Water Needs Estimation for Agricultural Land Management

Pietro Sciusco (PhD)
April 4th, 2025

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Agenda

- Quick self-introduction
- Background of “Water Legislation” (EU → National → Regional) & End-Users’ POV
- Focus on “*RIPARTI*” project

Self-introduction (my education)

Pie(t)ro Sciusco

University of Bari "A. Moro"

BS: Forestry and Environmental Sciences

MS: Sustainable Management & Development of Mediterranean Rural Systems

Michigan State University

PhD: Geography, Environment & Spatial Sciences

"Landscape Ecology and Ecosystem Science (LEES) lab"

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Senior Technical Specialist Geoservices

2011

2018

2023

FieldSpec (ASD) Spectroradiometer reflectance collection at Maize fields at Kellogg Biological Station, MI (US)

Water Needs Estimation for Agricultural Land Management

- **Efficient use of water resources**
  - To determine irrigation water needs based on crops' needs, as well as environmental conditions;
- **Maximization of crop production**
  - To maximize agricultural production through the accurate evaluation of crop water needs;
- **Water risk management**
  - To fight drought and seasonal water scarcity;
- **Reduction of cost production**
  - To reduce farmers' cost production by avoiding waste in water use (more water than needed) and by minimizing energy costs for irrigation;
- **Environmental impact**
  - To preserve water resources (whether ground water or not), to reduce nutrients and pesticides leaking, and to preserve marine ecosystems;
- **Support to agricultural policies**
  - To develop programs and policies, within the agricultural sector, aimed at agriculture production, food security, and environmental sustainiability.

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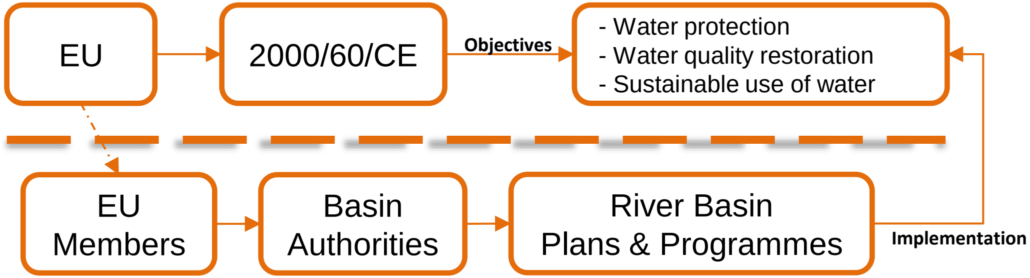
Water Needs Estimation for Agricultural Land Management

Water Framework Directive (WFD; 2000/60/CE)

WFD defines a legal framework which sets out rules to **halt deterioration** in the **status** of **EU water bodies** and achieve good status for Europe's **rivers**, **lakes** and **groundwater**.

<<It requires Member States to use their River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs) to **protect** and, where necessary, **restore** water bodies in order to reach good status, and to **prevent deterioration**. Good status means both good chemical and good ecological status.>> (European Parliament)



Water Needs Estimation for Agricultural Land Management

Southern District River Basin Authority (ABdAM)

ABdAM operates on several regions in Southern Italy and is in charge of the draft of Water Management Plans (WMPs):

Phase I (2009-2014)
Phase II (2015-2021)
Phase III (2021-2027)

Operating groups responsible of:

- Monitoring of quali-quantitative water bodies status;
- **Monitoring of water resource uses**;
- **Definition** of **water** and hydrological **balance**;
- Definition of water price.

Extension of the AOI covered by ABdAM

ABdAM is end user for several Planetek projects and activities!

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Water Needs Estimation for Agricultural Land Management

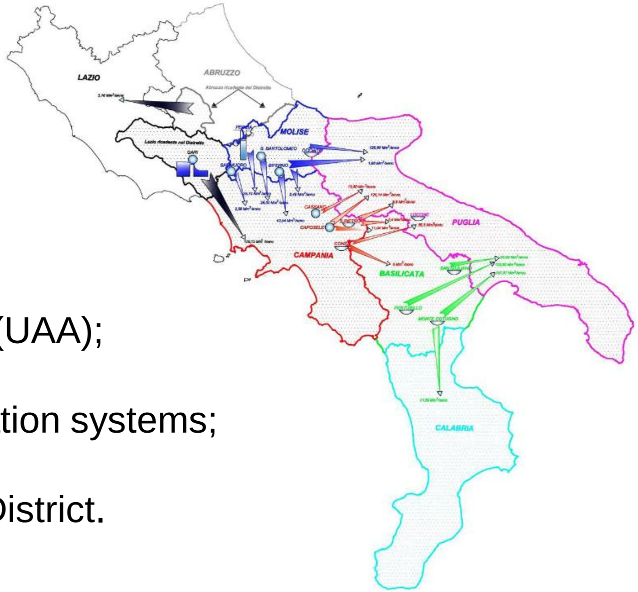
Southern District River Basin Authority (ABdAM)

- **Monitoring of water resource uses**;
- **Definition** of **water** and hydrological **balance**.

