ALTA SCUOLA POLITECNICA

POLITECNICO DI MILANO | POLITECNICO DI TORINO

# AIS4SIA

## Artificial Intelligence System for Sustainable Innovative Agricolture

Gabriele Balducci
Alice Ballestra
Pietro Brach del Prever
Carlo Ghiglione
Laura Mascheretti
Margherita Molinari
Giuseppe Nicoletti

September 29, 2022

1 | Problem Identification

2 | Stakeholders and Requirements

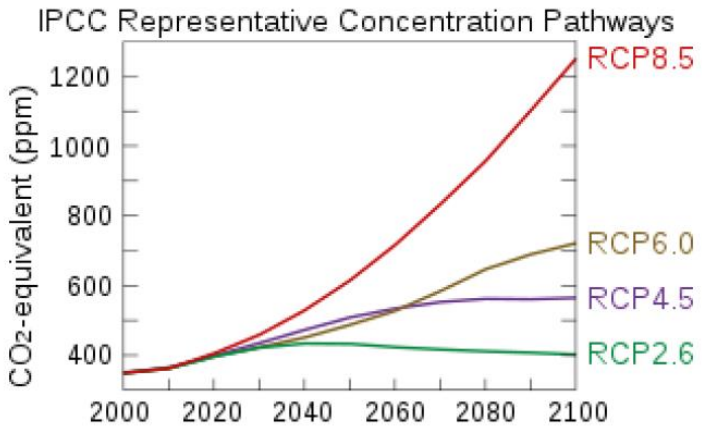
3 | Solution Definition

4 | Concept Validation

5 | Conclusion

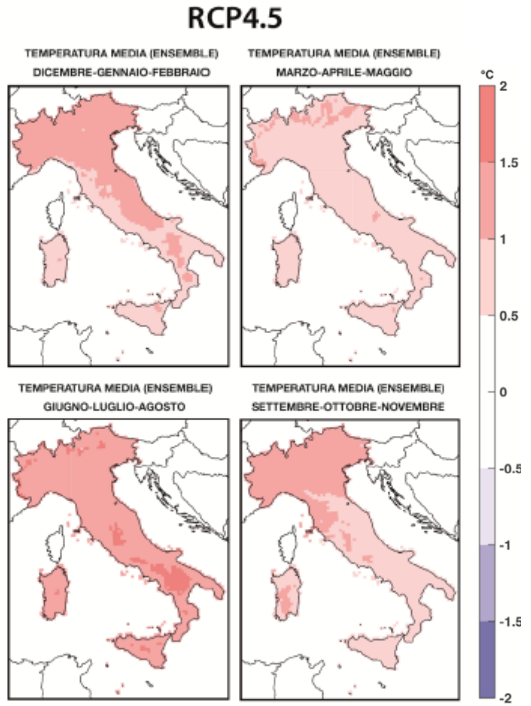
# Climate Change

## Increasing $CO_2$ concentration



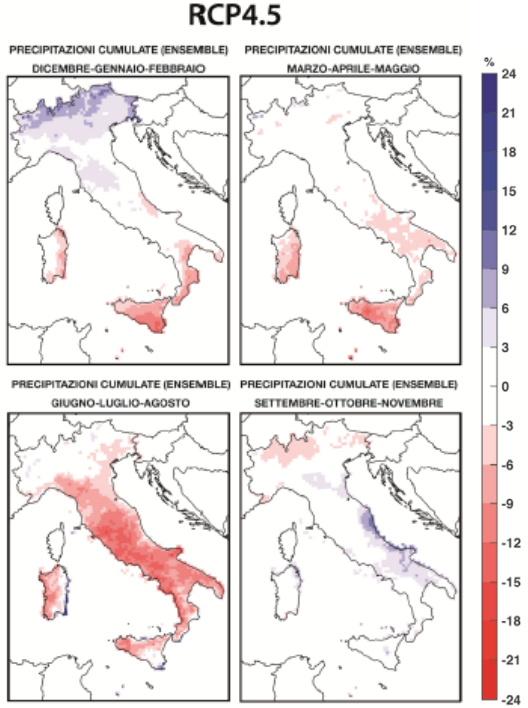

*All forcing agents' atmospheric CO2-equivalent concentrations (in parts-per-million-by-volume (ppmv)) according to the four RCPs used by the fifth IPCC Assessment Report to make predictions*

