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Verifica ed estensione del sistema di supporto alle decisioni per la gestione delle risorse idriche della O.P. Illuminati Frutta S.C.r.l.

Giovanni Rallo



UNIVERSITÀ
DI PISA



Gruppo di lavoro

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G. Asta

Stefano Giusti



Dr. P. Redi
Sig. L. Fantozzi



Schema Irriguo

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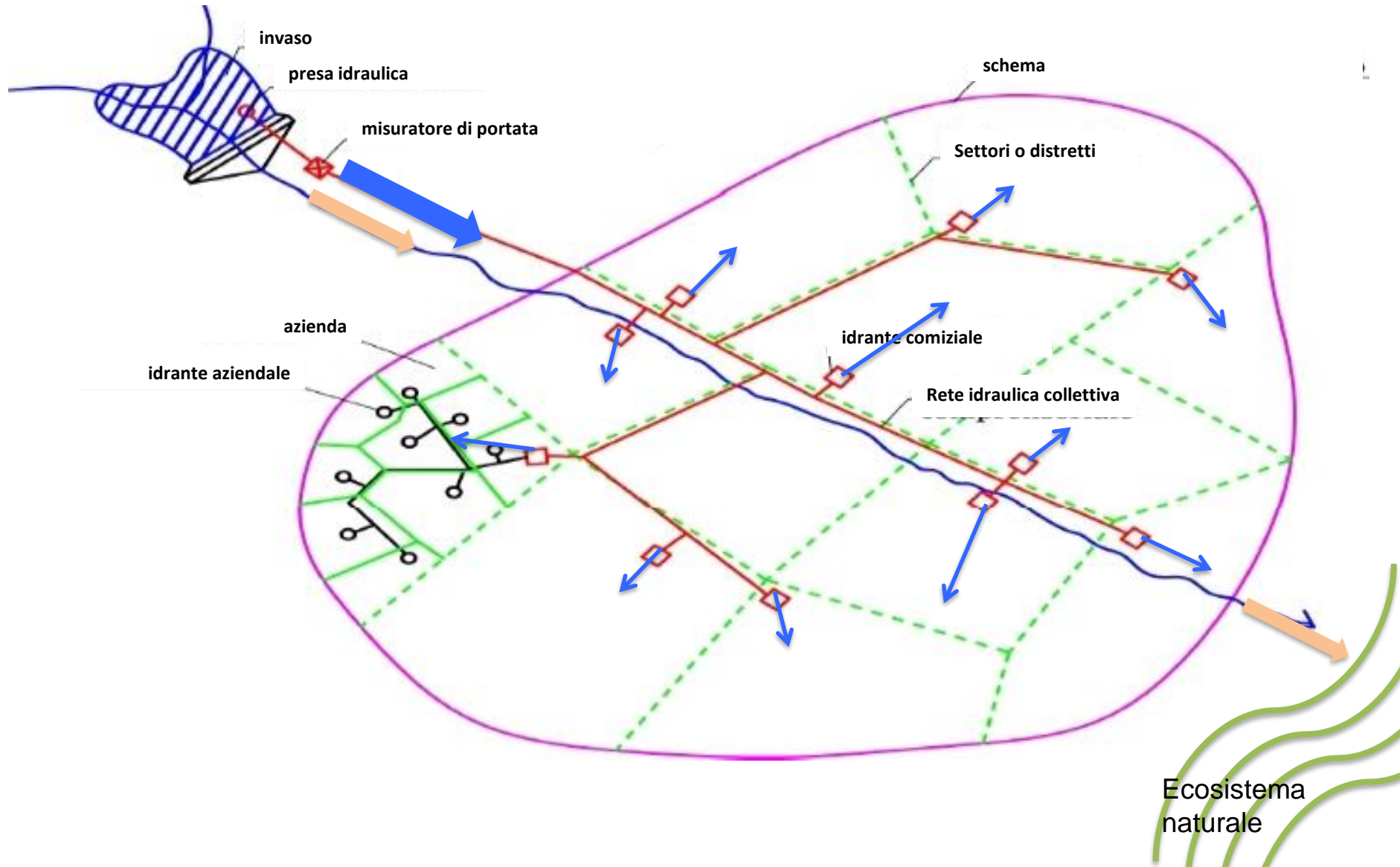


$L=f(\text{richiesta idrica, superfici, efficienza})$

$$E_{\text{schema}} = \frac{\sum_{i=1}^N V_{\text{ent_set}}}{V}$$

$$E_{\text{schema, s}} = \frac{\sum_{i=1}^N V_{\text{ent_set}} + Vr}{V}$$

s: sagacia
r: uso ragionevole



Schema Irriguo – settore – azienda - campo

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$$E_{campo} = \frac{\sum_{i=1}^N V_{zona_radicale}}{V_{rec_campo}}$$

$$E_{azienda} = \frac{\sum_{i=1}^N V_{rec_campo}}{V_{rec_azienda}}$$

$$E_{settore} = \frac{\sum_{i=1}^N V_{rec_azienda}}{V_{ent_set}}$$

Schema Irriguo – settore – azienda – campo – SPAC – chioma –



Sistema continuo suolo-pianta-atmosfera (SPAC)



Traspirazione/Assimilazione



Evaporazione



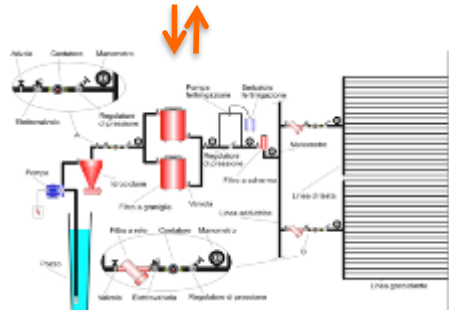
Attingimento idrico



campo



Erogatori



Impianto irriguo

Efficienza Annidata (Nested-WUE)

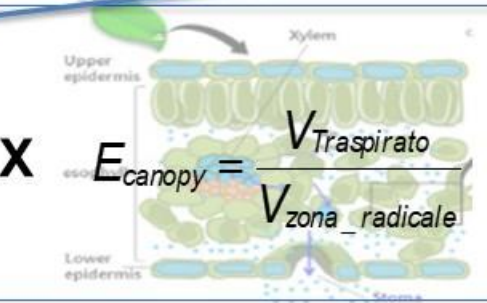
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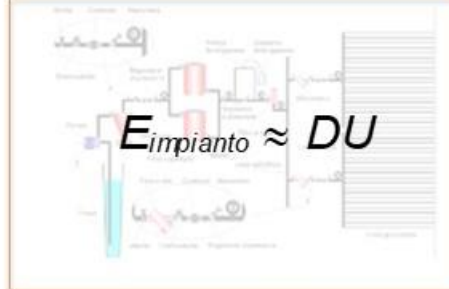


Idraulica

$$E_{schema} = \frac{\sum_{i=1}^N V_{ent_set}}{V} \times E_{distretto} = \frac{\sum_{i=1}^N V_{rec_azienda}}{V_{ent_set}} \times E_{azienda} = \frac{\sum_{i=1}^N V_{rec_campi}}{V_{rec_azienda}} \times E_{campo} = \frac{\sum_{i=1}^N V_{zona_radicale}}{V_{rec_campo}} \times$$