1) Quantification of the utilized agricultural area (UAA);

2) Quantification of the irrigation area and types of irrigation systems;

3) Identification of irrigation consortia within the District.

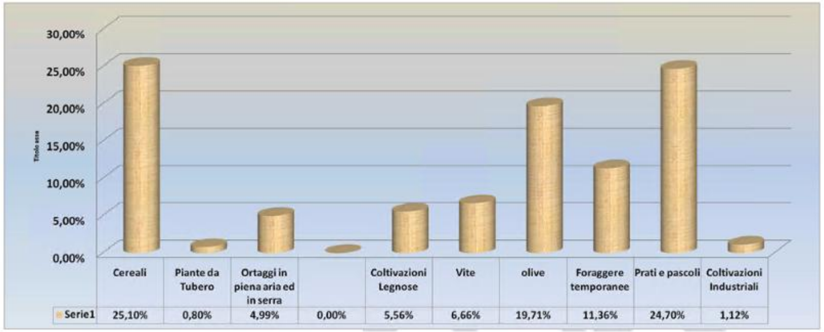


(PGA Relazione Generale; Allegato 3.1 – I Sistemi per il Trasferimento Idrico Interregionale)

Water Needs Estimation for Agricultural Land Management

Southern District River Basin Authority (ABdAM)

1) Quantification of the utilized agricultural area (UAA)



	Distribuzione della SAU						
	Abruzzo	Molise	Campania	Puglia	Basilicata	Calabria	Lazio (solo FR)
Cereali	19,46%	47,73%	19,98%	26,87%	43,20%	16,24%	13,01%
Piante da Tubero	1,01%	0,66%	2,07%	0,39%	0,07%	1,02%	0,00%
Ortaggi in piena aria ed in serra	3,90%	2,04%	5,77%	6,94%	3,45%	3,59%	0,23%
Coltivazioni Legnose	1,15%	1,08%	10,90%	4,57%	5,31%	8,99%	0,22%
Vite	8,08%	3,38%	5,12%	11,01%	2,16%	2,44%	0,00%
olive	10,22%	7,52%	12,18%	27,24%	9,23%	32,59%	0,00%
Foraggere temporanee	10,32%	11,71%	19,44%	9,72%	10,74%	6,86%	15,28%
Prati e pascoli	44,32%	21,05%	22,78%	12,30%	25,55%	28,15%	71,11%
Coltivazioni Industriali	1,54%	4,83%	1,76%	0,96%	0,30%	0,12%	0,15%

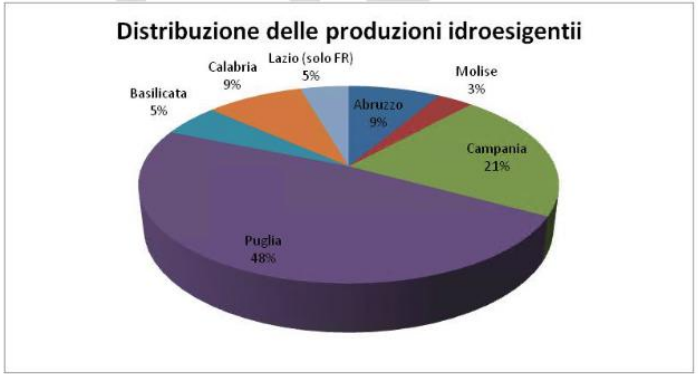
Subdivision of UAA, within the District, by crop types (sx) and regions (dx)

(PGA Relazione Generale; Allegato 7 – Uso delle acque nel sistema agricolo)

Water Needs Estimation for Agricultural Land Management

Southern District River Basin Authority (ABdAM)

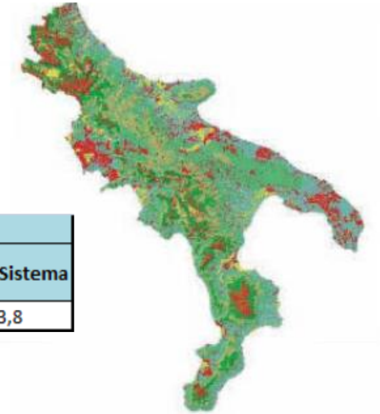
2) Quantification of the irrigation area and types of irrigation systems



