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LAND and WATER
Resource Management

SMART TECHNOLOGIES FOR SUSTAINABLE IRRIGATION MANAGEMENT

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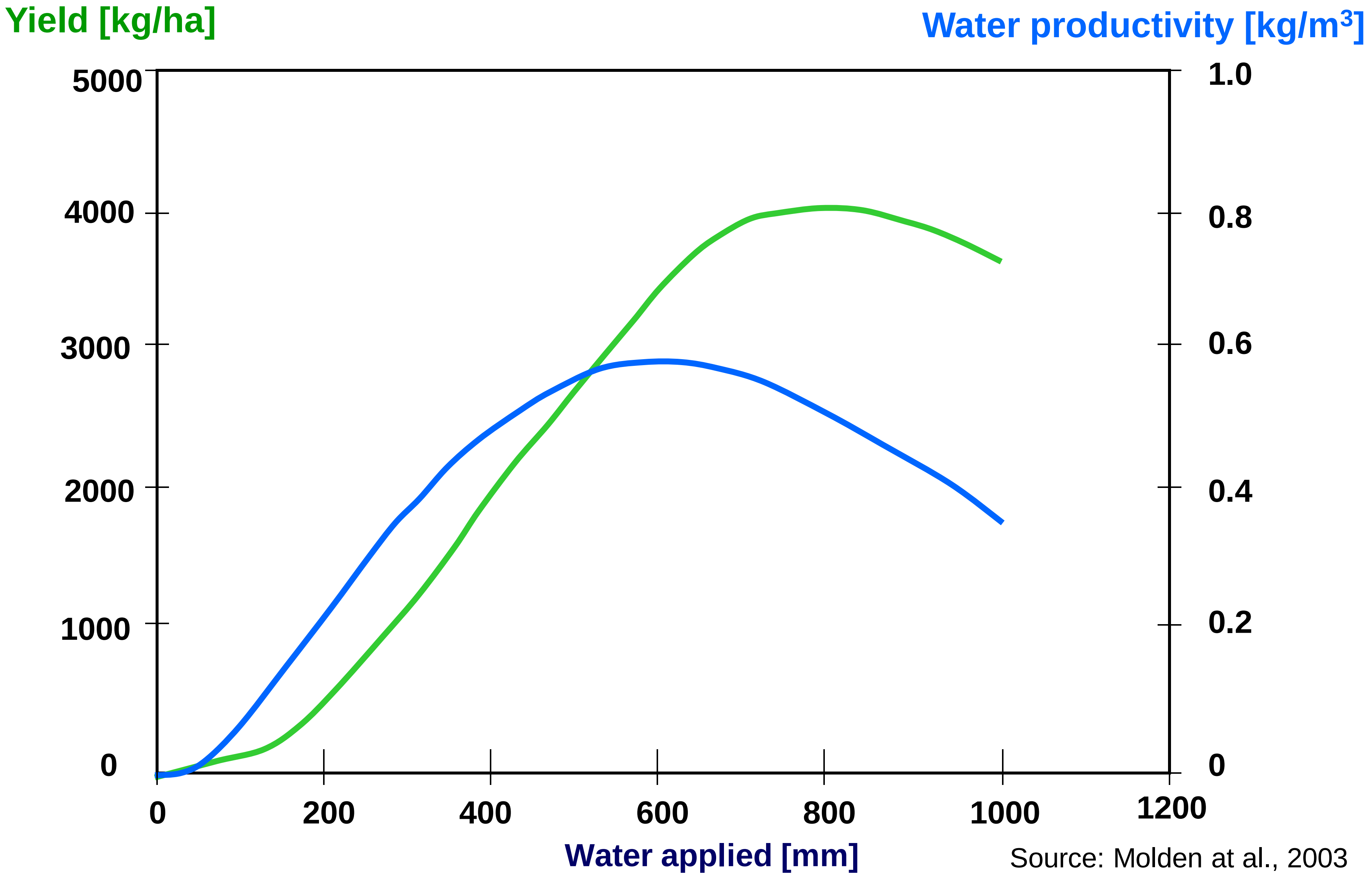
1° Training on CLIMASOUTH

Beirut, 19 January 2015

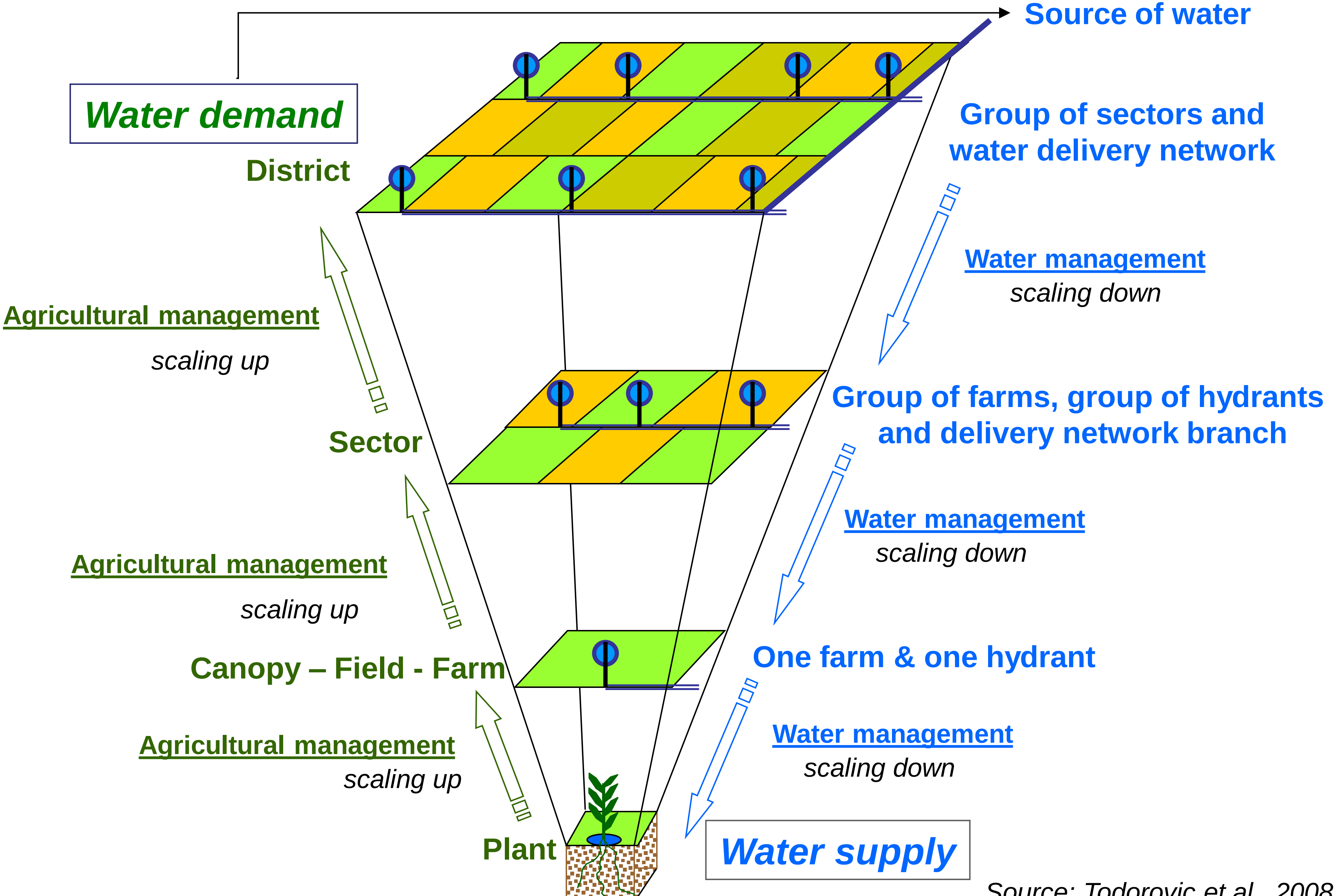
Farm approach

Maximizing YIELD vs. WATER PRODUCTIVITY



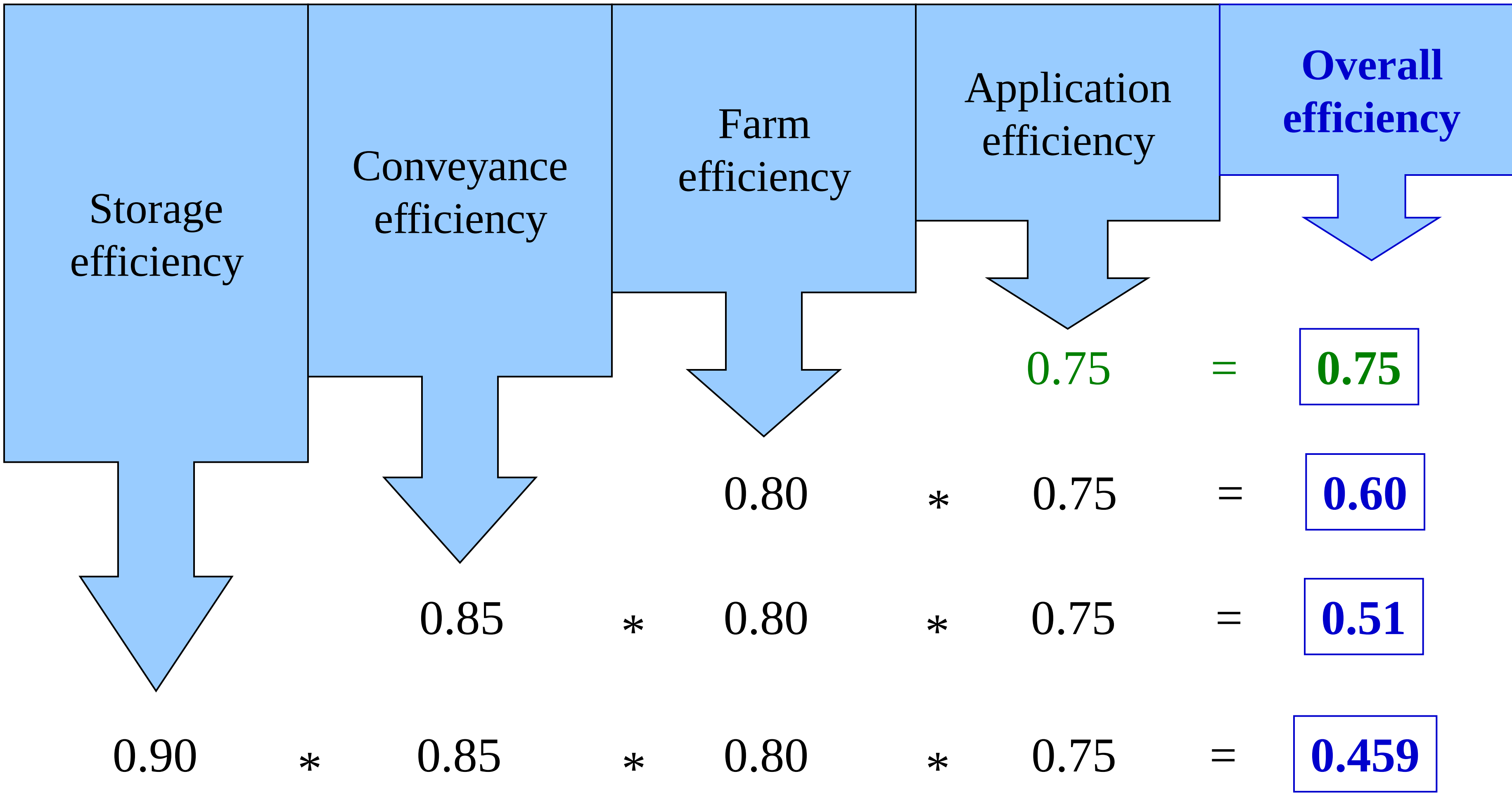
Source: Molden at al., 2003

AGRONOMIC AND ENGINEERING ASPECTS OF WATER MANAGEMENT IN AGRICULTURE



Source: Todorovic et al., 2008

Efficiency Chain of Water from Reservoir to Plant: a multiplicative approach



Source: adapted after Hsiao et al., 2007

Water demand, supply & withdrawal

- Water Demand, WD

$$\mathrm{WD} = \sum_{i=1}^{n} \left(\frac{ET_c - P_{eff}}{EFF_{app}} A\right)_i$$