## Rising temperature




*Two-meter seasonal-scale temperature change maps over Italy from the EURO-CORDEX ensemble according to the RCP4.5 for the period 2021-2050 compared to the reference period 1981-2010*

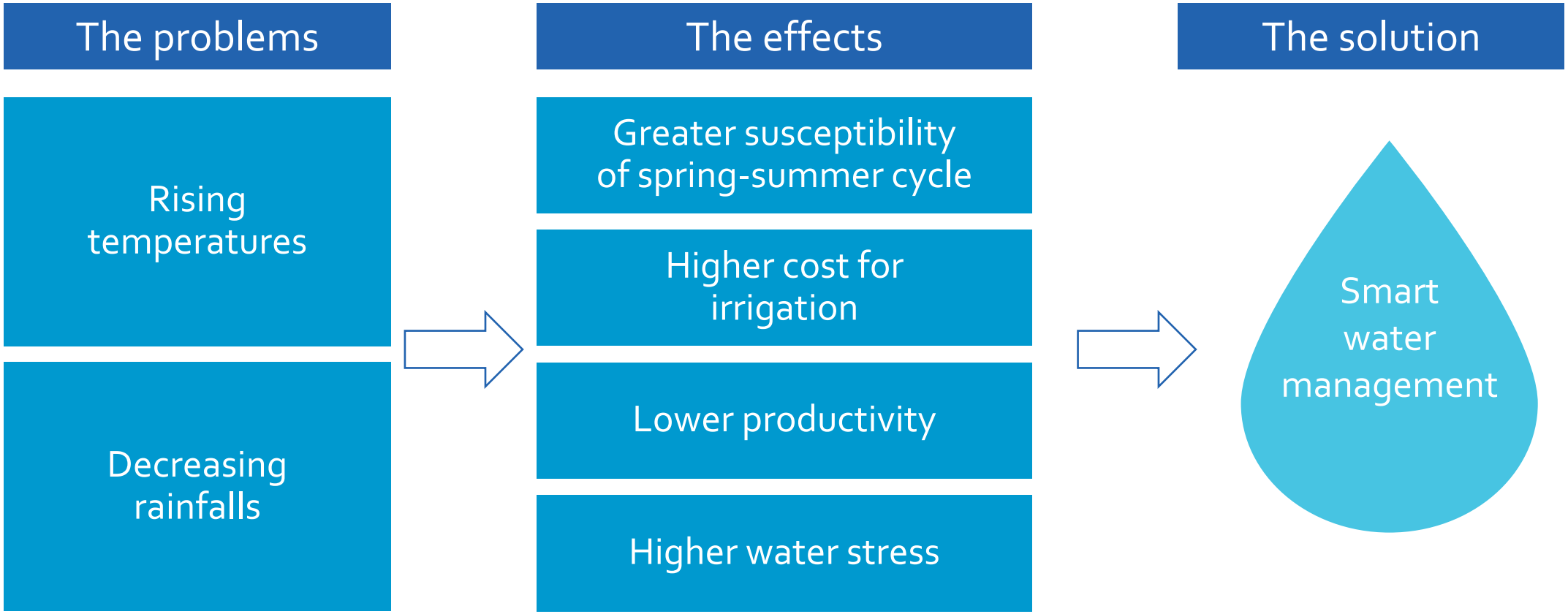
## Decreasing rainfalls




*Seasonal maps of precipitation variation over Italy from the EURO-CORDEX ensemble according to the RCP4.5 for the period 2021-2050 compared to the reference period 1981-2010*

