Sustainability of irrigated crops under future climate: the interplay of irrigation strategies and cultivar responses

De Lorenzi F. Bonfante A. Alfieri S. Patanè C.
Basile A. Di Tommasi P. Monaco E. Menenti M.*

ISAFOM-CNR, Ercolano (NA) and Catania, Italy
*and *Delft University of Technology, Delft, The Netherlands*

francesca.delorenzi@cnr.it

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introduction

•Climate evolution will cause significant changes in the quality and availability of water resources

•Present irrigation practices will be sustainable in the future?

•With respect to crop productivity, which adaptation measurements will protect primary production?

• Our point of view - the biodiversity of agricultural crops is a powerful mean to cope with the effects of the changing climate

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Outline

- the AGROSCENARI project
- the research approach and the study area
- the case study on processing tomato crop
  - temporal and spatial pattern of soils' water balance
  - crops' yield responses to water availability
  - adaptation options

the AGROSCENARI project

OBJECTIVE - to identify adaptation options to climate change of the most important Italian agricultural systems

Poster session SSS 11.3
Bonfante et al The use of an hydrological physically based model to evaluate the effects of climate change and of irrigation strategy on maize crop: the case study of an irrigation district in Southern Italy

Agroscenari

funded by the Italian Ministry for Agricultural, Food and Forest Policies (MIPAAF, D.M. 8608/7303/2008)

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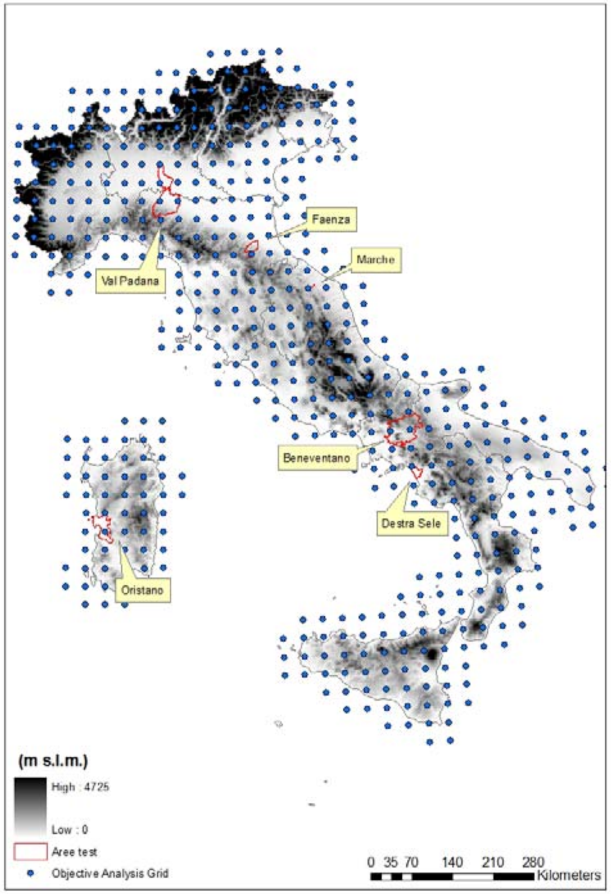
the representation of climate in AGROSCENARI

