDS00a: ordinary input



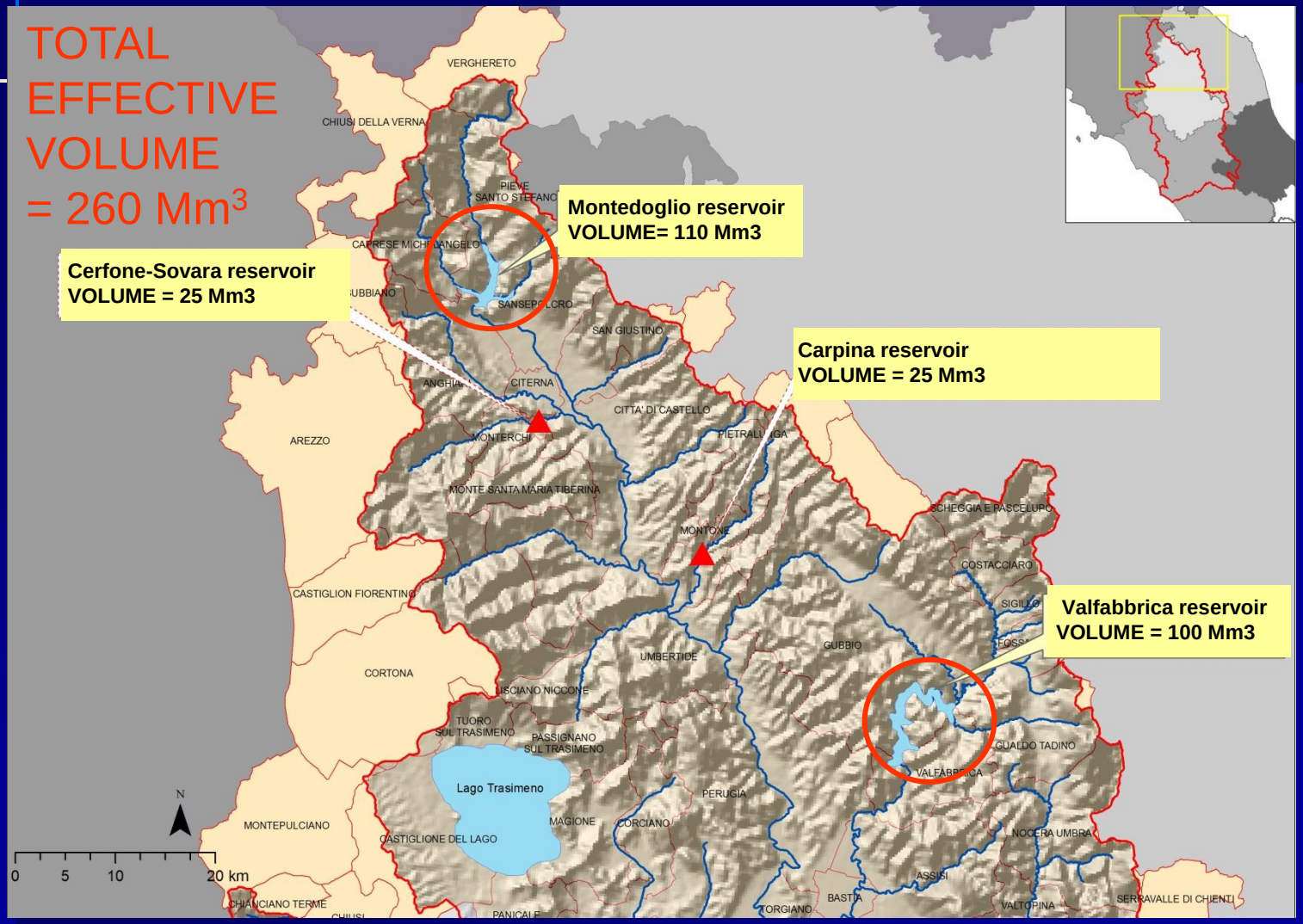
SDS00d: trend – 8%, std.dev. + 20%



RESERVOIRS FULLY OPERATING

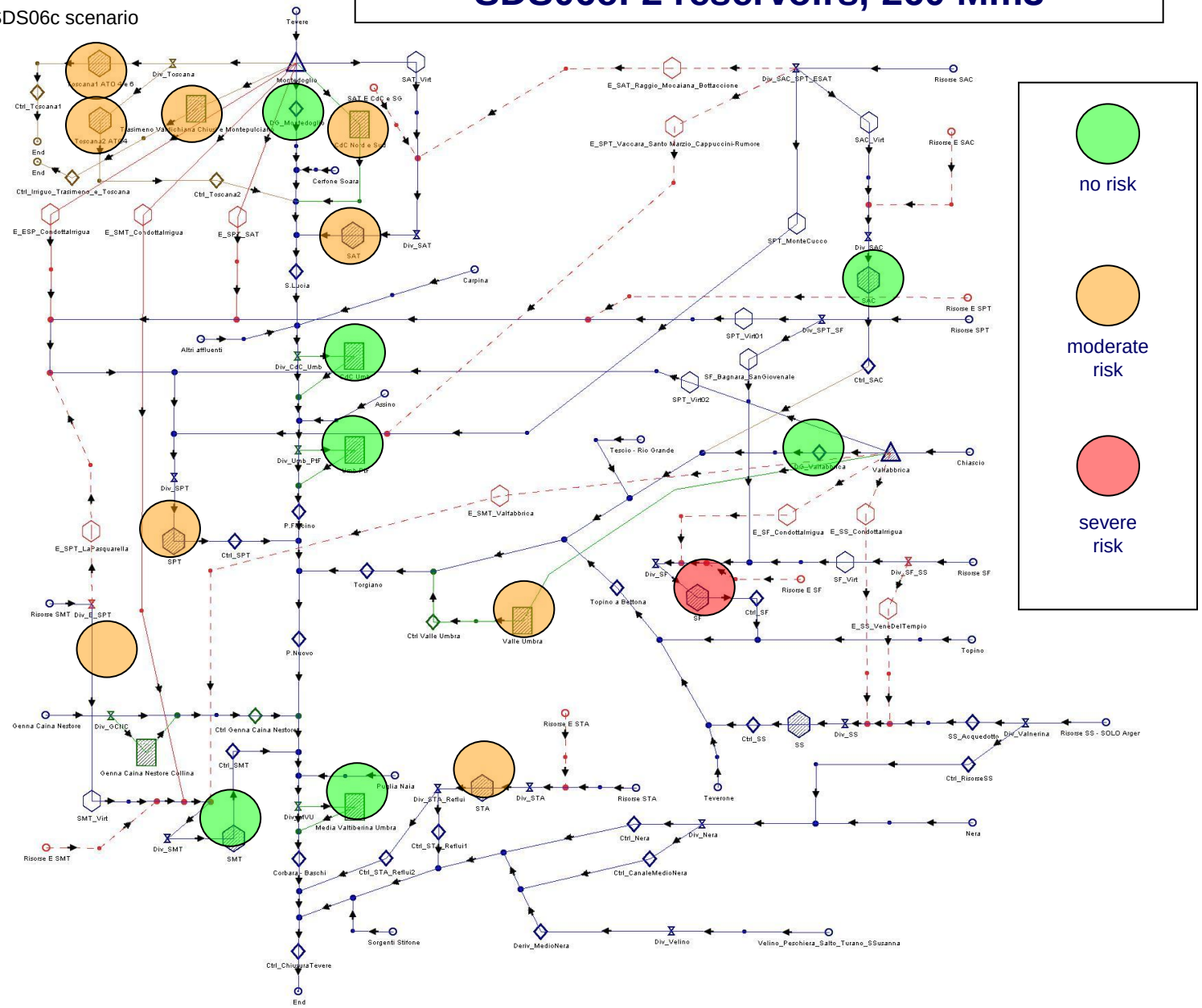


STRUCTURAL OPTION EVALUATION



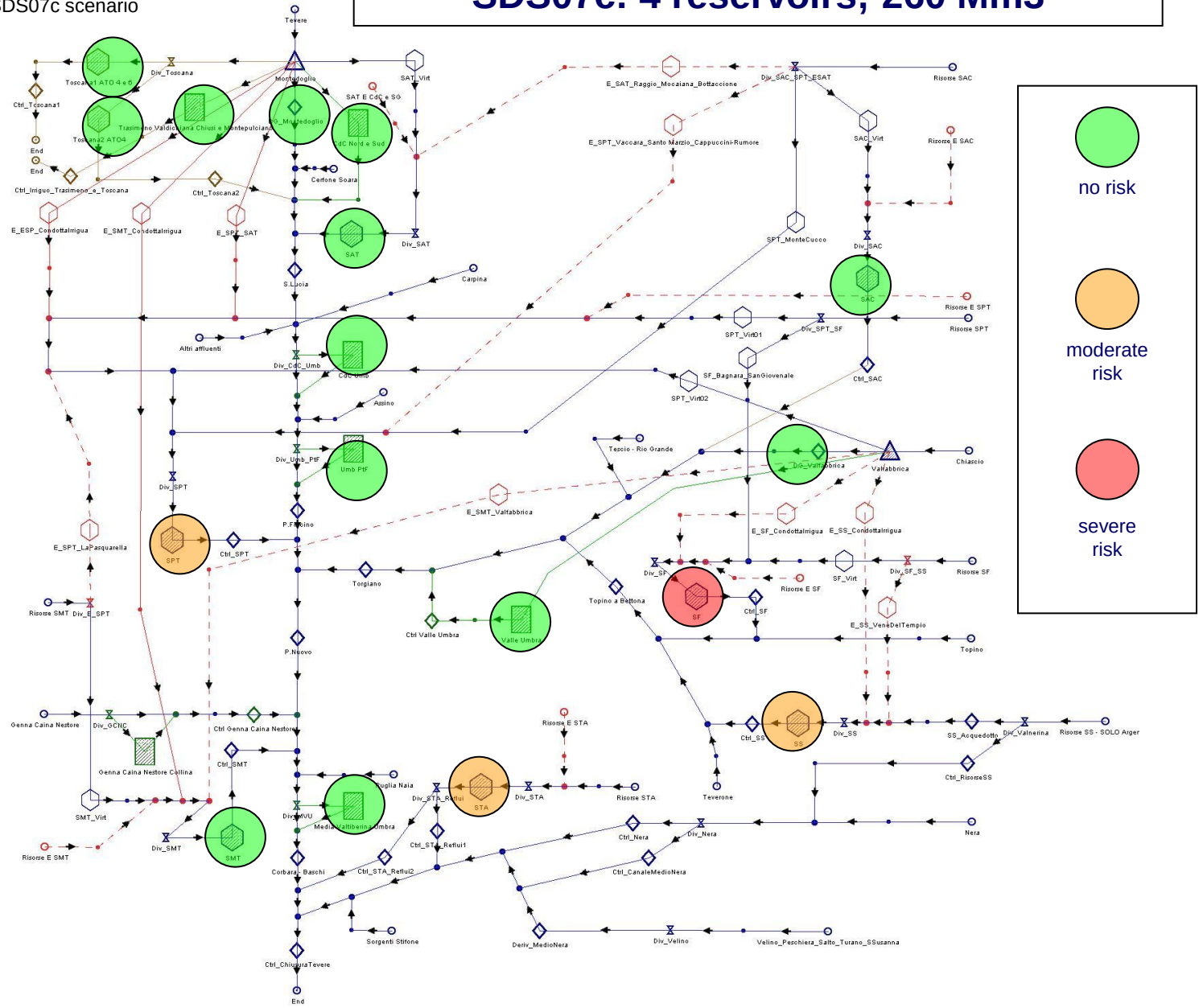
SDS06c: 2 reservoirs, 260 Mm3

SDS06c scenario



SDS07c scenario

SDS07c: 4 reservoirs; 260 Mm3



Conclusions

- The proposed procedure provides a synoptic evaluation of the risk of failure in different hypothesis of water availability
- It allows for the preparation of a common platform for a participatory approach in a river basin management planning in view of climate change scenarios
- Comparing the indices through the graphs and maps gives important and immediate information. This is an important feature that can be appreciated by water managers especially in order to use them in a decision making framework considering negotiating among the main users

More information:

Poster Preziosi et al. today Hall A at 17:30 - 19:00

Poster Romano et al. Wednesday session HS4.4 Hall A 17:30-19.00