- Water Supply, WS

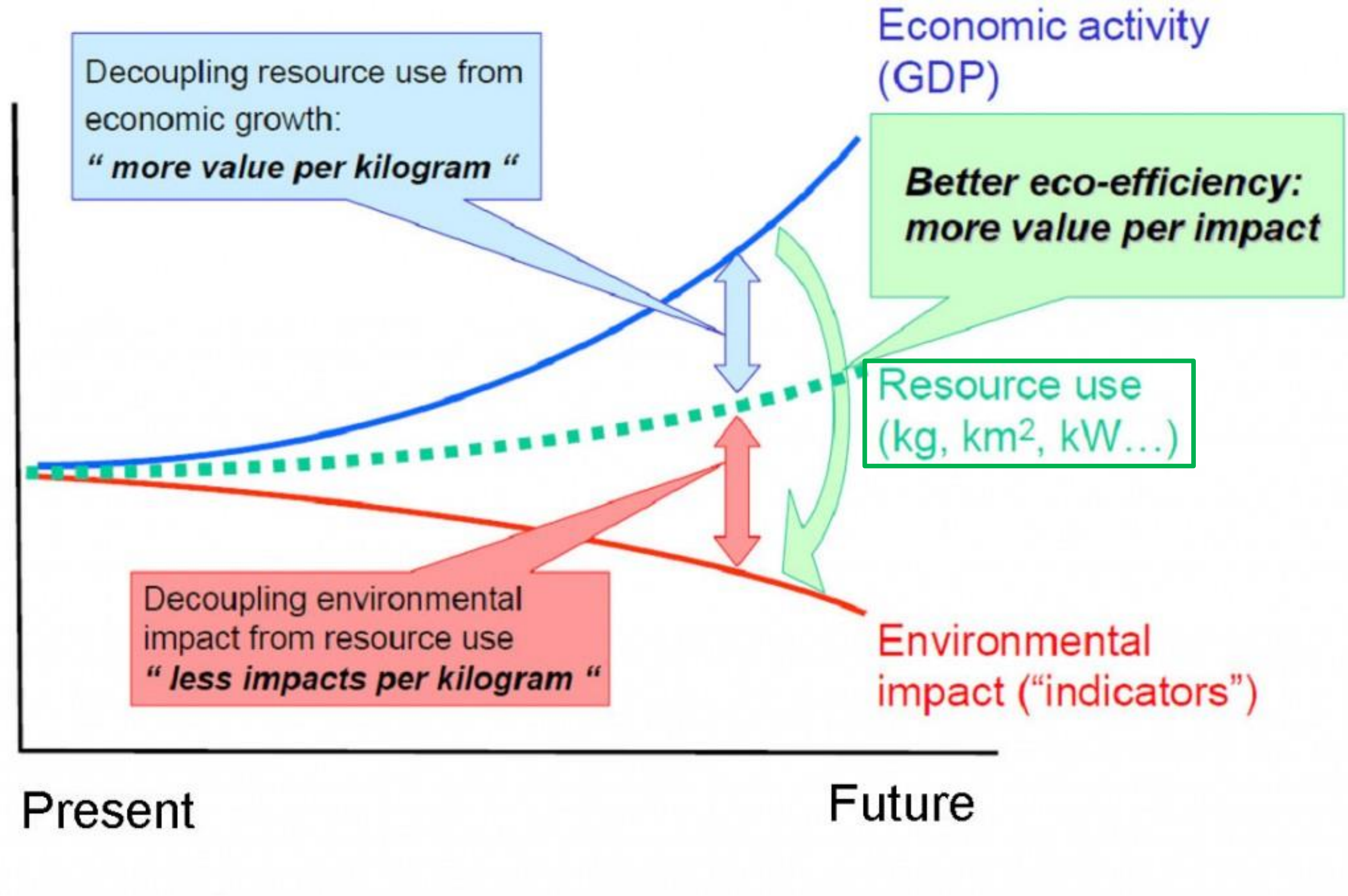
WS=WD

- Water withdrawal, WW

$$WW = \frac{WD}{\prod_{j=1}^{m} EFF_j} = \frac{\sum_{i=1}^{n} \left(\frac{ET_c - P_{eff}}{EFF_{app}} A\right)_i}{\prod_{j=1}^{m} EFF_j} = \frac{Agronomic\ demand}{Engineering\ Efficiency} \approx \mathbf{EE}$$

Technology uptake

Economic activity, **RESOURCE USE**, environmental impact



Source : http://www.eea.europa.eu/

Assessing Agricultural Eco-Efficiency

Product/Service value – cost of production/service (€)

↑

PRODUCT/SERVICE ADDED VALUE

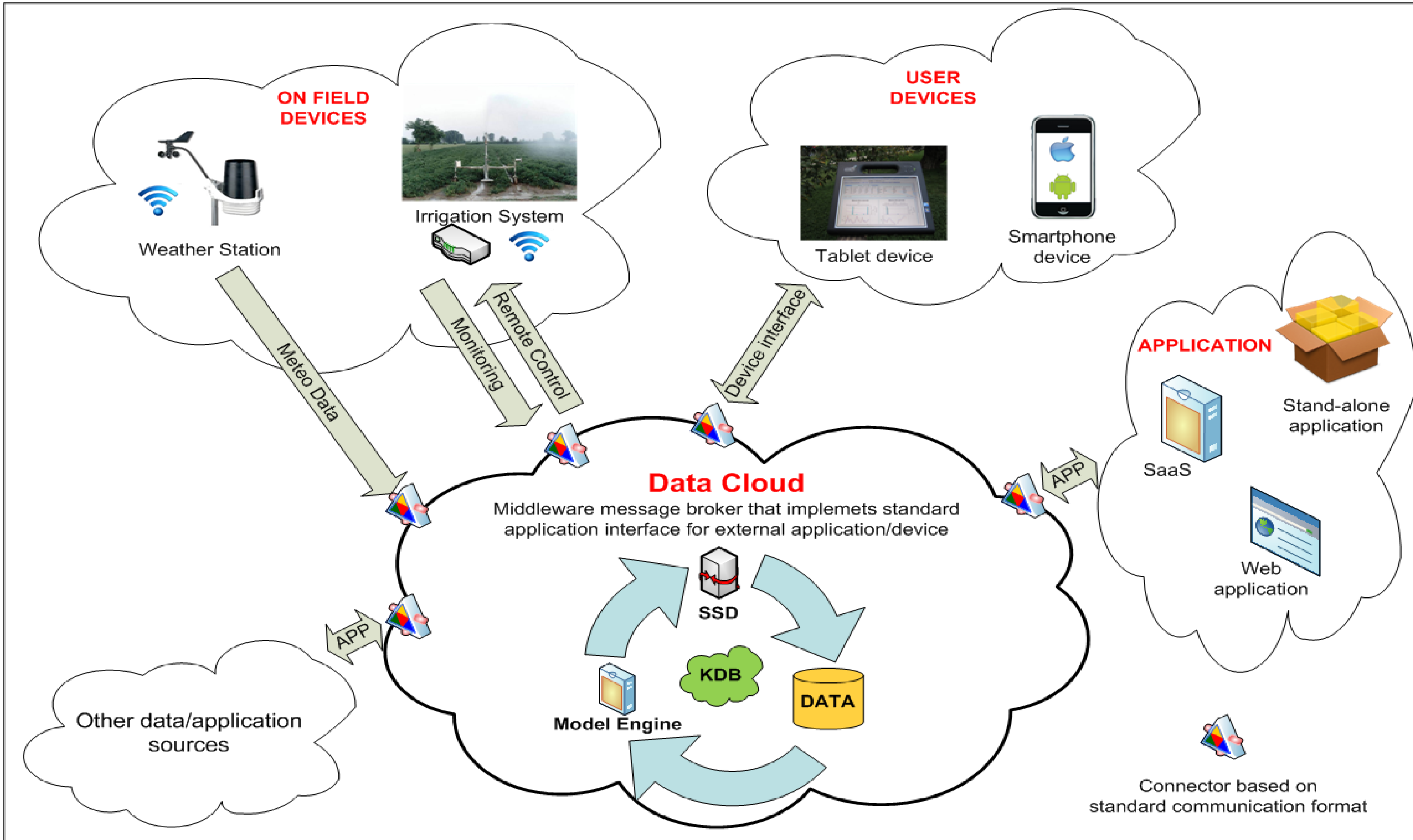
ENVIRONMENTAL IMPACT

↓

- Water withdrawal (m3)
- Energy consumption (kWh)
- CO_2 emissions (tons)
- Fertilizers (N, P) application (kg)