*Spano et al. 2020. "Analisi Del Rischio I Cambiamenti Climatici in Italia." Fondazione CMCC - Centro Euro-Mediterraneo sui Cambiamenti Climatici.*

# Implications for Agriculture: the Case of Vines



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# Requirements


| Requirement category | Design desiderata |
|---|---|
| Crop quality and production | Ability to control crop significant physiological parametres |
| Environmental sustainability | Low impact on landscape<br>Water consumption reduction |
| Commercial feasibility | Inexpensive components<br>Easiness of use / automation<br>Integrability |

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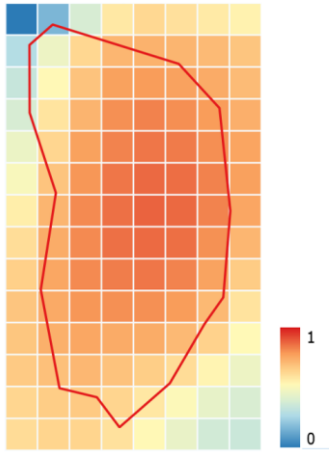
# State of the Art

## Crop Analysis from Satellite Images

TRL 8

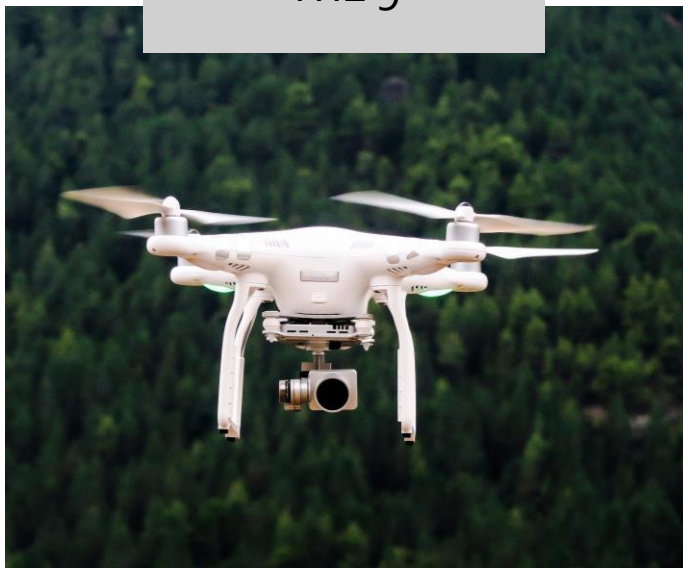



## Crop Monitoring from On-Site Sensors and Information Fusion

TRL 9

## Robotics in Agriculture

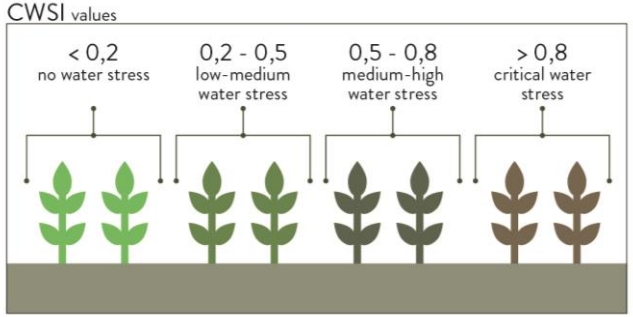
TRL 9



# Innovation Opportunities & Added Value

**Where is the opportunity for innovation?**

- **Low-cost** distributed sensing system
- **High detail** monitoring strategy
- Vegetation indexes: **CWSI***
- **Water stress** of each plant over time




* CWSI = Crop Water Stress Index

# Design Statement

## Core functions and features

- Continuous and real time **data collection**;

- **Georeferenced CWSI** evaluation;

- Results:
  1. Long term: Estimation of **production;**
  2. Short term: Easy-to-read **thematic maps.**