Idrologia

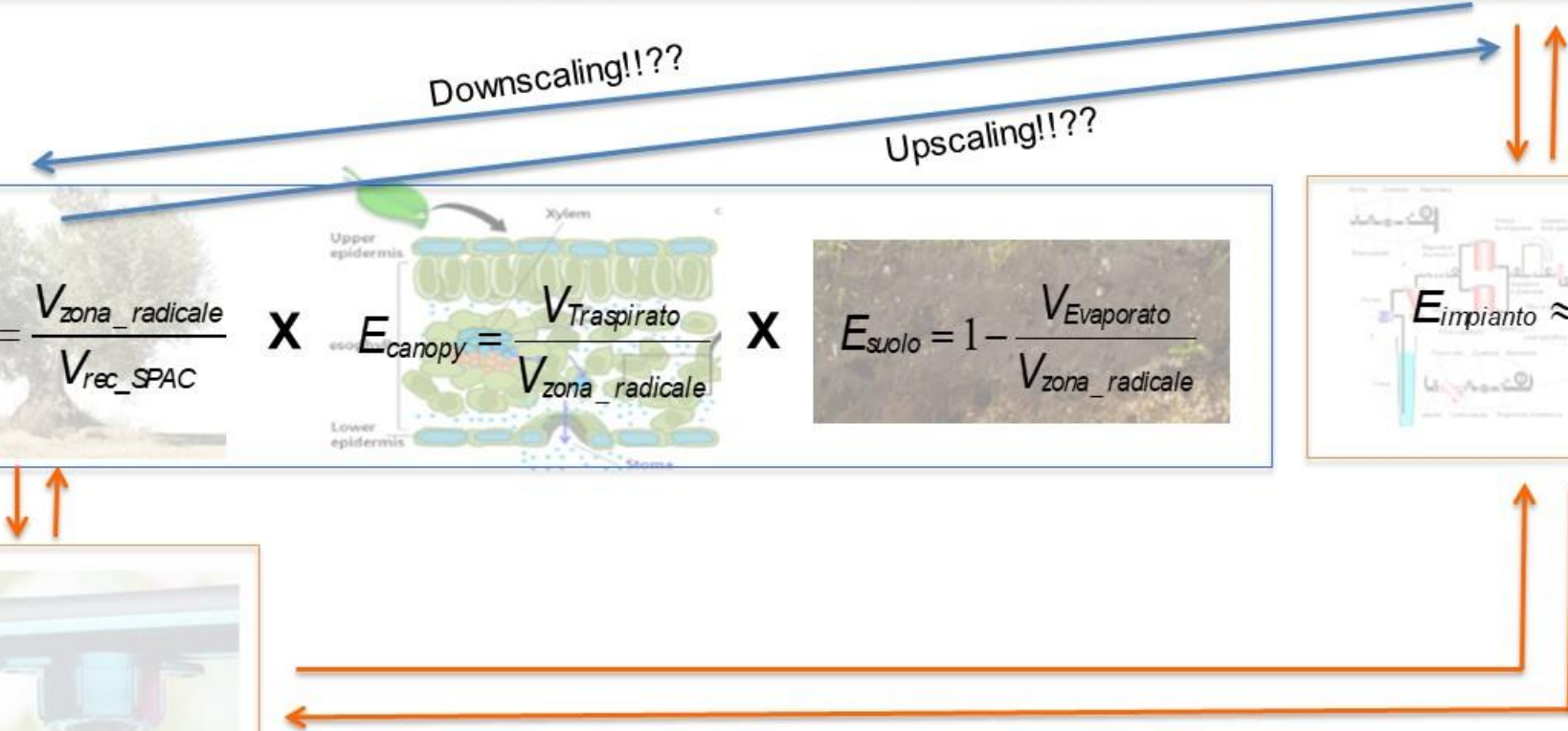
$$E_{SPAC} = \frac{V_{zona_radicale}}{V_{rec_SPAC}} \times E_{canopy} = \frac{V_{Traspirato}}{V_{zona_radicale}} \times E_{suolo} = 1 - \frac{V_{Evaporato}}{V_{zona_radicale}}$$


$$E_{impianto} \approx DU$$


$$E_{erogatore} = f(CVT; topologia)$$


Downscaling!??

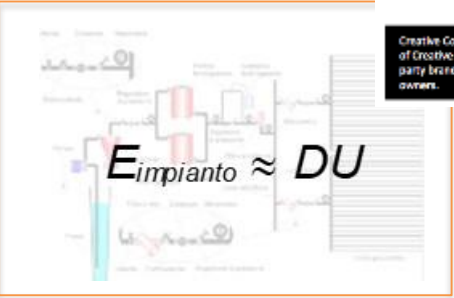
Upscaling!??



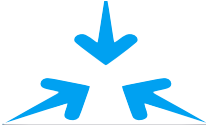
Gestione di precisione



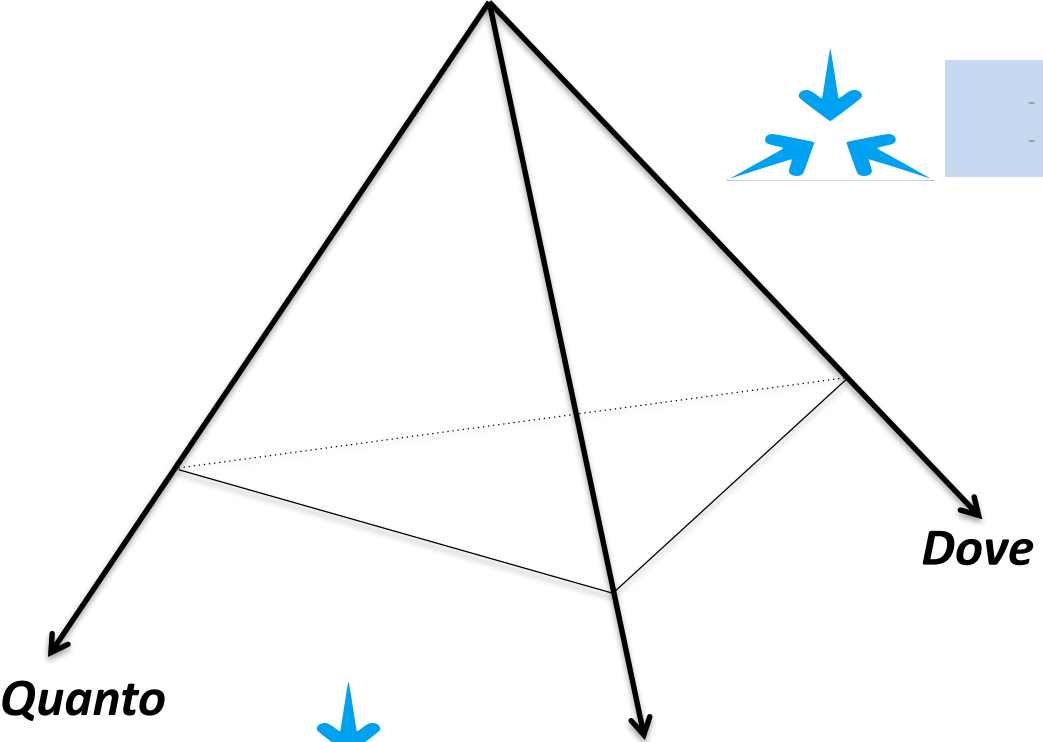
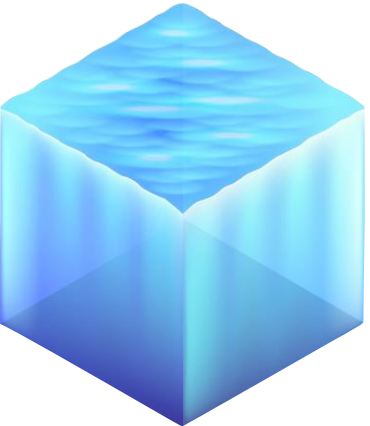
Come



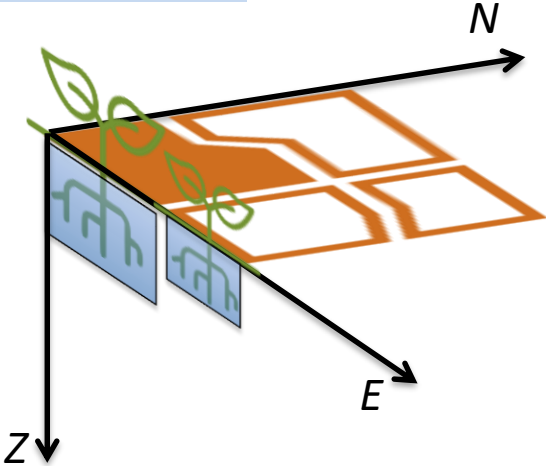
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Controllo delle pressioni