Composite System Indicator

Integrating and automating … a complex ADSS at farm and district scale

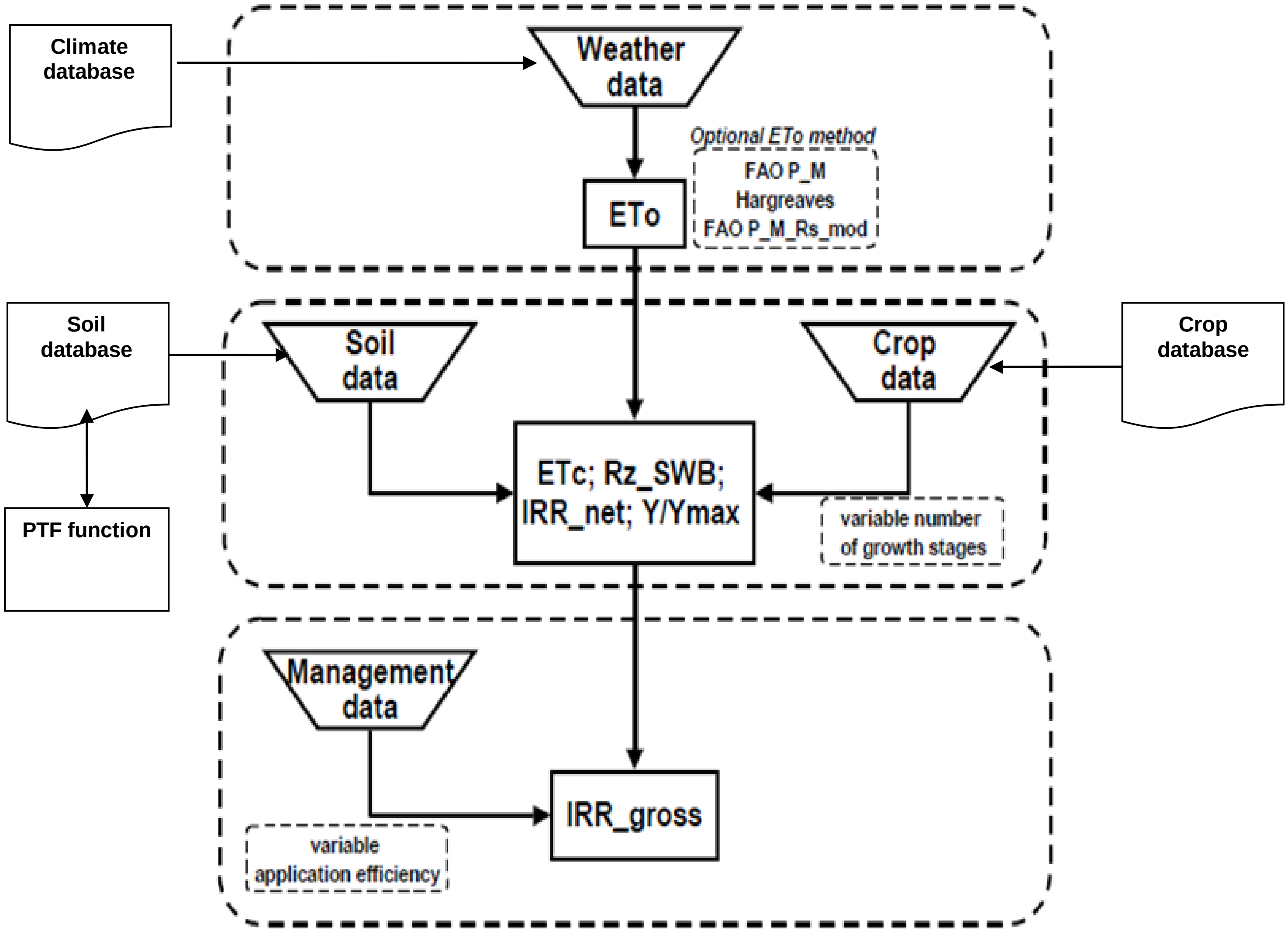


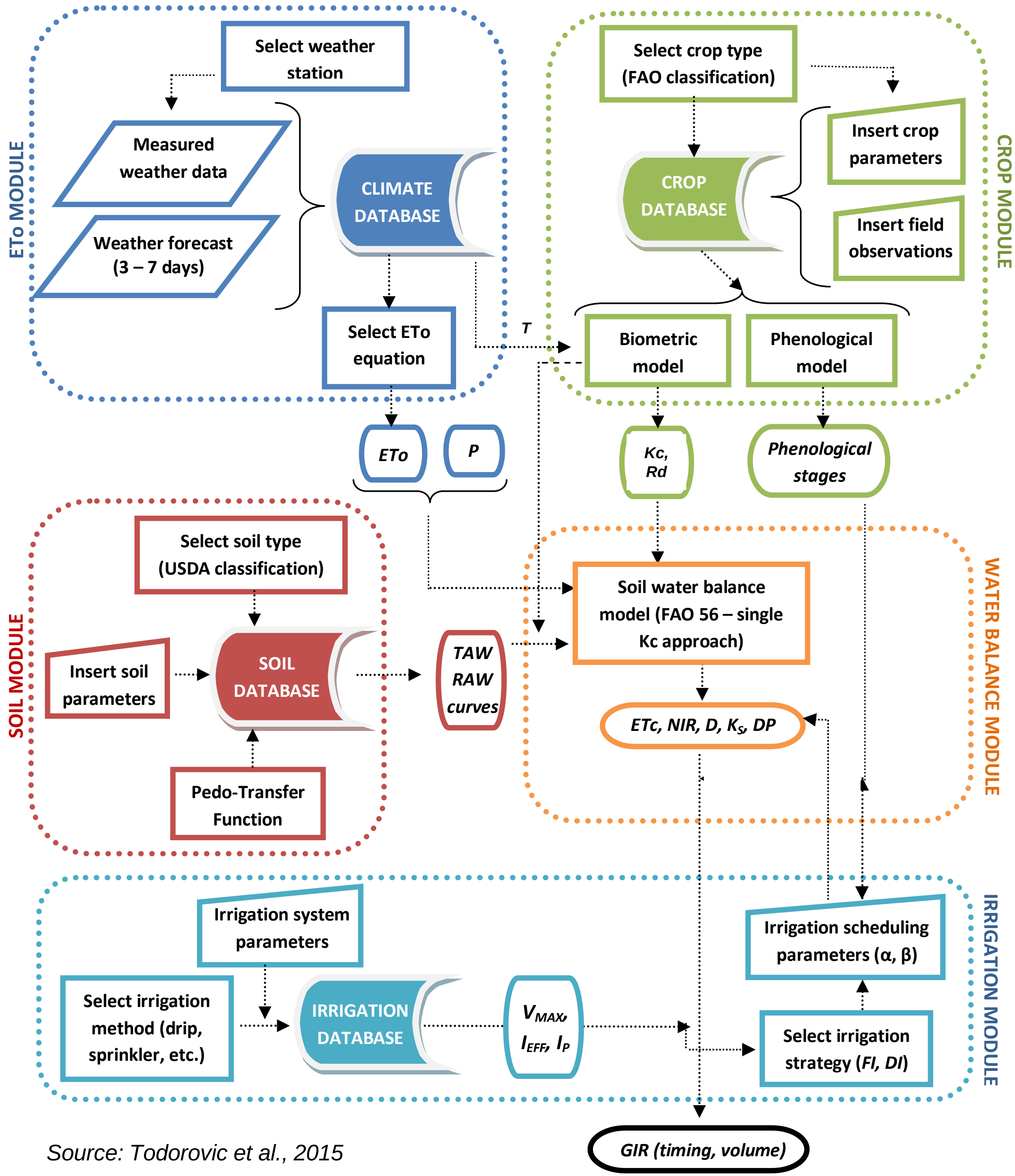
HYDROTECH architecture

Hydro-Tech: main features

- Combines soil/crop water status monitoring and soil water balance modeling
- Multi ETo model (depending on data availability)
- “Adjustable” K_Rs and Rs_measured, Kc to local conditions
- Multi crop development model (days/heat units) with adjustable number of development stages
- Multi “Crop response to Water” model and yield prediction (Stewart+Rao)
- Weather forecasting use in DSS
- Separate crop development and water management phases/thresholds (RDI)
- Completely/partially automated (level of automation managed by user)
- Real time remote control and management
- Multi plot/crop management … Multi-scale (field, farm, irrigation district)
- Water management optimization for dynamic management strategies for different crops/fields
- On field/crop specific management strategies (priorities water / yield / energy / profit …, inclusion/exclusion of irrigation days/time, etc.)
- Eco-efficiency considered
- Improvable – permits insert of new/additional sensors/modules

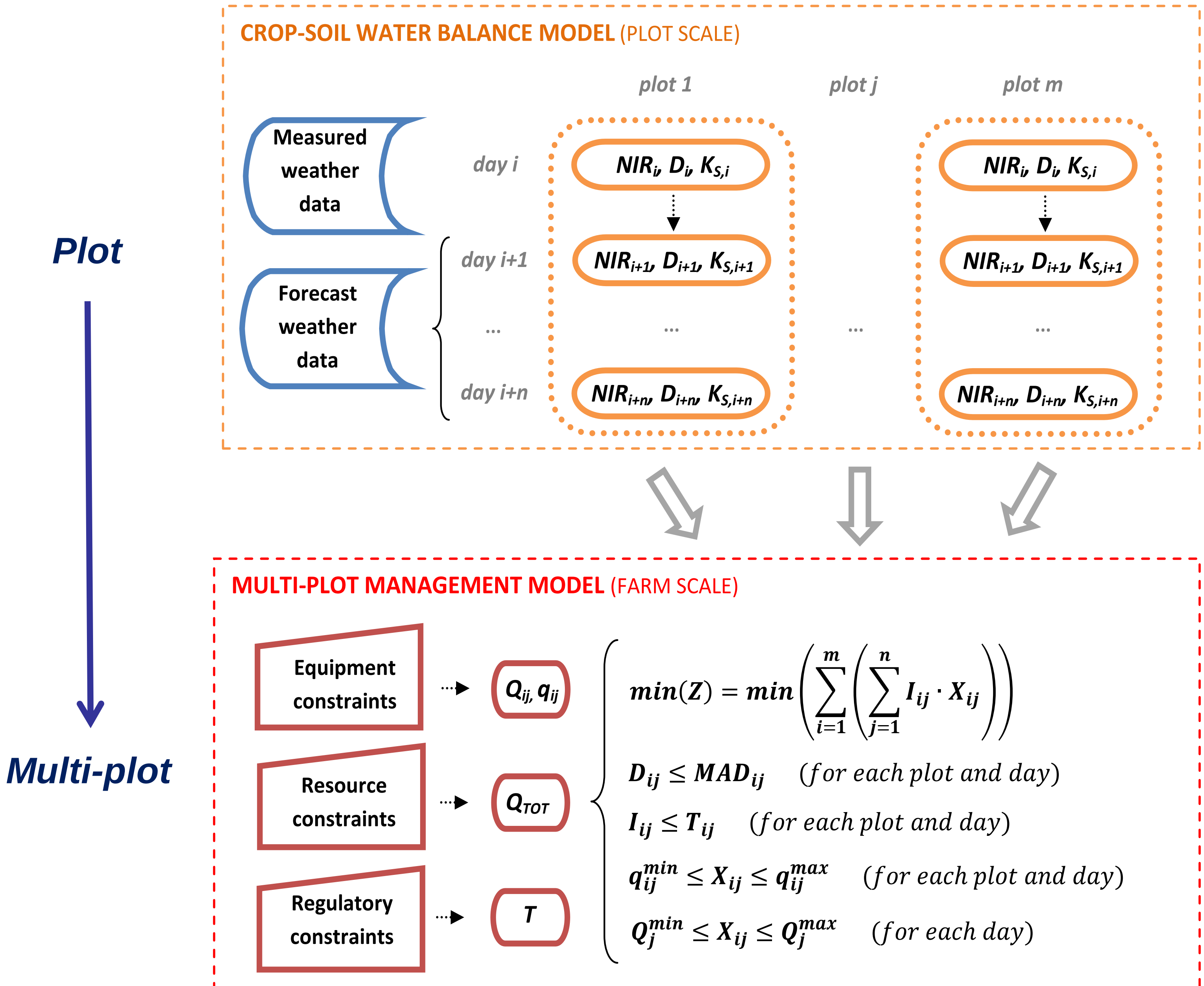
Main calculation modules and databases of the irrigation scheduling model





Source: Todorovic et al., 2015

Multi-plot dynamic water delivery optimizer



Kc corrections

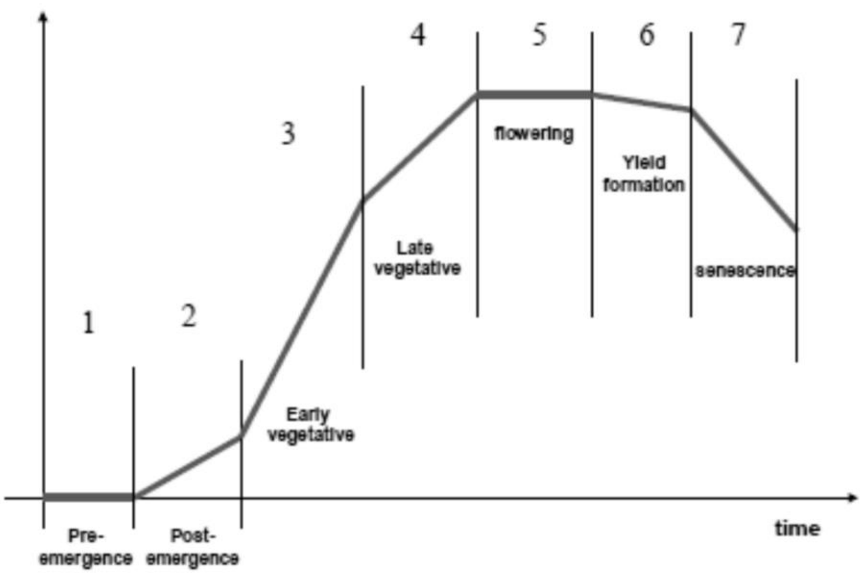
Correction of the Kc values in relation to local climate and crop characteristics