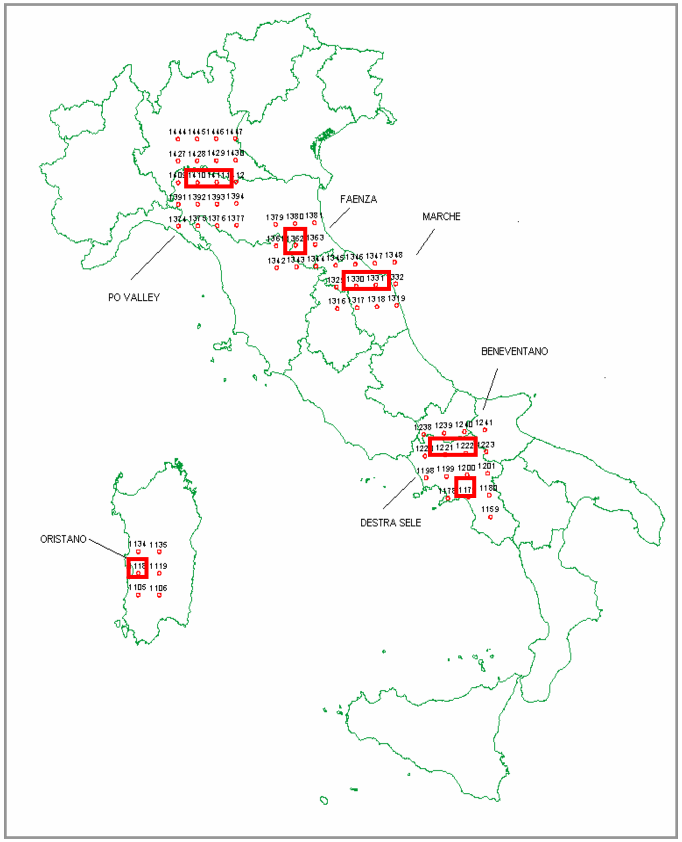
reference climate 1961-90
grid with 35 km spatial resolution



daily data

Tmax
Tmin
rain

future climate 2021-50
focused on grid points in the study areas



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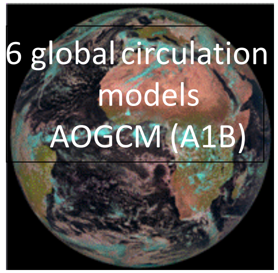
three components of the research approach

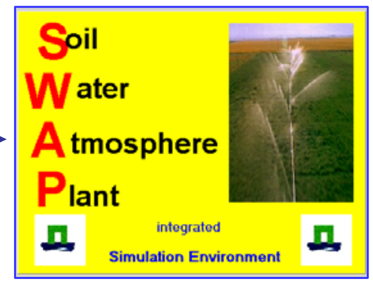
climate scenarios



Statistical downscaling → Tmin Tmax rainfall seasonal → Weather generator → Tmin Tmax rainfall daily

hydrological model of the soil - plant - atmosphere system at landscape scale

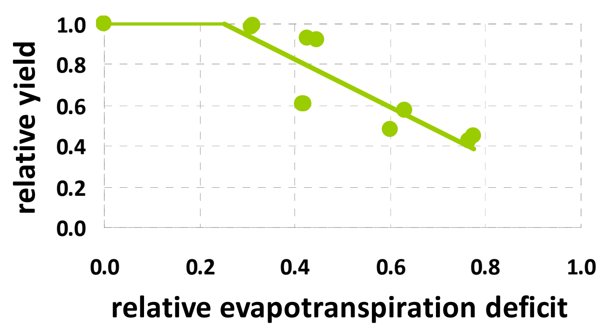
inputs
climate
soil
crop
management



outputs
actual ET
actual T
soil water content
soil matric potential
irrigation volume

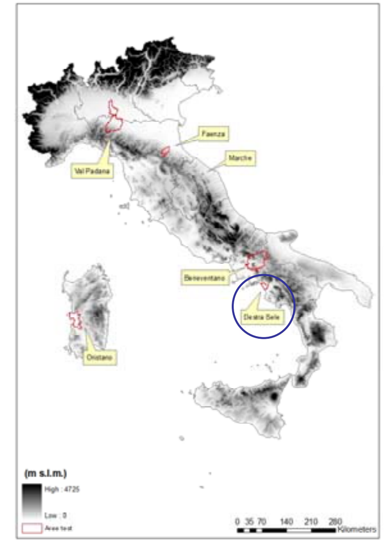
climatic requirements of crops and cultivars