- Zonazione
- Serbatoio degli attingimenti



- Controllo retroattivo
- Controllo in base alle previsioni



SSD per la gestione delle risorse idriche della O.P. Illuminati Fru



Via Chiana Casanova, 20/A
52040 Civitella in Val di
Chiana (Arezzo)

SAU IRRIGUA (ha) 230
mele
pere
pesche
susine



Gestione ordinaria	# addetti per l'irrig.	3
	durata adattamento (h)	5-7
	turno (gg)	3
	approvvigionamento	Pozzo+Montedoglio

Campo pilota

- Pereto di 6.4 ha
- # 3 cv: Carmen, William, Conference
- Irrigazione a goccia
- Fenomeni di deficit idrico del suolo

Performance dell'impianto irriguo (uniformità distribuzione irrig)



Quartile inferiore

$$DU_{lq} = \frac{\sum q_{(25\% \text{ inf.})}}{q_m * N}$$

Quartile inferiore e ottile superiore

$$CUa.c = 2 * \frac{q_{m(25\% \text{ inf.})}}{q_m} + \frac{q_m}{q_{m(12,5\% \text{ sup.})}} * 100$$

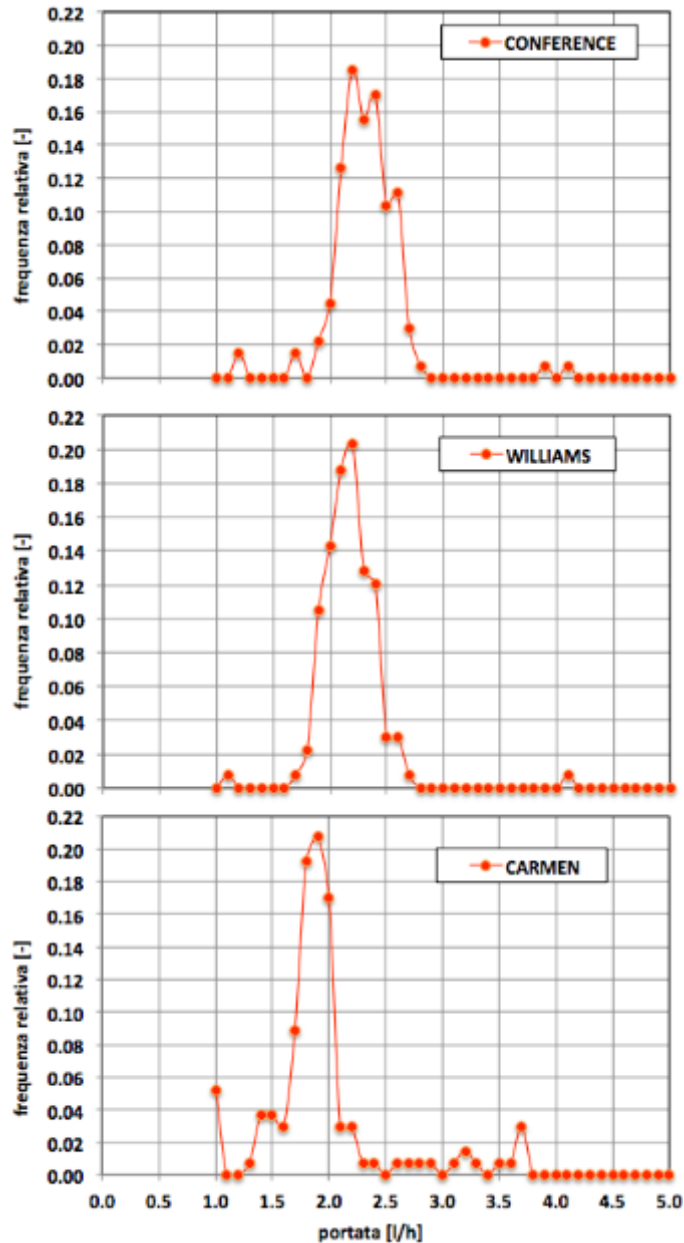
Giudizio

Quality of the Irrigation System	Irrigation System Rating (ISR)	Distribution Uniformity (DU _{LQ} overall)
Exceptional	10	> 85%
Excellent	9	75-84%
Very Good	8	70-74%
Good	7	60-69%
Fair	5	50-59%
Poor	3	40-49%
Fail	< 3	< 40%



Performance dell'impianto irriguo (uniformità distribuzione irrig)

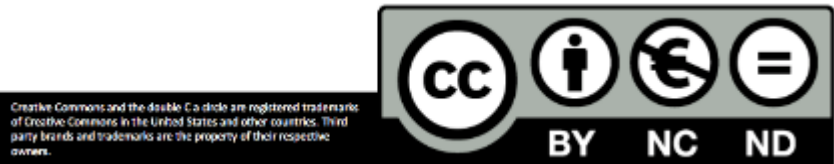
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	CONFERENCE	WILLIAMS	CARMEN
CV [%]	14.2	13.0	31.4
CUc[%]	88.7	89.6	75.0
DUIq [%]	87.7	87.6	70.1
CUa.c[%]	77.9	87.6	62.5

Quality of the Irrigation System	Irrigation System Rating (ISR)	Distribution Uniformity (DU _{LQ} overall)
Exceptional	10	> 85%
Excellent	9	75-84%
Very Good	8	70-74%
Good	7	60-69%
Fair	5	50-59%
Poor	3	40-49%
Fail	< 3	< 40%

Progettazione della WSN (Zonazione)