$$Kc_{mid/end} = Kc_{tab} + [0.04(u_2 - 2) - 0.004(RH_{min} - 45)](h/3)^{0.3}$$

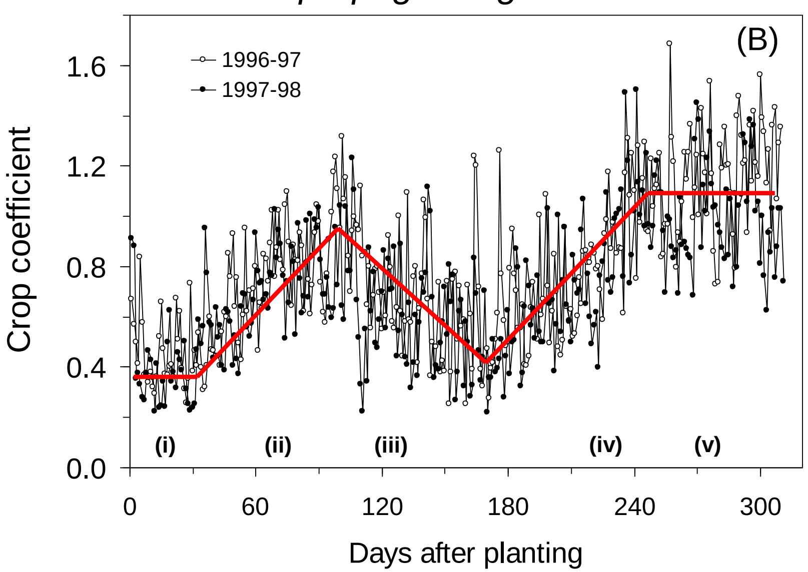
Correction based upon the fraction of ground covered by vegetation and its height

$$K_d = \min\left(1, M_L f_{eff}, f_{eff}^{(1/1+h)}\right)$$

Allen and Pereira, 2009

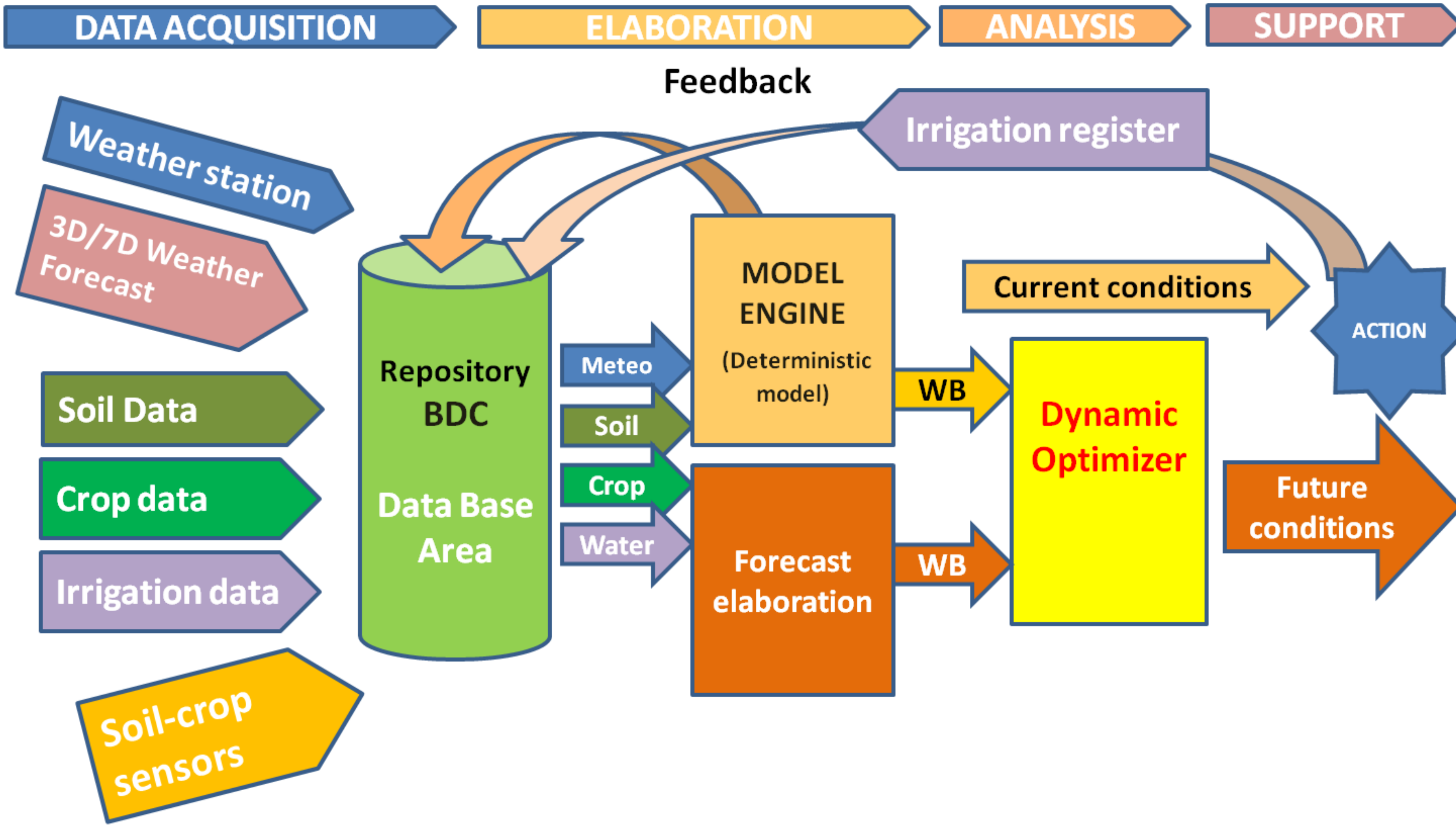


seed propagated globe artichoke

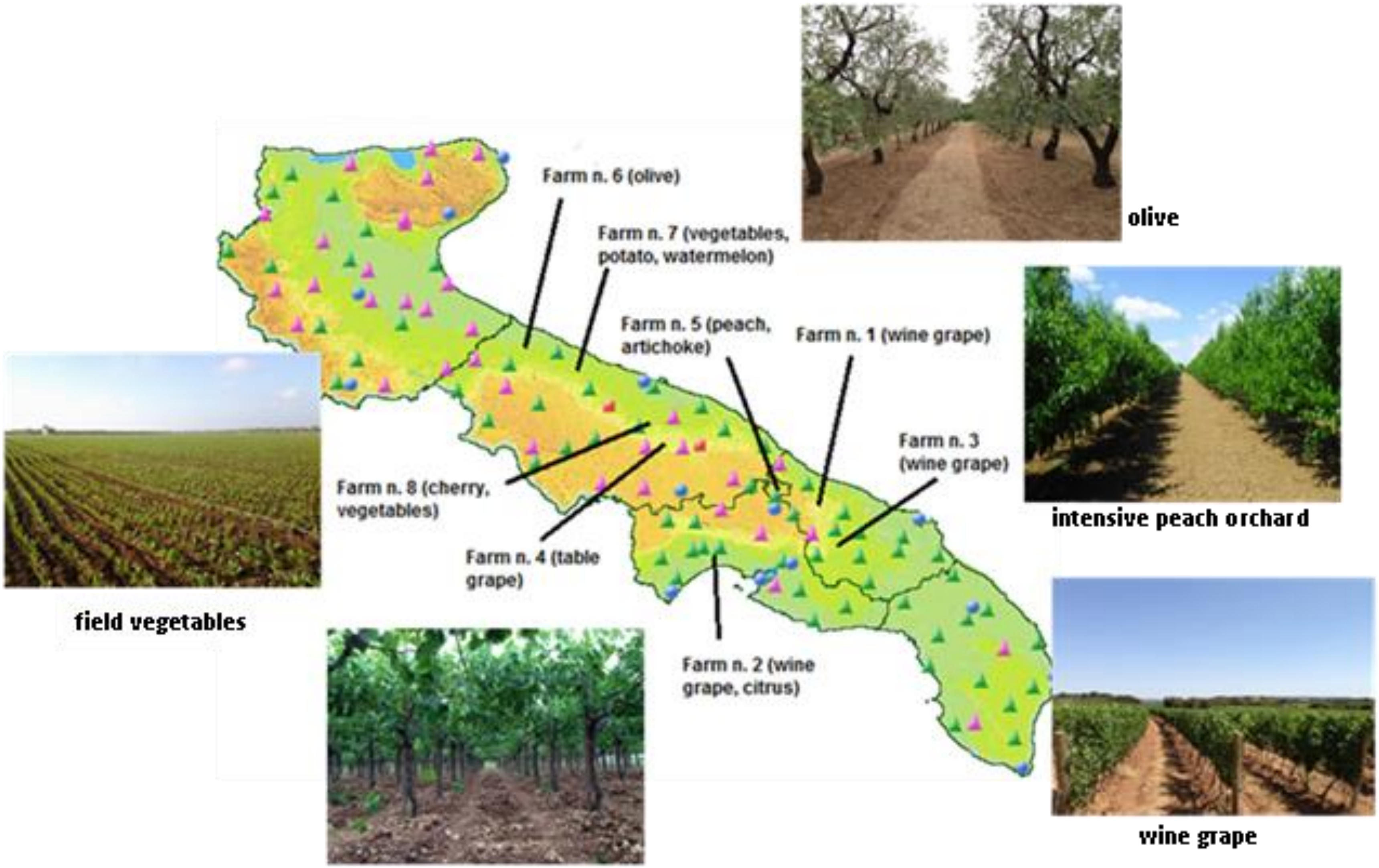


Cantore et al., 2013

Hydro-Tech: Data Flow Scheme



Geographical location of selected experimental farms together with some representative pictures of different cropping system.

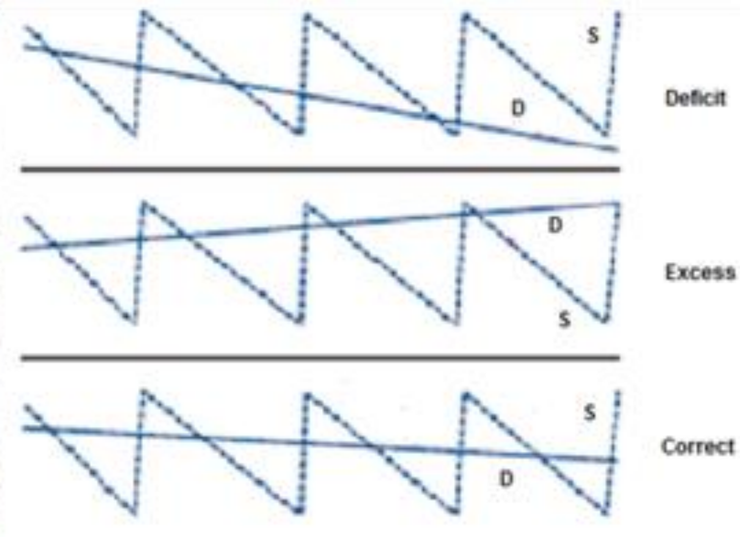


In the map, the symbols refer to the network of the stations of the regional agro-meteorological service.