yield response functions – variety specific

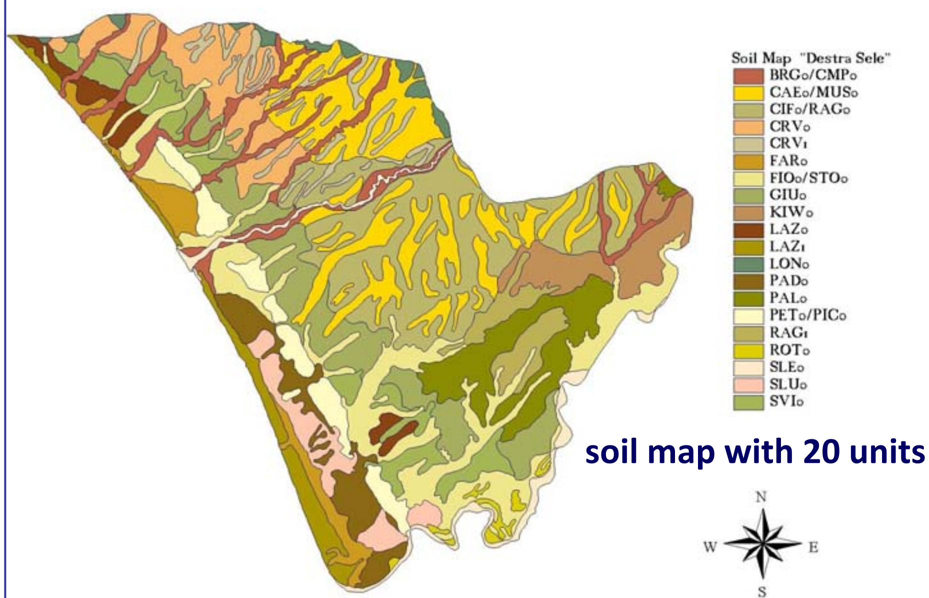


the study area "destra sele"

Campania region



soils



soil map with 20 units

- heterogeneous parent material: conoid, terraces, alluvial plain
- very different soil types: mollisols, alfisols, inceptisols and entisols
- see Bonfante et al – Poster session SSS 11.3

irrigation

- 15.000 ha irrigated surface
- pipeline pressurized network
- on-demand schedule

crops

protected horticulture		3500-4000 ha
field horticulture	spring-summer	3300 ha
	winter	8000 ha

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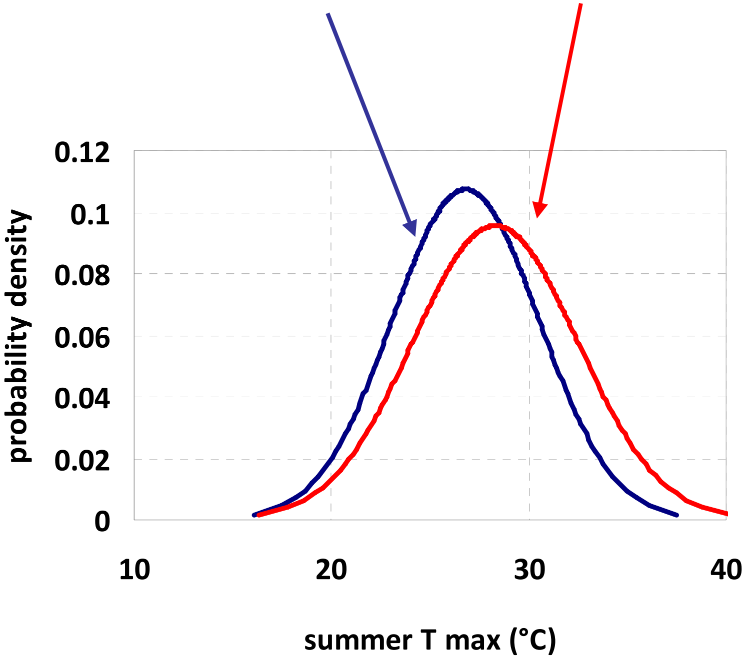
the study area "destra sele"