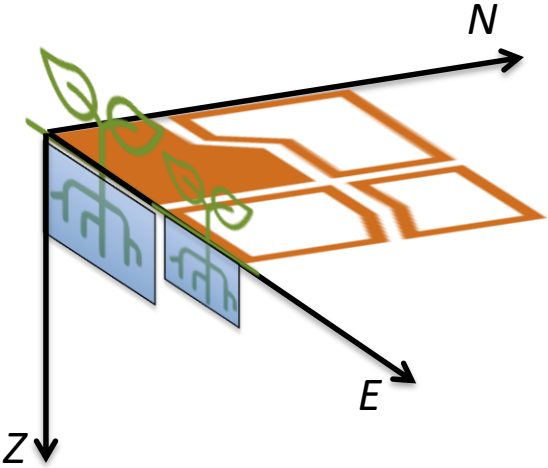
- Programmazione del volo drone



- mappa NDVI

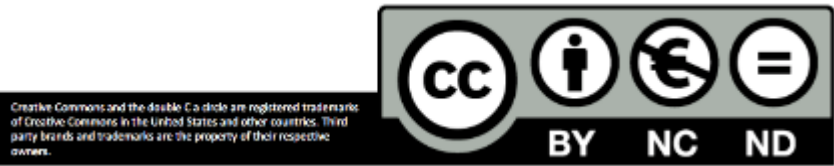


- mappa zone

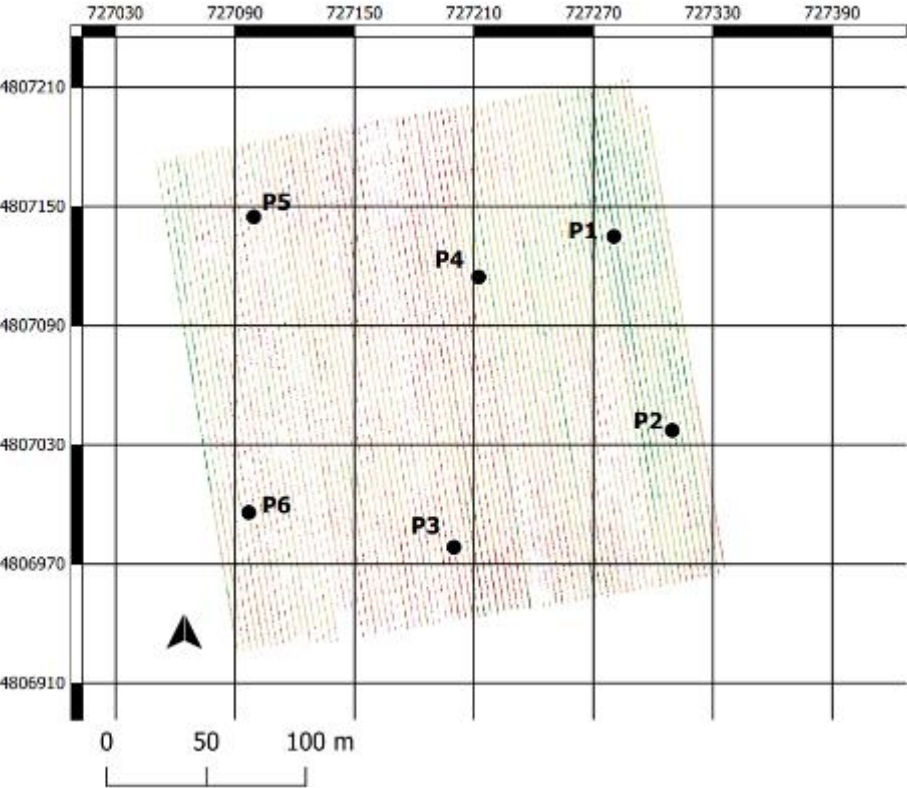


- Precisione sul piano orizzontale

Progettazione della WSN (Installazione nodi)

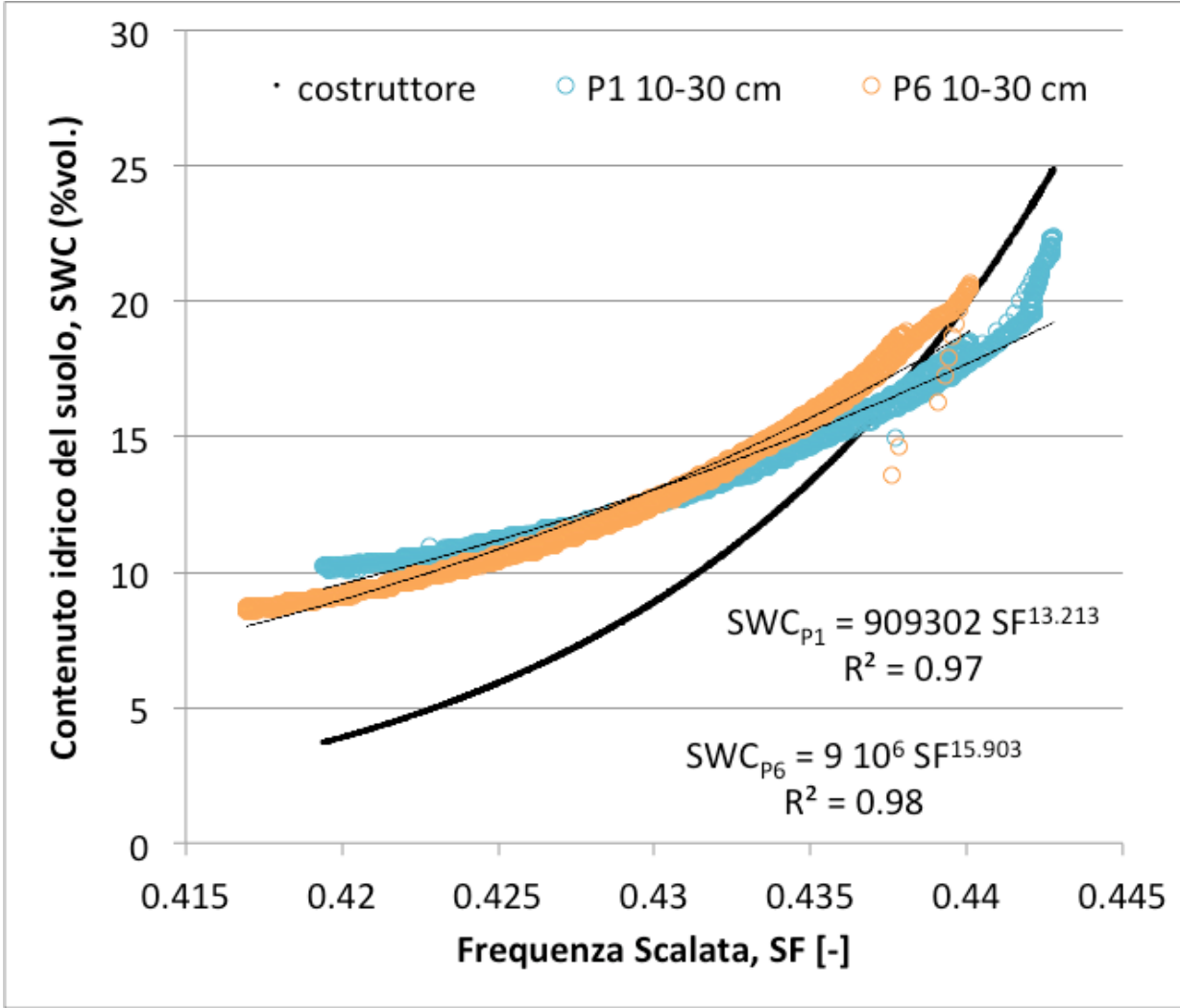


- WSN Topologia



Progettazione della WSN (calibrazione sensori)