Examples of field units for data acquisition

Weather and soil sensors connected to wireless radio dataloggers
(Decagon and DyrectaLab devices, Villa Castelli – BR, wine grape)

Soil moisture monitoring with 'capacitance' sensors

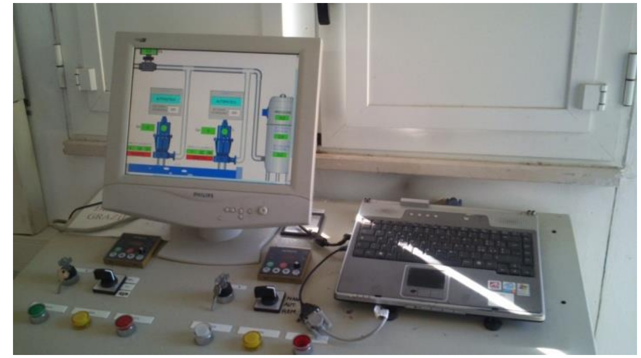


ECH2O Decagon sensors

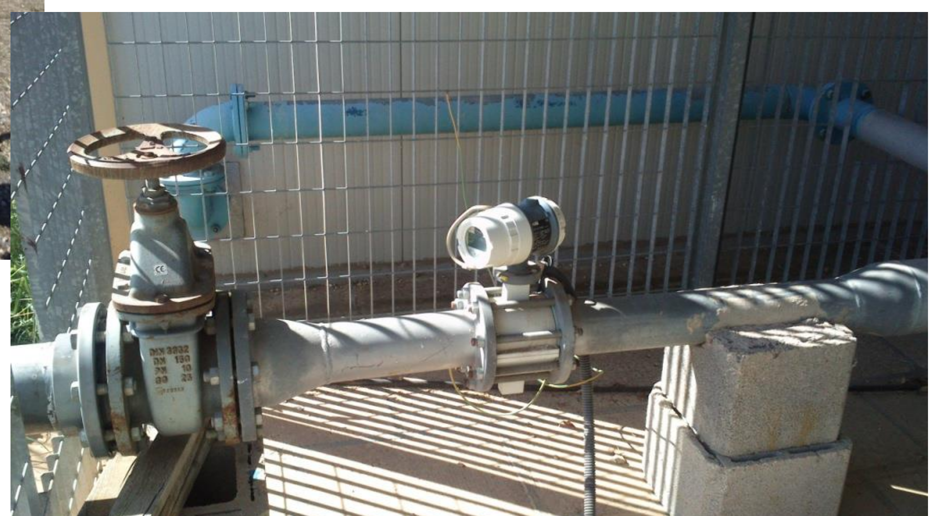
DeltaT PR2 probe

schematic representation of the soil moisture content at the shallow (S) and deeper (D) sensor position, respectively (from Fereres et al., 2012)

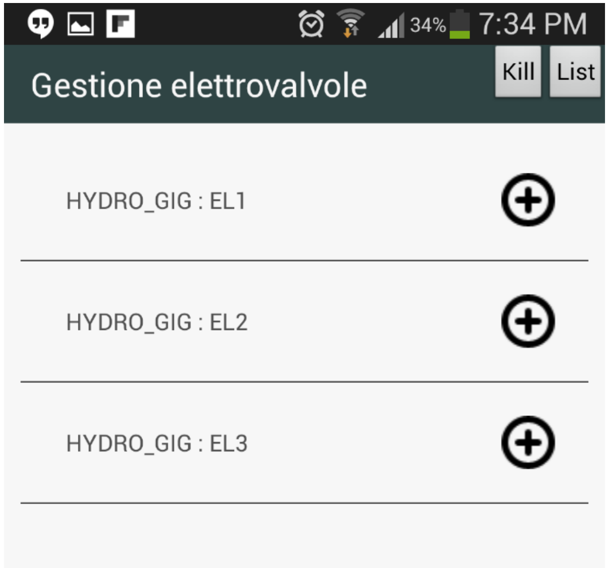
Examples of field units and remote control of water supply network

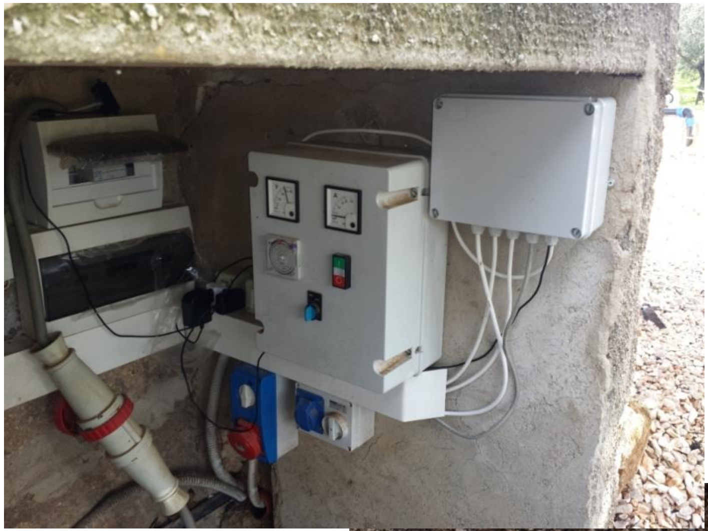


Hydrants and pumps monitoring and control with wireless radio dataloggers (ETG devices, IAMB, Valenzano – BA, pumping station and hydrant network)