## Outcomes

- Correlate the **water stress** of each plant with the **ideal growth** plant and grape;

- **Optimized water management**;

- Improved **plants care**;

# Design Description

Drone

Canopy temperature

Pressure

Air temperature

Air humidity

Ambient light

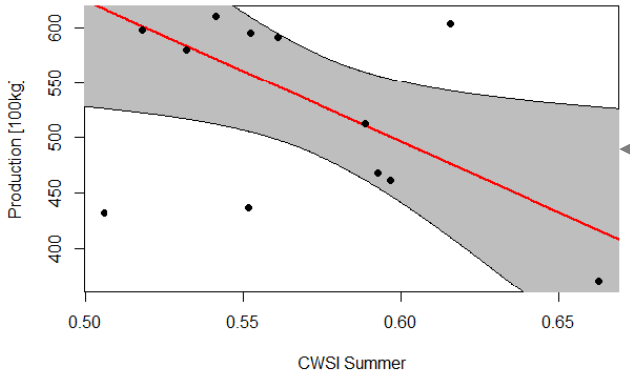
IR radiation

UV radiation

Fixed sensors

PHYSICAL LAYER

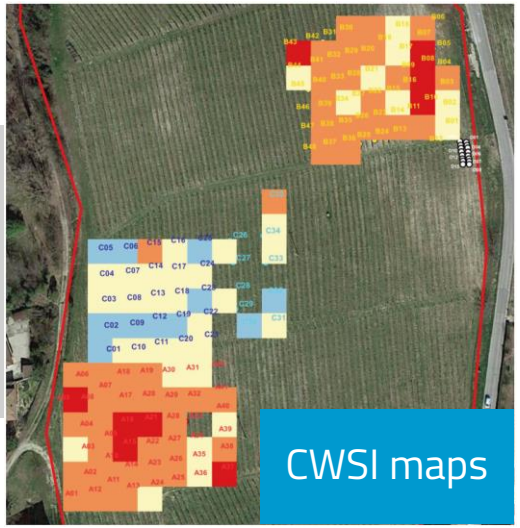
SOFTWARE LAYER




Artificial Intelligence Algorithms

Server (backend)

Application (frontend)



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# **On-field Measurement Campaign** (Azienda Agricola Balladore Pallieri)

**Real case study**

- *On-field data collection session*, vineyard by Azienda Agricola Balladore Pallieri.
- Basic *low-cost prototype* we designed and assembled ad-hoc for the purpose.

# On-field Measurement Campaign (Goal)

## Goal

Verify the validity of the concept and its implementation.

Collect climatic variables and elaborate the data into *real CWSI heatmaps.*

## Outcome

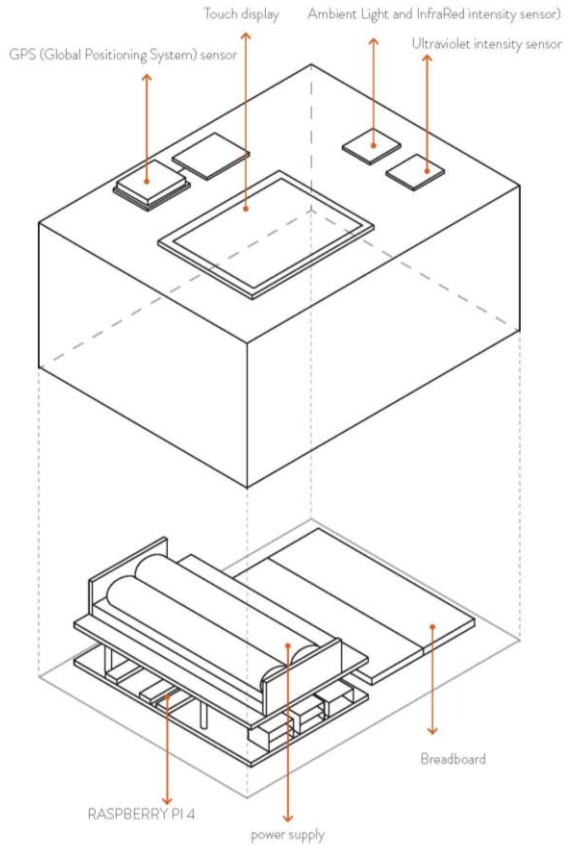
Initial design constraints and requirements assessed.