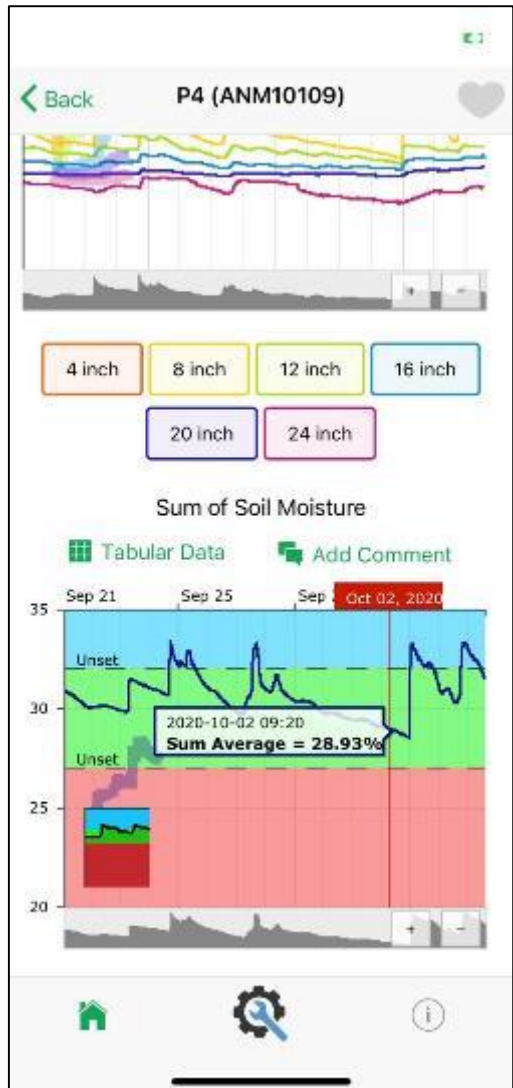
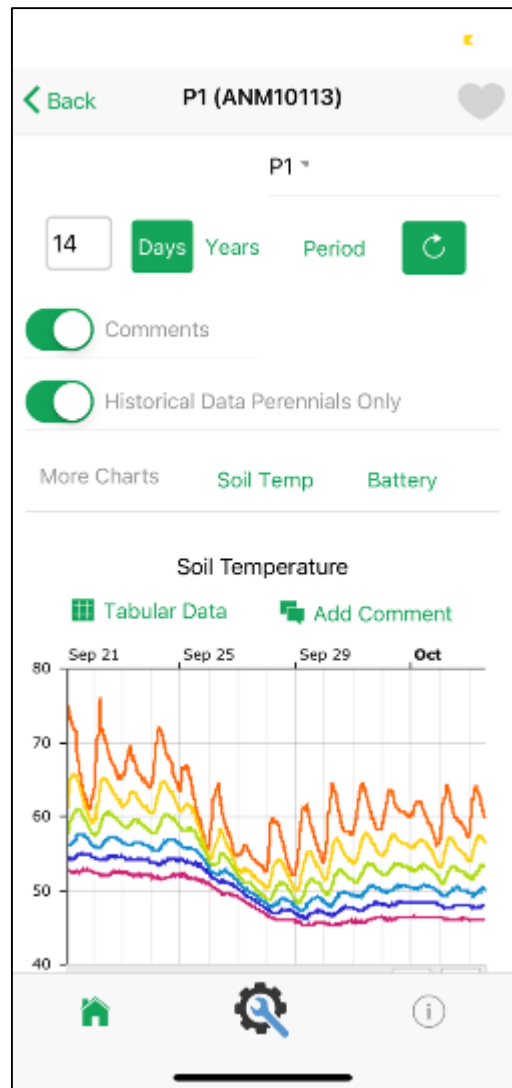
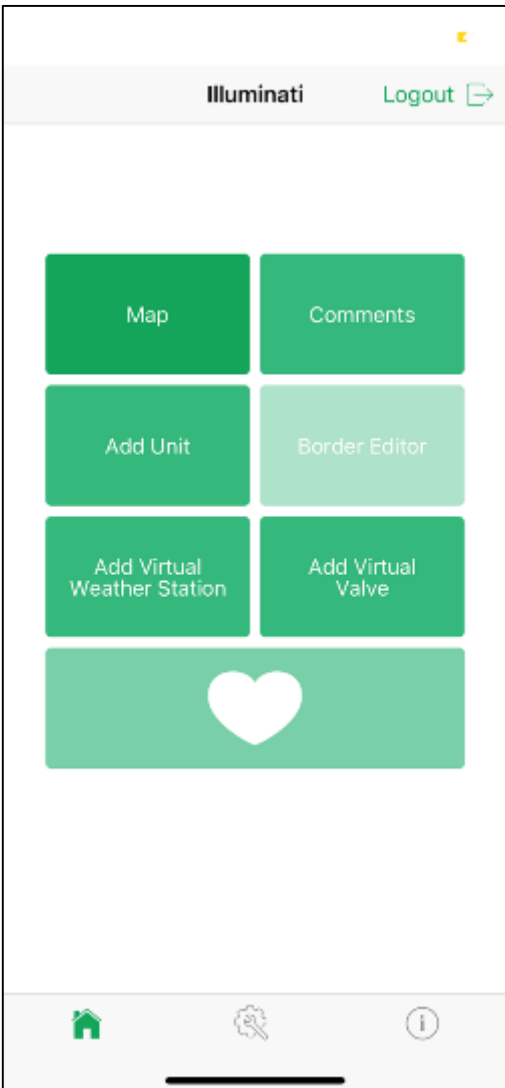
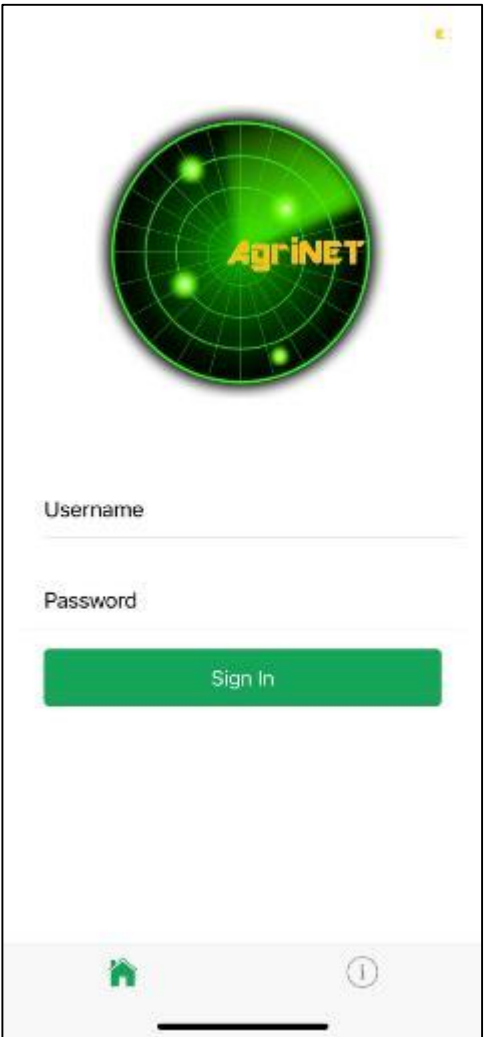
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Progettazione della WSN (Applicativo web)



AGRINET/Tuctronics (Walla Walla, Stati Uniti)

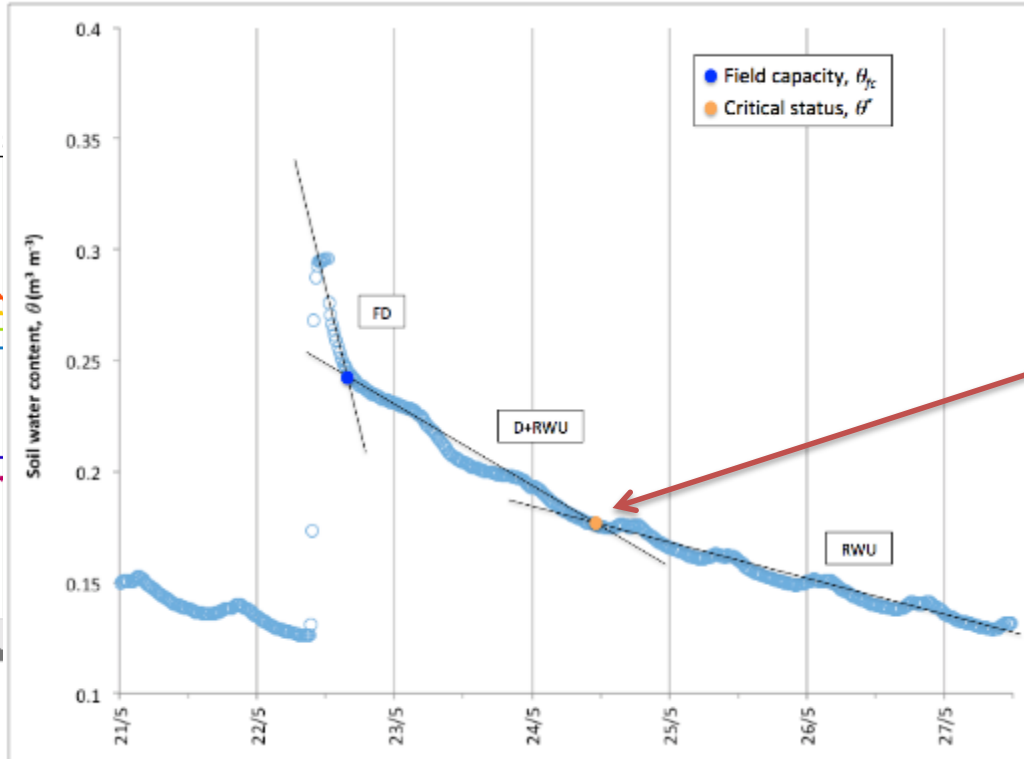
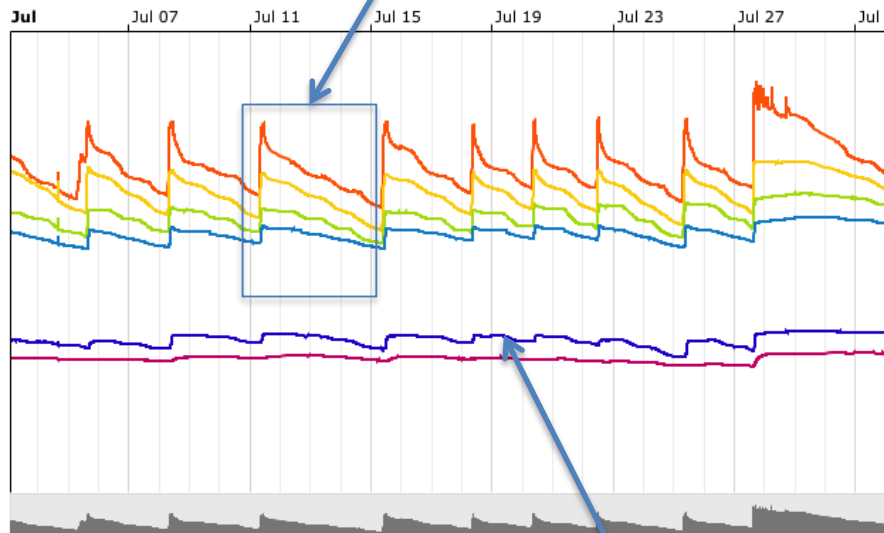