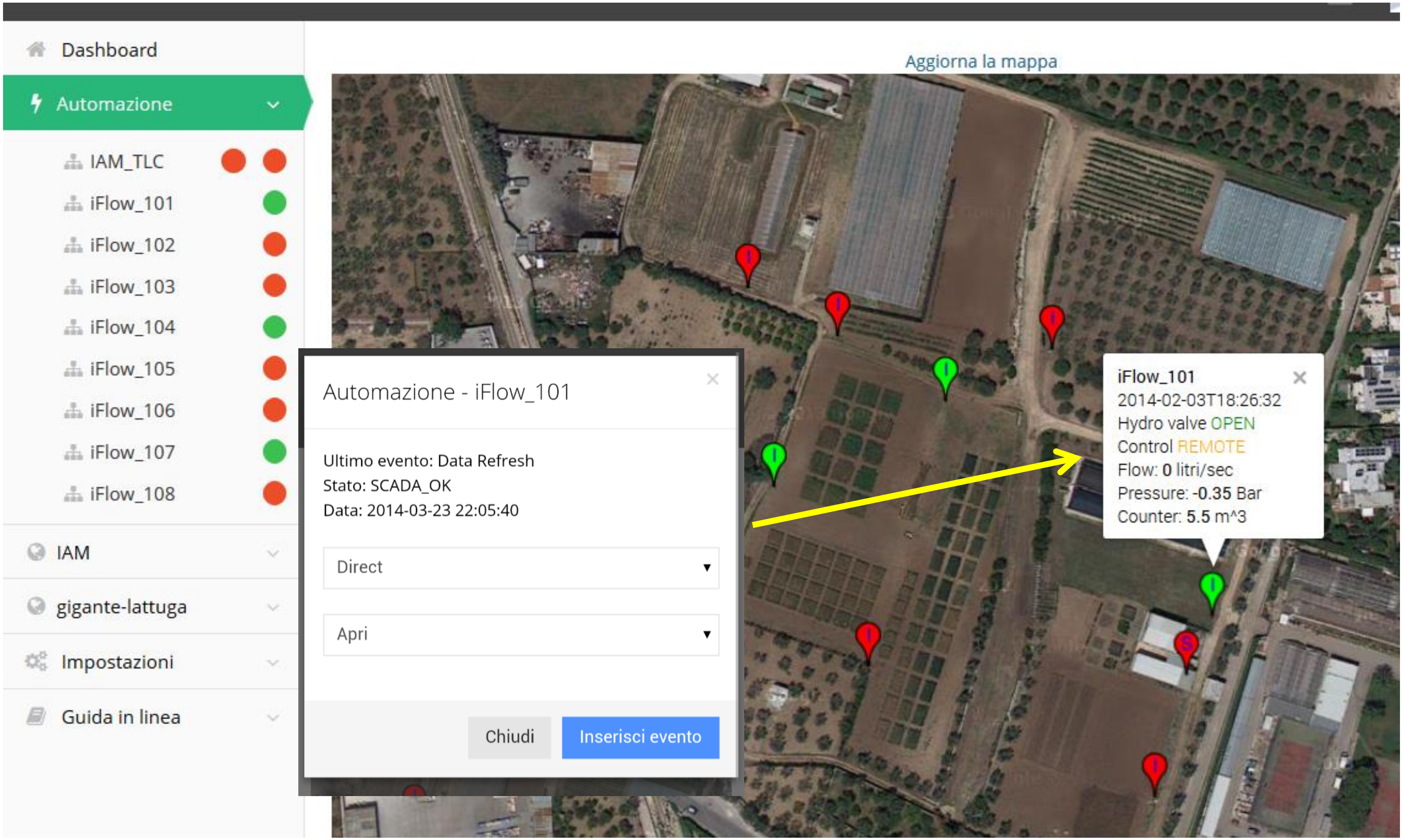


Examples of remote control of electro-valves and pumps at a private farm

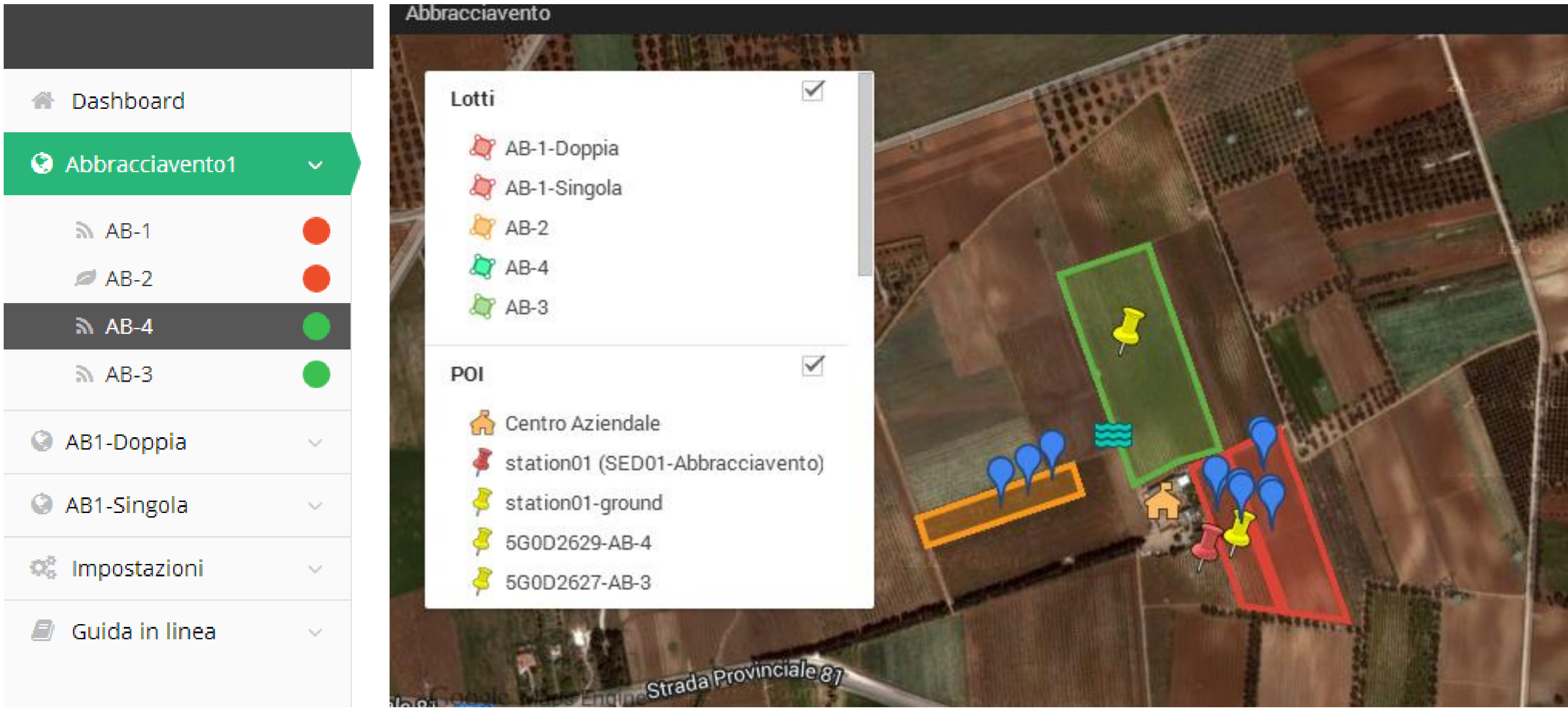




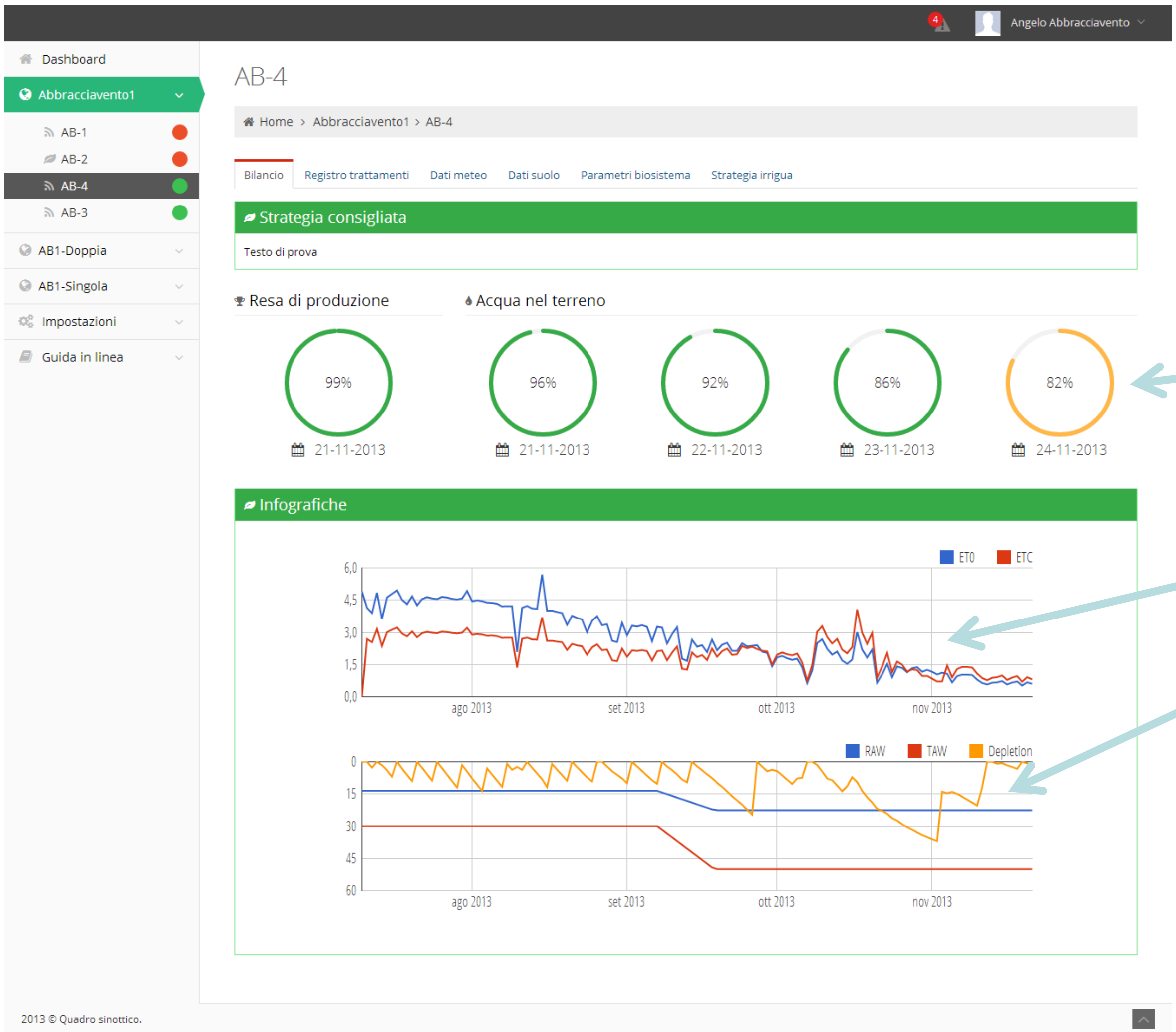
Examples of ‘web’ applications at district scale



Examples of ‘web’ applications at farms scale

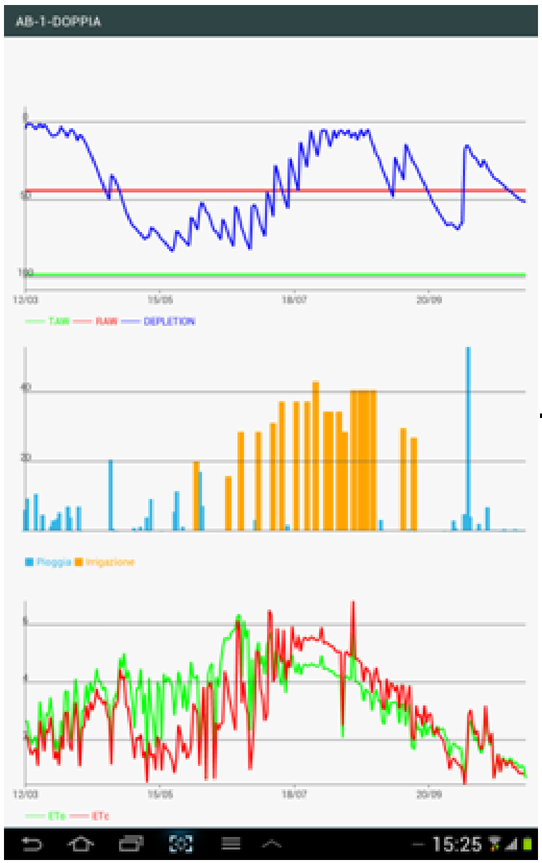


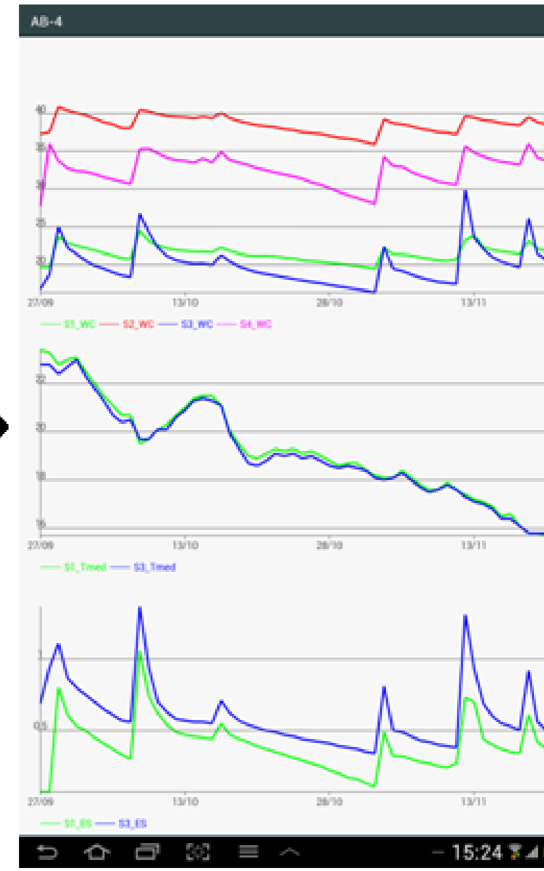
Examples of ‘web’ applications at field scale



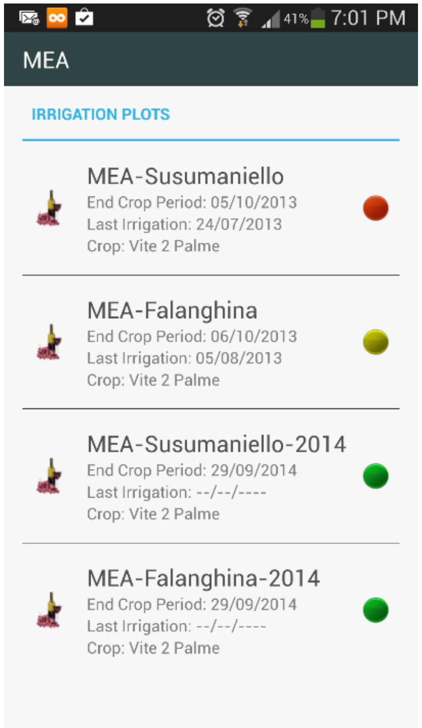
Current status and **projected 3-days changes** in the percentage of soil water content, with the seasonal **trend of ETo versus ETc** and the seasonal trend of **soil water depletion**