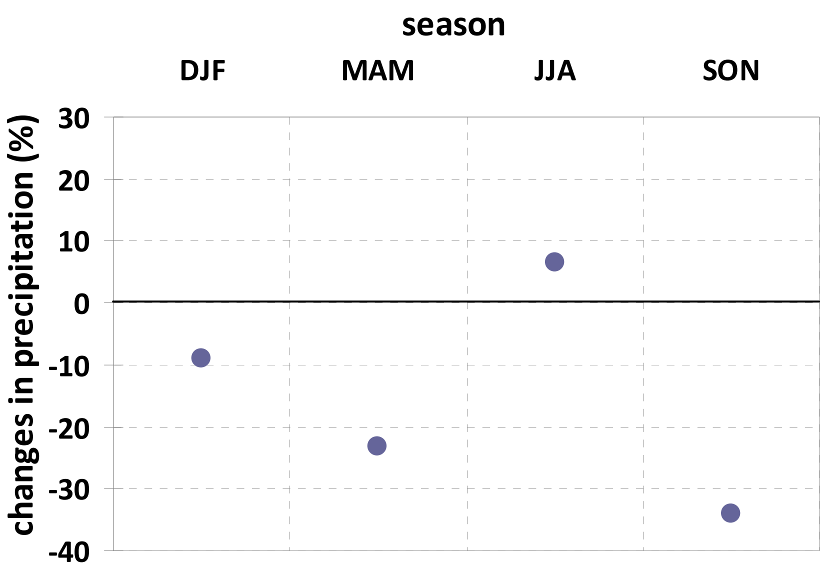
climate change projections

from reference (1961-90) to future (2021-50) climate scenario

summer maximum temperatures
1961-90 and 2021-50



% variation of seasonal precipitation
2021-50 vs 1961-90



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the case study on processing tomato crop

- tomato crop from May to August (rotation: tomato cauliflower melon fennel)
- two climate scenarios: 1961-90 and 2021-50
- three scenarios of water management:
    - unlimited on-demand irrigation schedule
    - 20% and 40% reduction of irrigation volumes

environmental and management variables (May-August)

climate	ETp	rain	seasonal irrigation volumes		
			optimal	deficit -20%	deficit -40%
	mm	mm		mm	
1961-90	556 (±16)	104 (±46)	392 (±51)	314 (±41)	235 (±31)
2021-50	596 (±9)	116 (±37)	435 (±44)	348 (±35)	261 (±26)
Δ 2021-50 vs 1961-90	+ 7%	+ 11%	+ 11%		

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estimation of potential ET in the future climate scenario

data set of future climate scenario → only daily maximum and minimum temperatures

Yates and Strzepek (1994) WP - International Institute for Applied System Analysis (A)

- **4 river basins spanning a range of size and climate variability**
- **sensitivity analysis to temperature variations of methods to estimate potential ET**

variation of ETp with temperature increase

method	*change in potential ET estimates per 1°C*	
	mean	**CV**
Penman	**3.75%**	**0.77**
Priestley-Taylor	**3.5%**	**0.68**
Hargreaves	**5.5%**	**0.18**
Thornthwaite	**8.75%**	**0.38**
Blaney-Criddle	**4.75%**	**0.31**