Progettazione della WSN (parametrizzazione)

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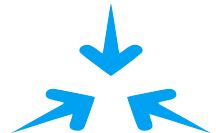


Limite sup. del serbatoio degli attingimenti (capacità di campo, Polak et al., 2001): dimensione idrologica



validato
attraverso
misure
ecofisiologiche
(potenziale
idrico-stelo
mezzogiorno)

Limite inf. del serbatoio degli attingimenti (50 cm): dimensione geometrica

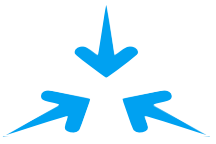


Precisione sul piano verticale

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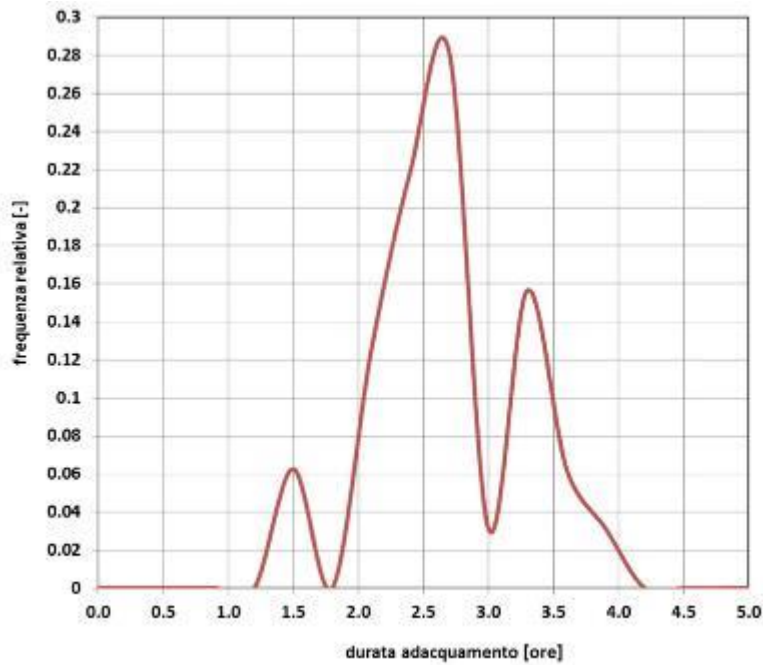


Piattaforma cibernetica -> consapevolezza

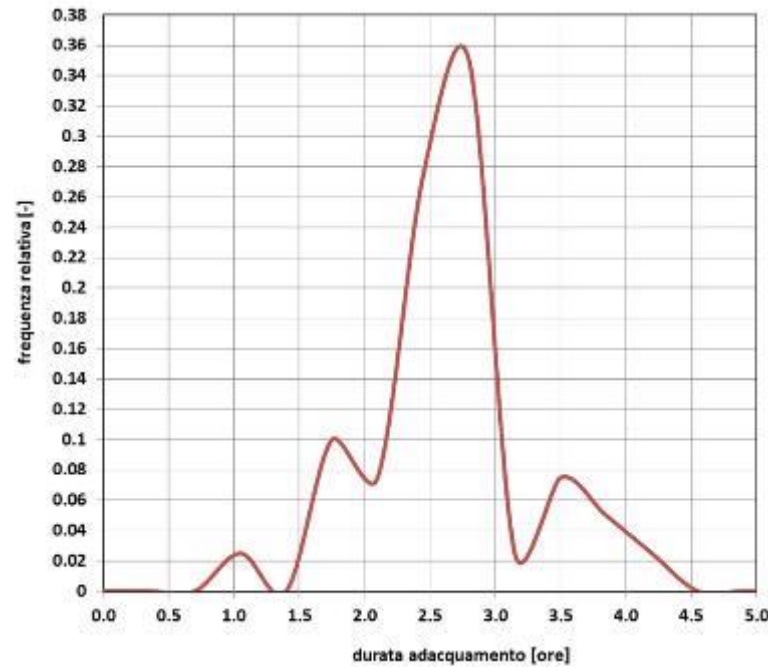


Durata adacquamento

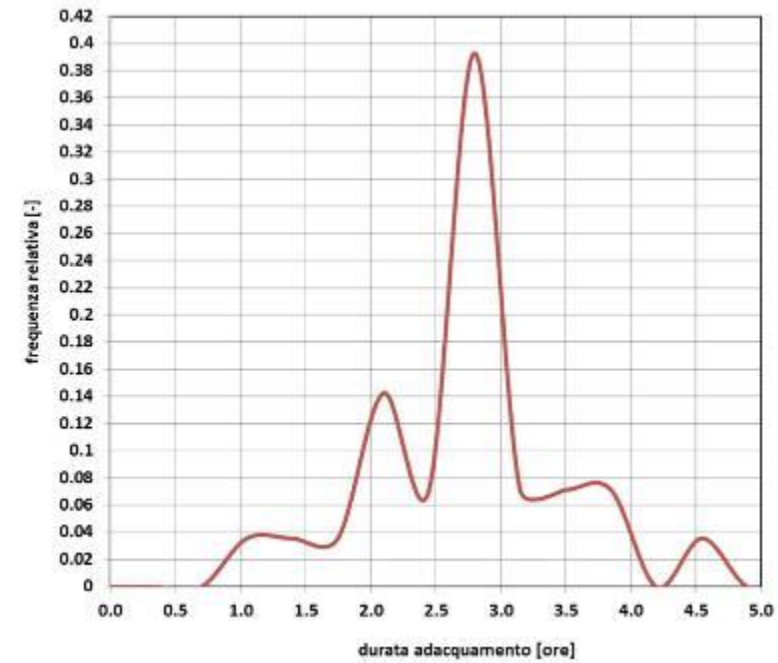
Carmen



Williams



Conference



Durata adacquamento → 2.5 - 3.0 ore



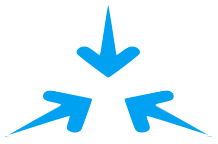
Variabili irrigue e risparmio idrico

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	CONFERENCE		WILLIAMS		CARMEN	
	2019	2020	2019	2020	2019	2020
SSD-soil moisture based						
DATA INIZIO STAGIONE IRR.	01/06/2019	03/06/2020	01/06/2019	01/06/2020	01/06/2019	27/06/2020
DATA FINE STAGIONE IRR.	13/09/2019	17/09/2020	13/09/2019	17/09/2020	09/09/2019	17/09/2020
GIORNI STAGIONE IRRIGUA	104	106	104	108	100	82
DATA RACCOLTA	03/09/2019	26/08/2020	20/08/2019	17/08/2020	27/07/2019	23/07/2020
NUM. ADACQUAMENTI (-)	19	28	28	41	18	32
VOLUME IRRIGUO STAG. (m ³ /ha)	2402	2994	2098	2332	419	581
VOLUME ADACQU. (m ³ /ha)	μ 126.4	106.9	74.9	56.9	23.3	18.8
	σ 38.4	40.1	23.8	19.2	6.2	6.6
DURATA IRRIGAZIONE (hh)	57	78	98	103	67	80
	μ 3.0	2.8	3.5	2.5	3.7	2.6
	σ 0.8	1.5	1.1	0.8	1.4	0.8
PRESSIONE (bar)	μ 2.5	2.8	2.1	2.2	2.9	2.8
	σ 0.8	0.4	0.3	0.3	0.9	0.5
GESTIONE ORDINARIA (turno fisso=4 gg; durata irrigazione=5 hh)						
NUM. ADACQUAMENTI (-)	26	27	26	27	25	21
DURATA IRRIGAZIONE (hh)	130	133	130	135	125	103
VOLUME IRRIGUO STAG. (m ³ /ha)	5451	5094	2773	3056	784	742
RISPARMIO IDRICO	56%	41%	24%	24%	47%	22%