Improvement areas of the design highlighted.

# On-field Measurement Campaign

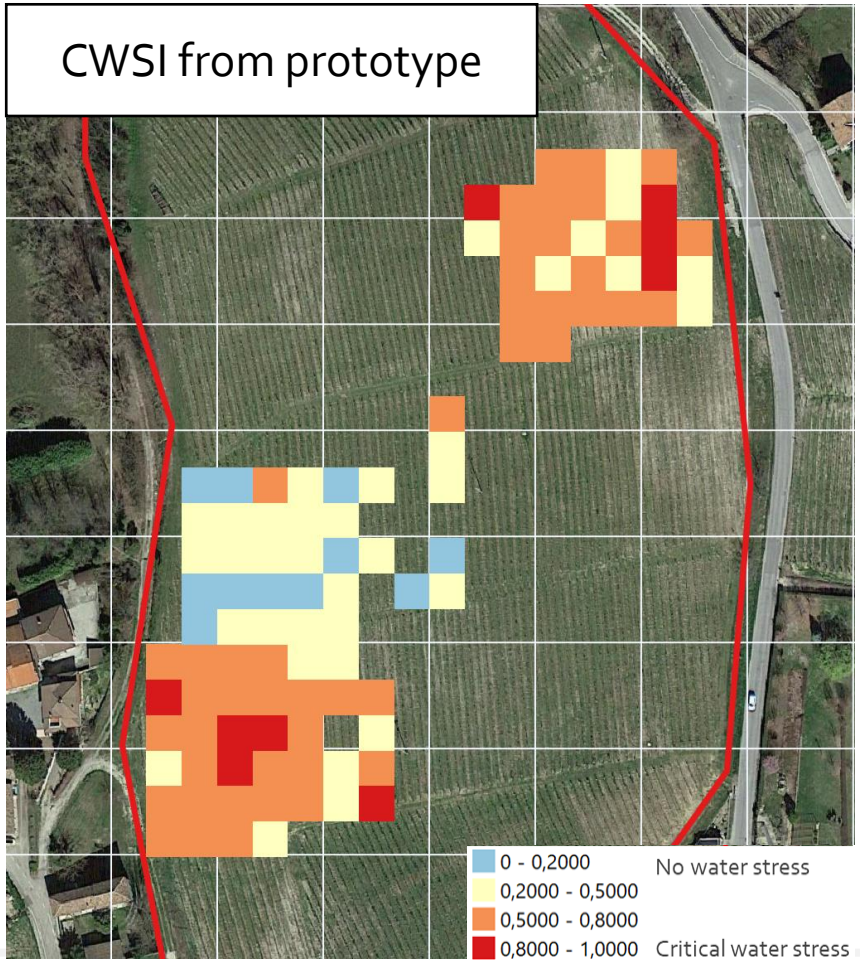
## Method

- precise *waypoints*, roughly every 10m.
- *Sectorization*.
- Snakelike path data acquisition.