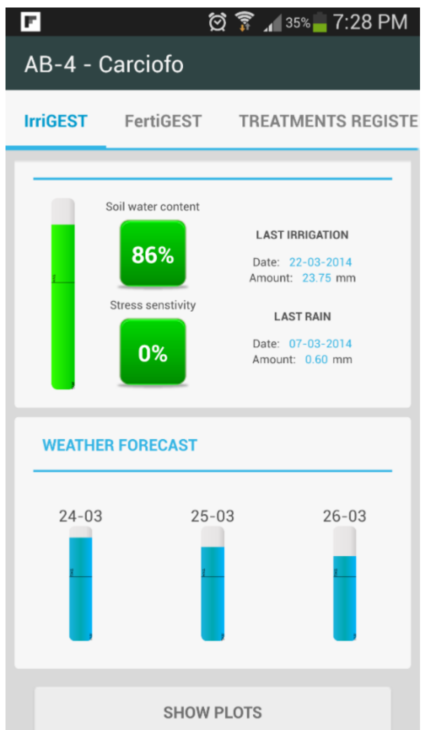
Example of MOBILE Android application

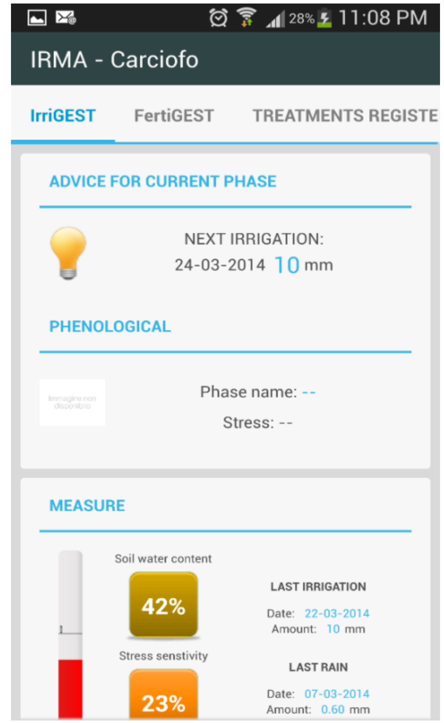


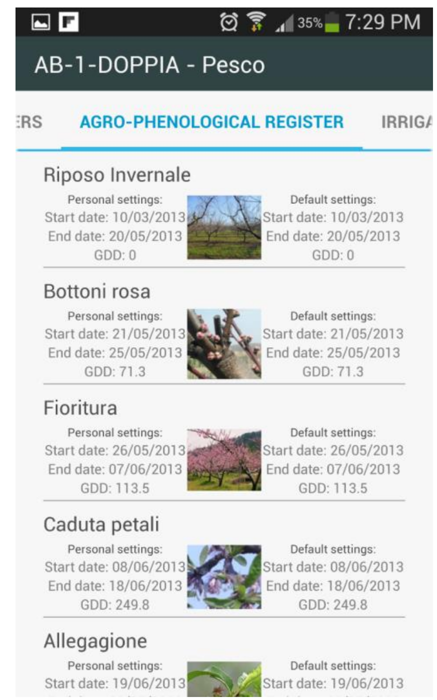


Examples of mobile Android applications

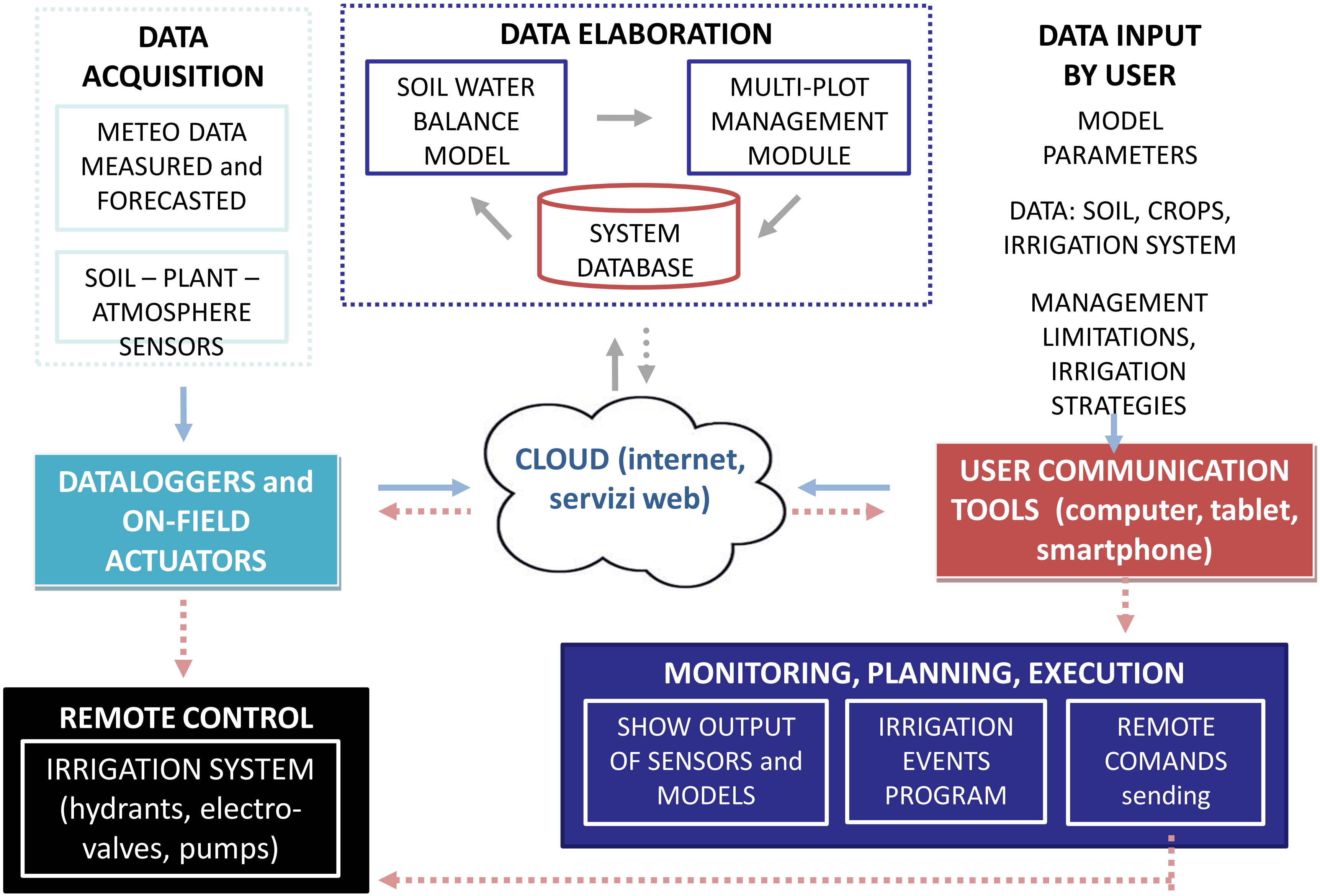


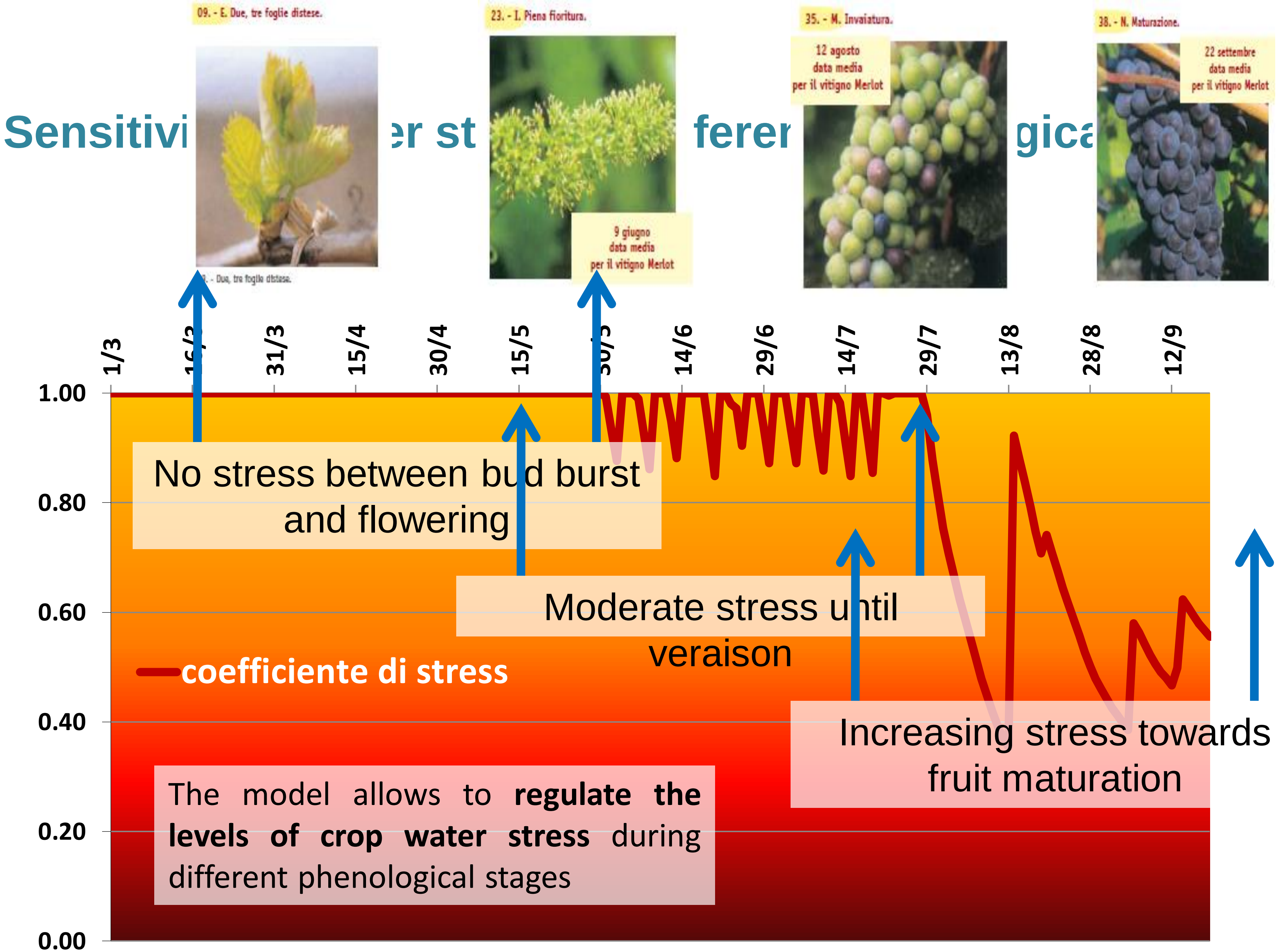






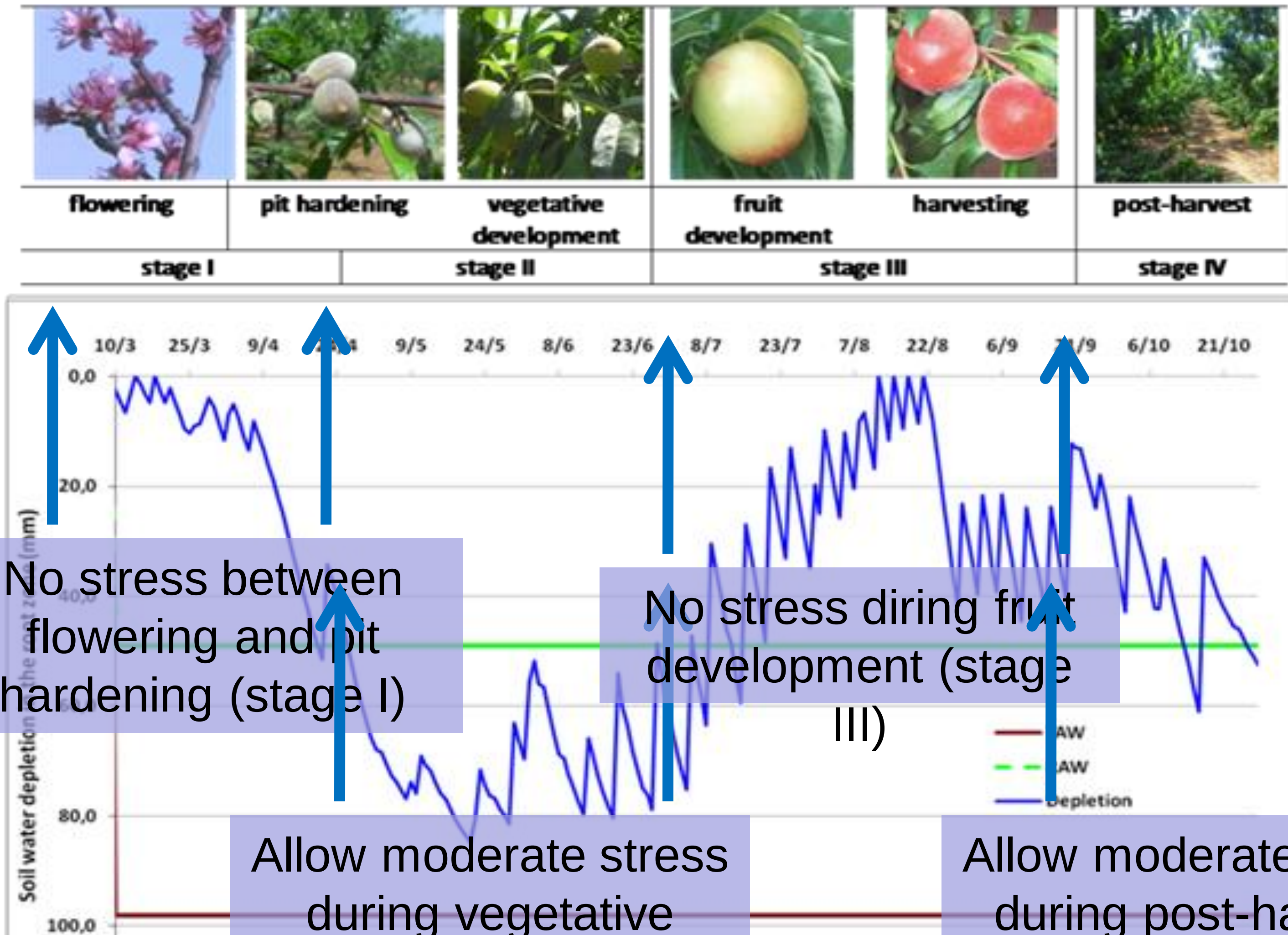
Architecture of HYDROTECH DSS





(Mesagne – BR, wine grape, loamy soil, depth 0.80 m)

Sensitivity to water stress in different phenological stages



No stress between flowering and pit hardening (stage I)