Risparmio idrico → 22% - 56%



Produttività (q ha⁻¹)

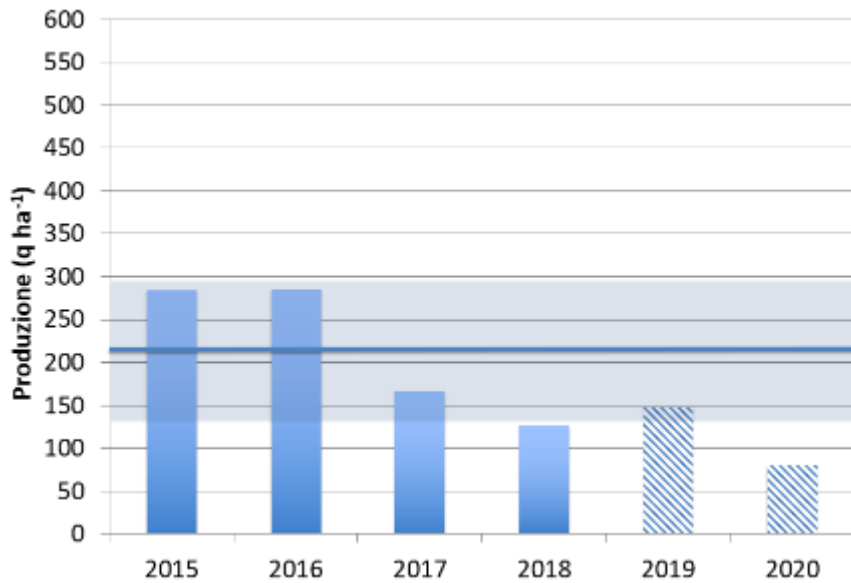


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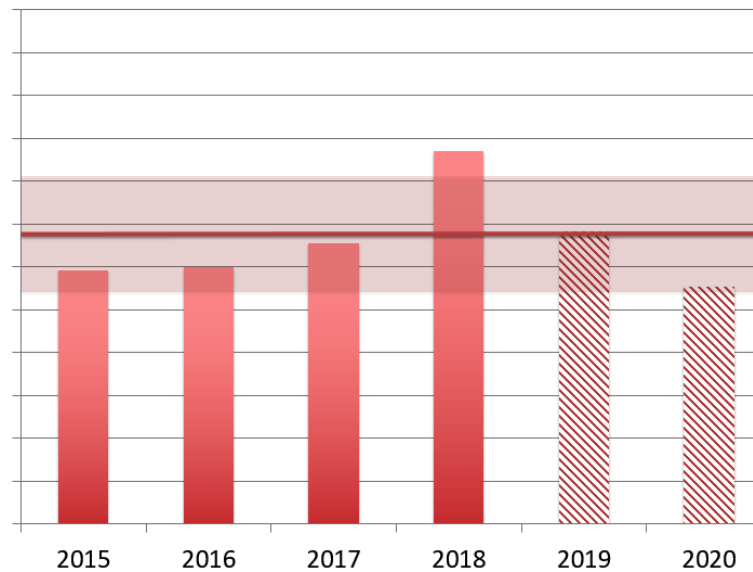
2019 – Minor numero di frutti allegati

2020 – Gelata di fine marzo inizio aprile

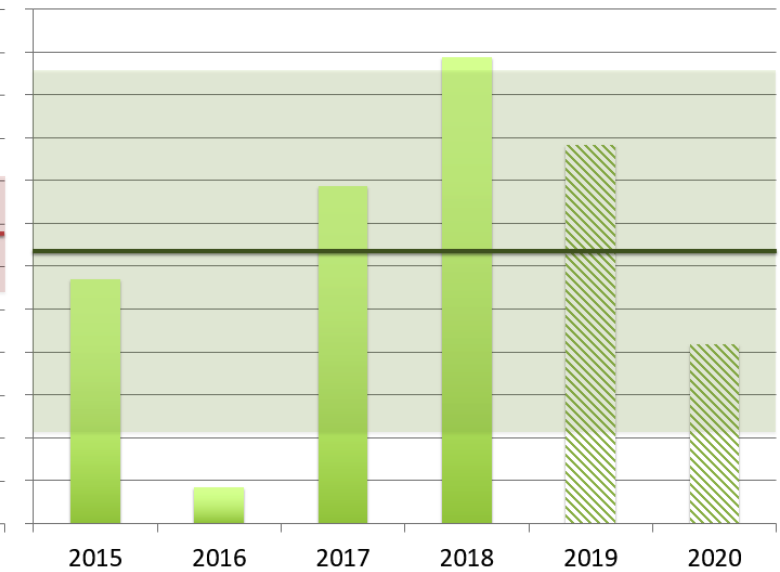
Carmen



Williams



Conference

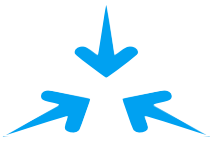


Media 2015-2018

Williams → 340

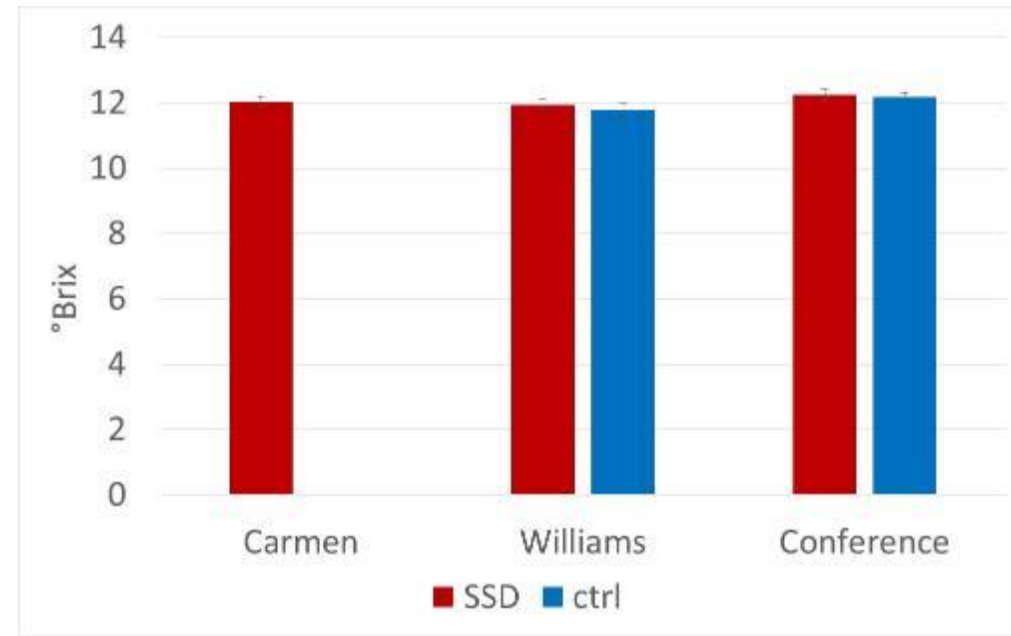
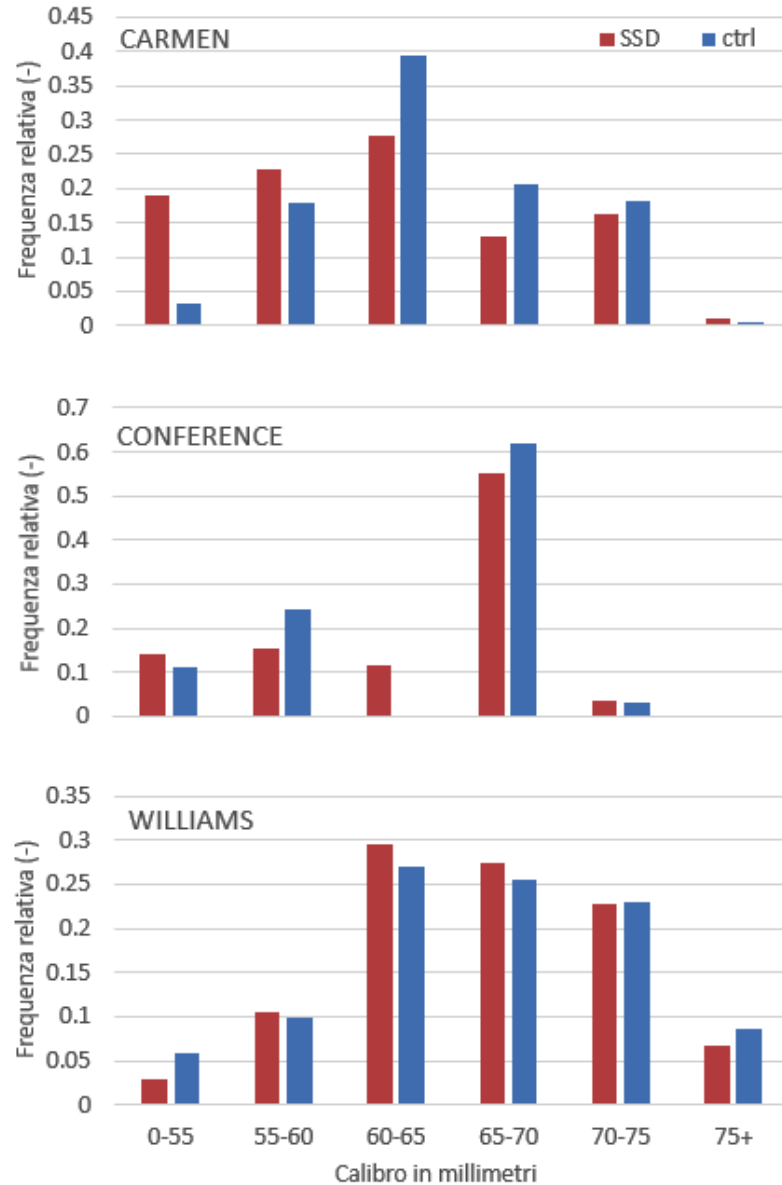
Conference → 316