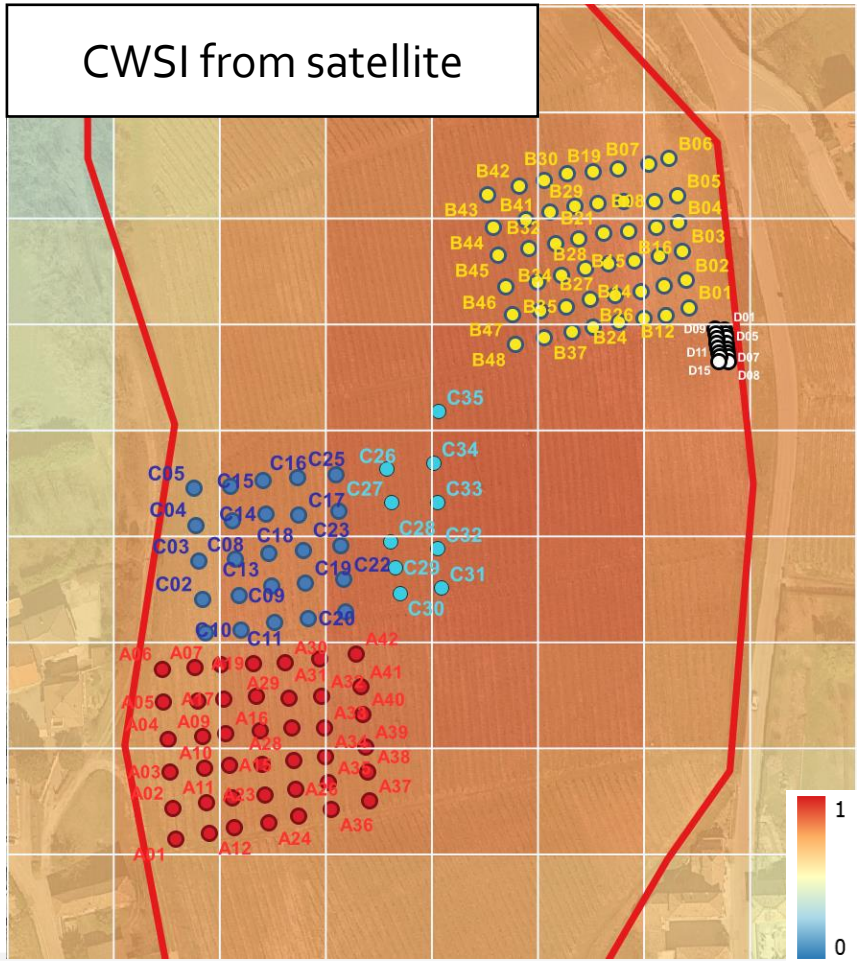



# Multilevel Resolution

CWSI from prototype

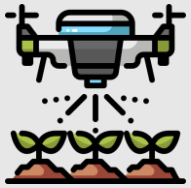



CWSI from satellite

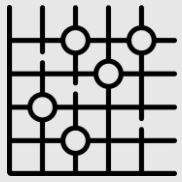


# From prototype to final design

## Revised Design



- A drone is necessary

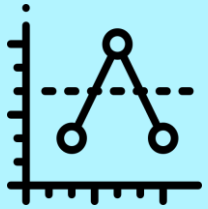


- Climatic variables: *average or finer sampling*

- What to install on the drone

## Further Requirements

- More performing thermal camera needed



- Automated software routine to manage outliers

- IoT platform to easily access results

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# Conclusions

## Main concept

- On-field cheap and efficient *sensing module.*
- Computation of *CWSI.*

## Outcome

*Georeferenced heatmap* of plant ***water status***.

## Value

Real-time, detailed and cheap information of crop status.

## Why it is important

Availability of water not guaranteed (e.g., last summer drought).

Balanced field water stress for a controlled production and risk reduction.

# Main references:


Anda, A. 2009. "Irrigation Timing in Maize by Using the Crop Water Stress Index (CWSI)." Cereal Research Communications 37 (4): 603–10.

Jackson, Ray D. 1982. "Canopy Temperature and Crop Water Stress." In , 43–85.

Spano, D et al. 2020. "Analisi Del Rischio I Cambiamenti Climatici in Italia." Fondazione CMCC - Centro Euro-Mediterraneo sui Cambiamenti Climatici.

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***Thank you for your attention !***