estimation of potential ET

1961-90 → Priestley-Taylor

2021-50 → ET1961-90 x T difference 2021-50 vs 1961-90 x rate of change

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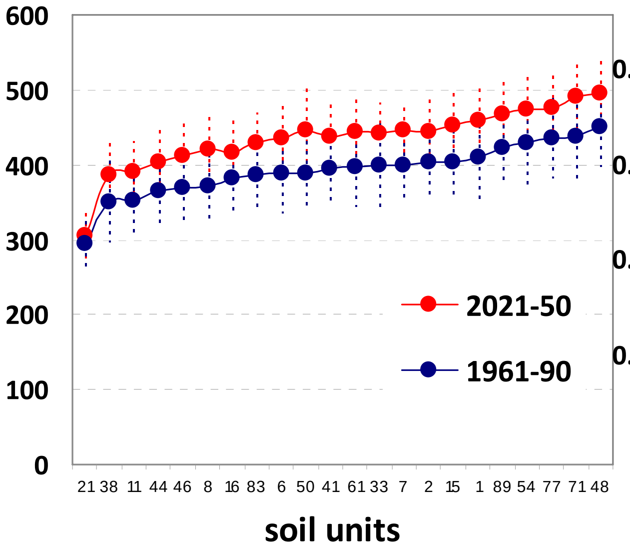
results: the soil water availability in the two climate scenarios

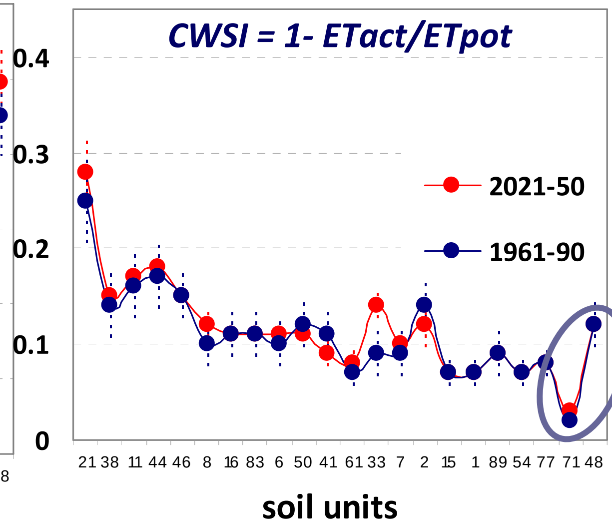
optimal irrigation scheduling

deficit irrigation - future climate

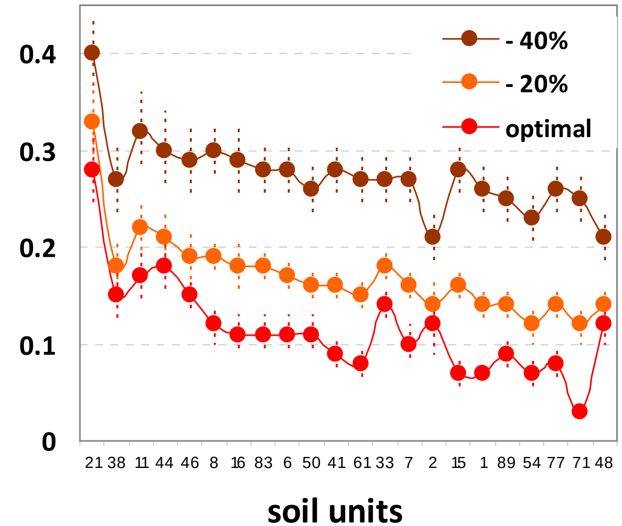
irrigation volumes



Crop Water Stress Index



Crop Water Stress Index



relevant impact of soil properties on irrigation volumes and plant water availability