Carmen → 216



Produttività (calibro dei frutti; °Brix)

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In conclusione....

Cosa migliora?

Idraulica

$$E_{schema} = \frac{\sum_{i=1}^N \dot{a}v_{ent_set}}{V}$$

X

$$E_{distretto} = \frac{\sum_{i=1}^N \dot{a}v_{rec_azienda}}{V_{ent_set}}$$

X

$$E_{azienda} = \frac{\sum_{i=1}^N \dot{a}v_{rec_campi}}{V_{rec_azienda}}$$

X

$$E_{campo} = \frac{\sum_{i=1}^N \dot{a}v_{zona_radicale}}{V_{rec_campo}}$$

X

Idrologia

$$E_{SPAC} = \frac{V_{zona_radicale}}{V_{rec_campo}}$$

X

$$E_{canopy} = \frac{V_{Traspirato}}{V_{zona_radicale}}$$

X

$$E_{suolo} = 1 - \frac{V_{Evaporato}}{V_{zona_radicale}}$$

$$E_{impianto} \gg DU$$



$$E_{erogatore} = f(CVT; topologia)$$



In conclusione....



- !! **Consapevolezza** ambientale da parte degli operatori
- !! impianti irrigui ad alta **uniformità** di distribuzione
- !! **sensori calibrati** per il tipo di suolo in esame
- !! ottimizzazione del **numero di nodi** della WSN
- !! **Calibrazione** automatica del SSD

Alte Performance

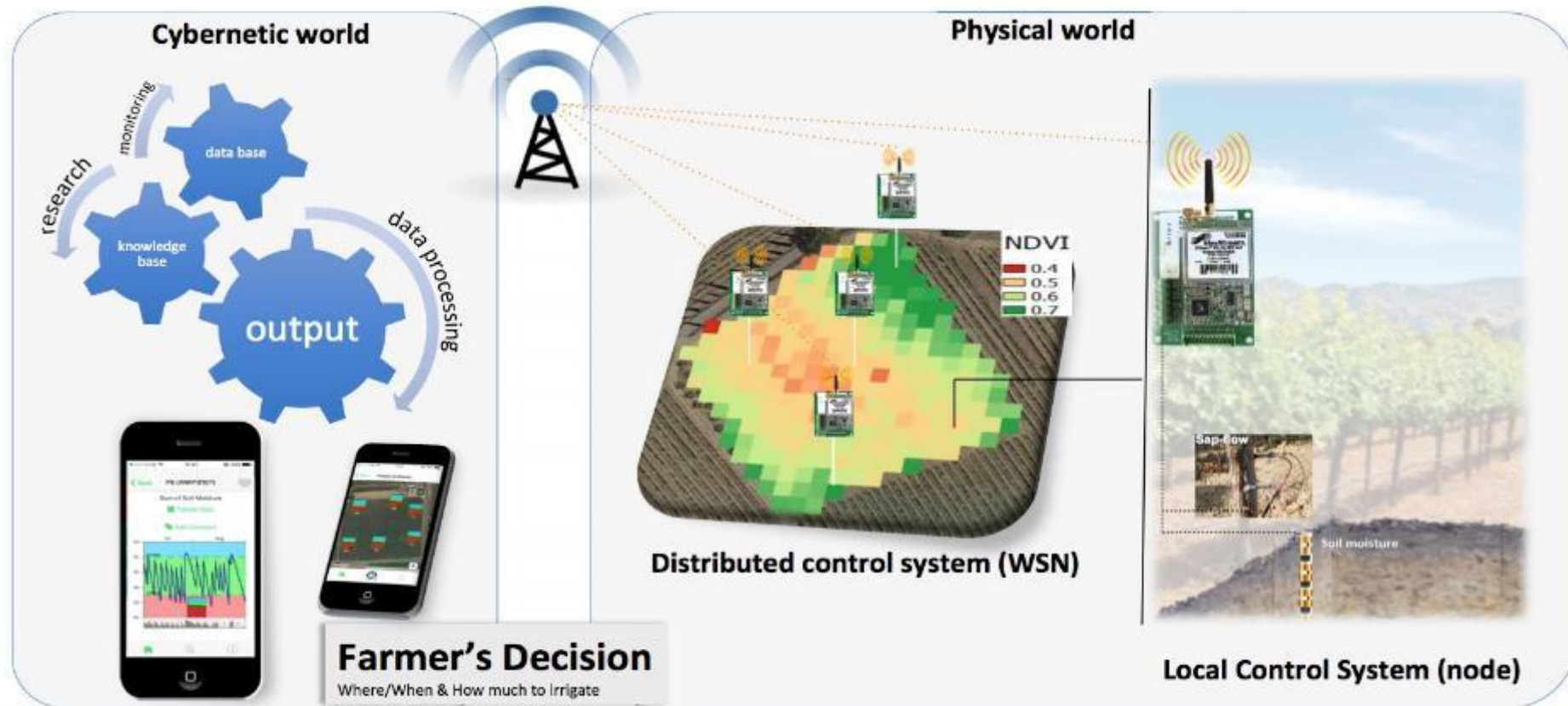
SCALABILITÀ

- ★ **Automazione** degli impianti di sollevamento, di filtrazione e distribuzione dell'acqua
- ★ **Specializzazione** degli addetti alla gestione esperta degli impianti e degli adacquamenti

Riduzione dei tempi di manovra idraulica
Ottimizzazione risorse umane aziendali

Grazie per l'attenzione!

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Stefano Giusti. Illuminati Frutta scarl, Via Chiana 20/A Loc. Pieve al Toppo 52041 - Civitella in Val di Chiana (AR). Tel 0575-410277 Fax 0575-410288. email: stefano.giusti@illuminatifrutta.it; website: www.illuminatifrutta.it

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