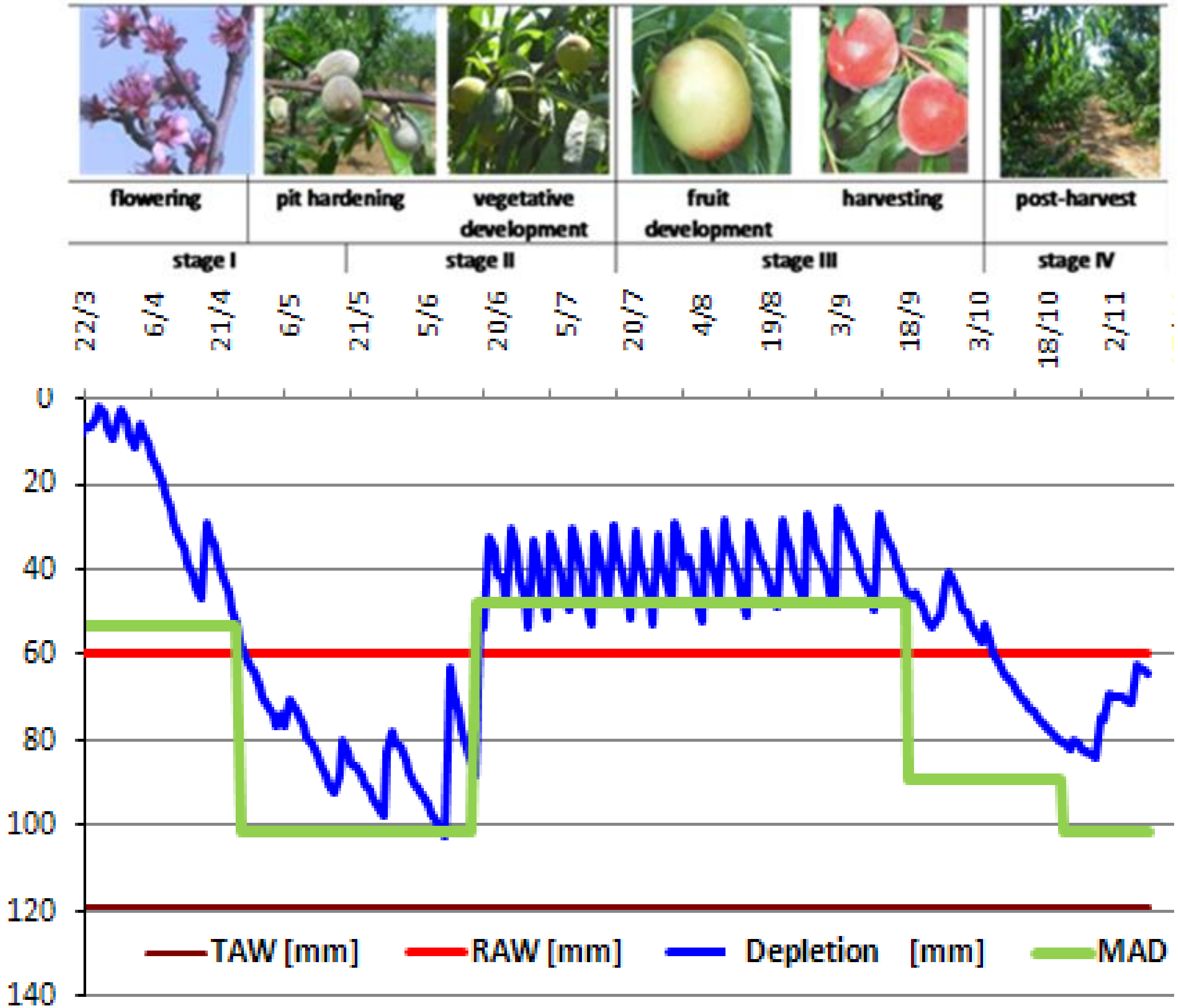
No stress diring fruit development (stage III)

Allow moderate stress during vegetative development (stage II)

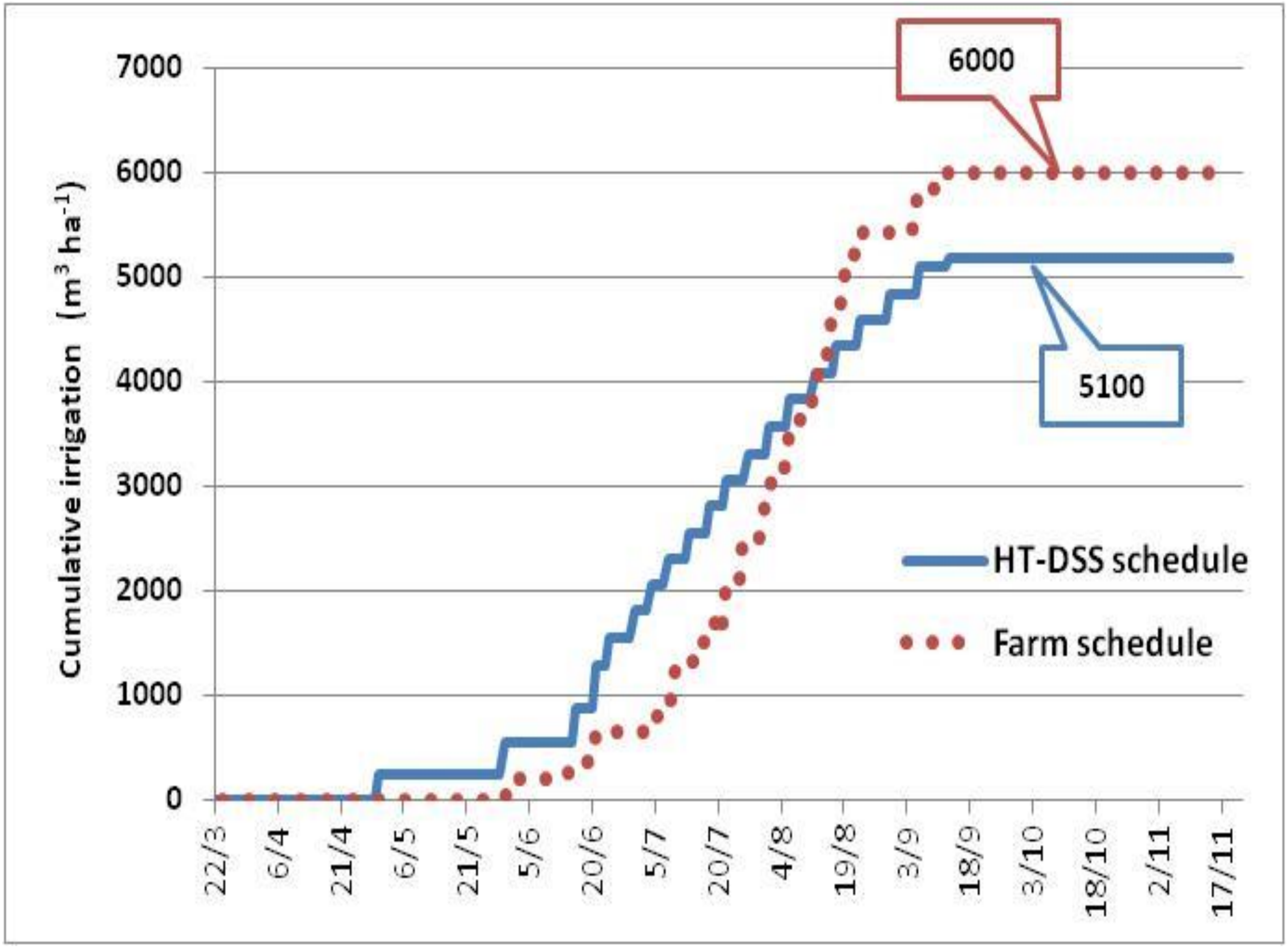
Allow moderate stress during post-harvest (stage VI)

(Mesagne – BR, late-maturing peach orchard, loamy soil, depth 0.70 m)

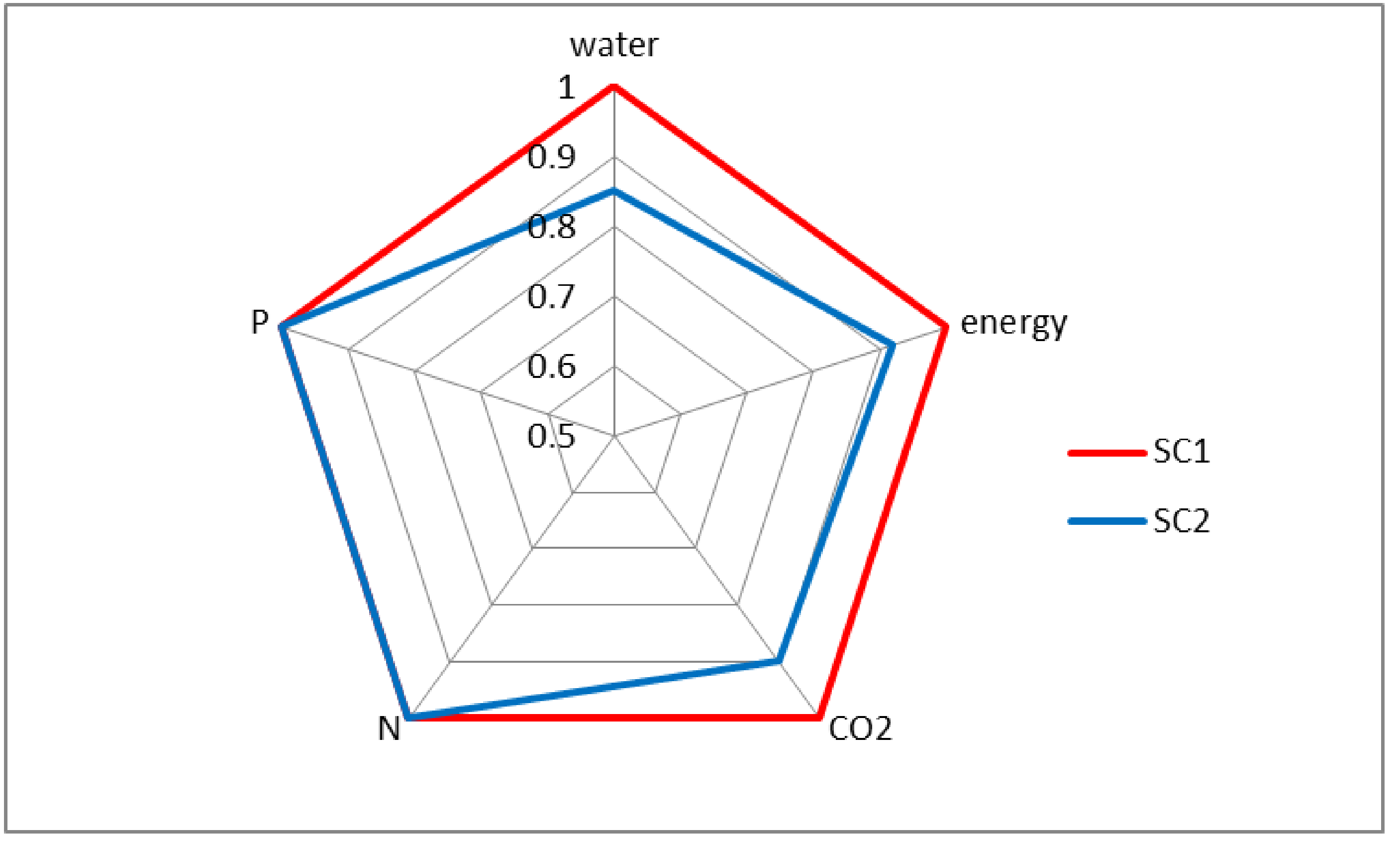
Main peach phenological stages and corresponding trend of the soil water depletion in the root zone adopting a regulated deficit irrigation with variable MAD



Cumulated irrigation volumes applied to peach orchard



Eco-efficiency assessment of two water management scenarios



SC1 Added Value = 4658 €/ha
SC2 Added Value = 4724 €/ha

Conclusions

- 2 years of experimental/testing activity provided the **field evidence of strengths and weaknesses** of the system.
- HT-DSS considered the **eco-efficiency aspects of water management** (economic benefits vs. resources use).
- **Product quality** in relation to water regime seems to be of higher relevance (wine grapes).
- HT-DSS **integrates the scientific knowledge with the local experience**: the best way to design DSS according to the farmer's perspectives.
- The results of testing indicated the **satisfaction of the farmers** who emphasized the saving of water, energy and time (dedicated to water management), economic benefits and eco-efficiency increase.
- This has confirmed that **the support tools and DSS** for agricultural water management **are effectively required** by farmers, technicians and decision makers.

LAND and WATER Dept.

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Many thanks for your attention

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