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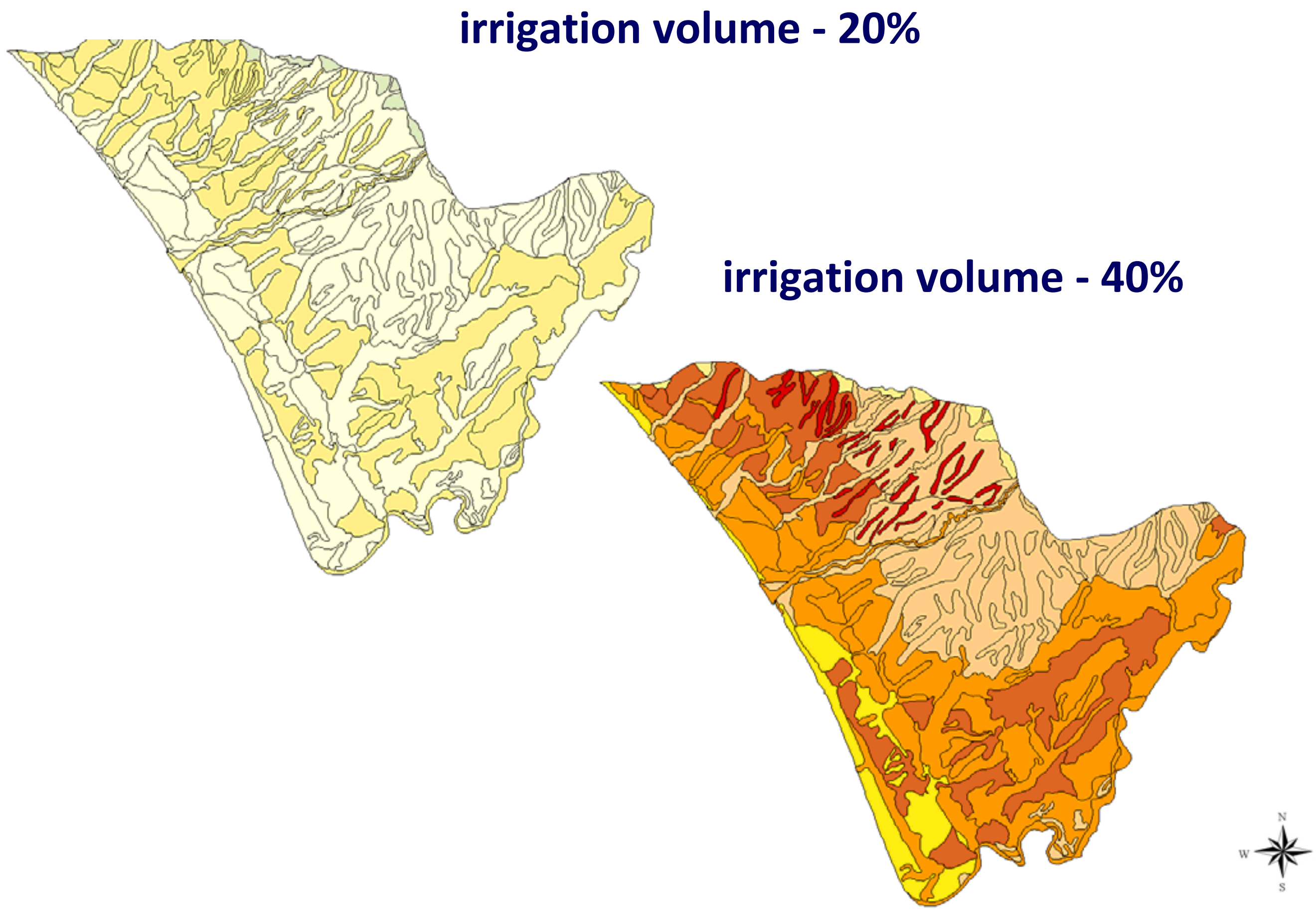
results: the spatial distribution of ET deficit

variations of CWSI in the future climate scenario – deficit irrigation

increase of CWSI vs optimal irrigation

0.01	0.03
0.03	0.06
0.06	0.09
0.09	0.12
0.12	0.15
0.15	0.18
0.18	0.21
0.21	0.23



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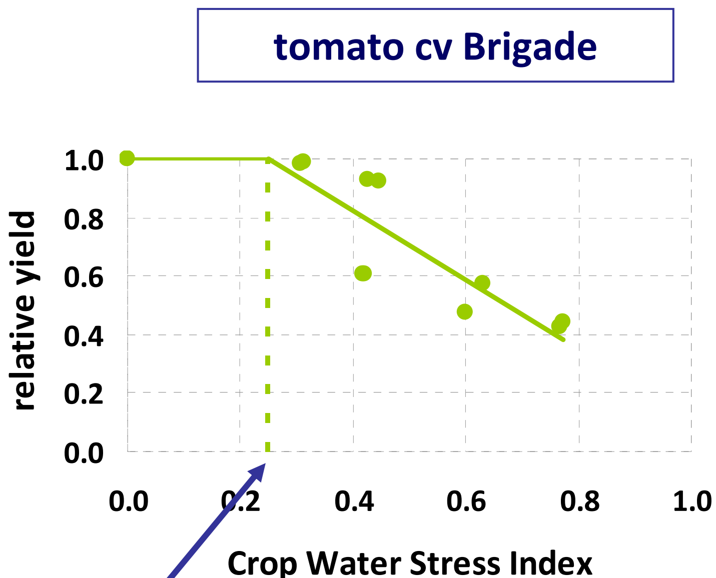
yield response functions to soil water availability

threshold-slope regression model fitted to experimental data



cultivar's specific critical value of CWSI

Cultivars' specific critical values of CWSI

Brigade	0.25
Solerosso	0.18
Design	0.15
Season	0.13

the indicator of soil water availability (e.g. CWSI) in each soil unit and for each realization of climate scenario is compared with the cv-specific critical value to identify adaptation options

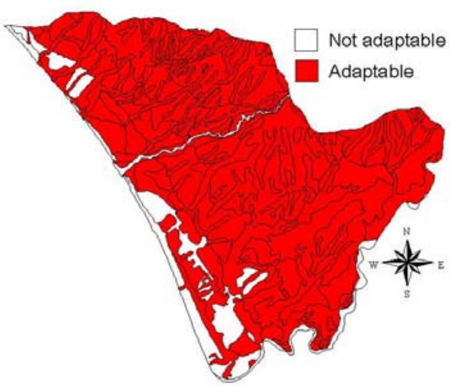
adaptation options

extent and spatial distribution of areas where 2 cvs will be adapted in the future climate scenario

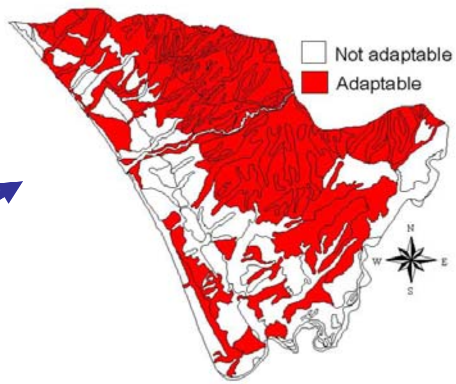
cultivars were considered adapted when the simulated CWSI in the soil unit resulted above cvs' critical values in at least 90% of realizations

optimal irrigation scheduling

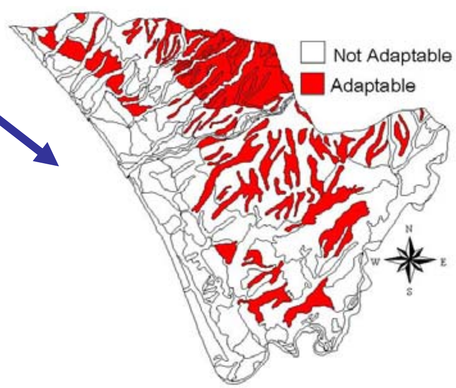
full adaptability for both cvs



deficit irrigation -20%



adaptability cv Solerosso critical value 0.18



adaptability cv Design critical value 0.15

concluding remarks

- ***impacts of CC on agro-ecosystems can be analyzed by simulation models, coupled with GCMs, accounting for local climate variability***

- ***studies that combine experimental results with simulation models of water regime allow to identify critical environmental conditions***

- ***the (already existing) intra- specific biodiversity of crops is relevant, and can provide significant opportunities for adaptation of agro-ecosystems***