Subdivision of irrigated areas by region

Sistemi di irrigazione utilizzati nelle aziende agricole					
Aspersione	Goccia	Micro irrigazione	Scorrimento infiltrazione	Sommersione	Altro Sistema
40,6	32,6	6,1	16,9	0,1	3,8

Types of irrigation systems



Red: irrigated areas

(PGA Relazione Generale; Allegato 7 – Uso delle acque nel sistema agricolo)

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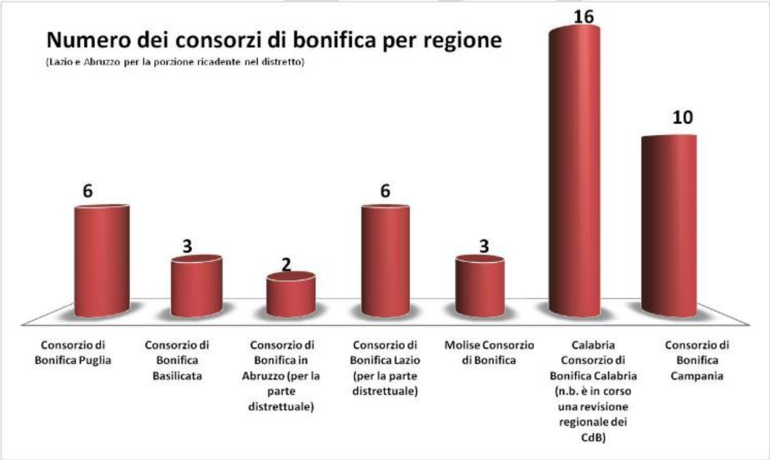
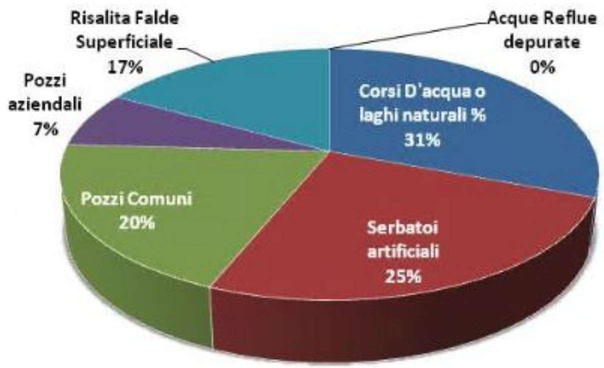
Southern District River Basin Authority (ABdAM)

3) Identification of irrigation consortia within the District



Subdivision of irrigation consortia by region



Infrastructures managed by irrigation consortia

(PGA Relazione Generale; Allegato 7 – Uso delle acque nel sistema agricolo)

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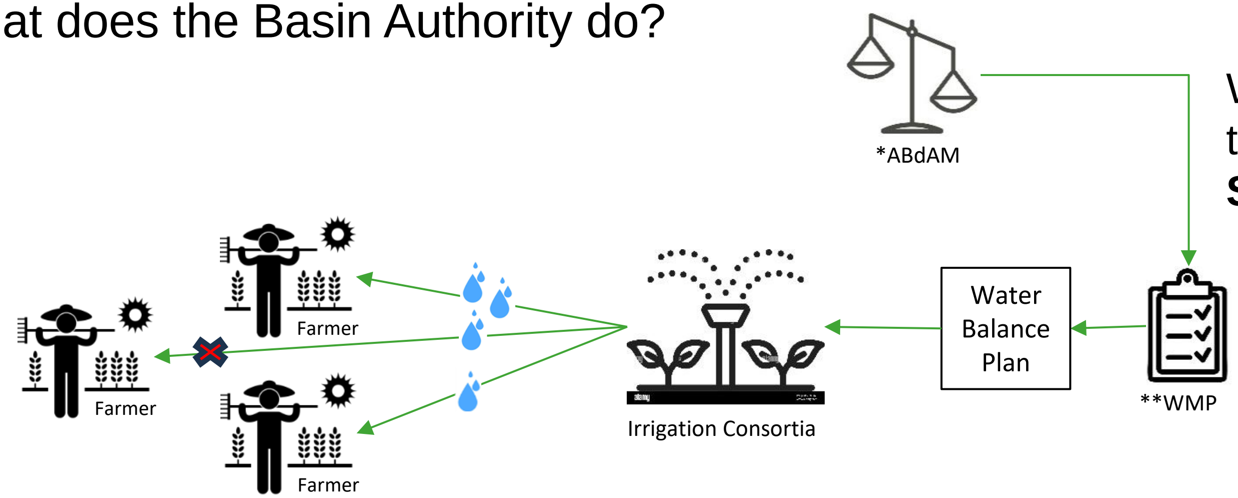
What does the Basin Authority do?

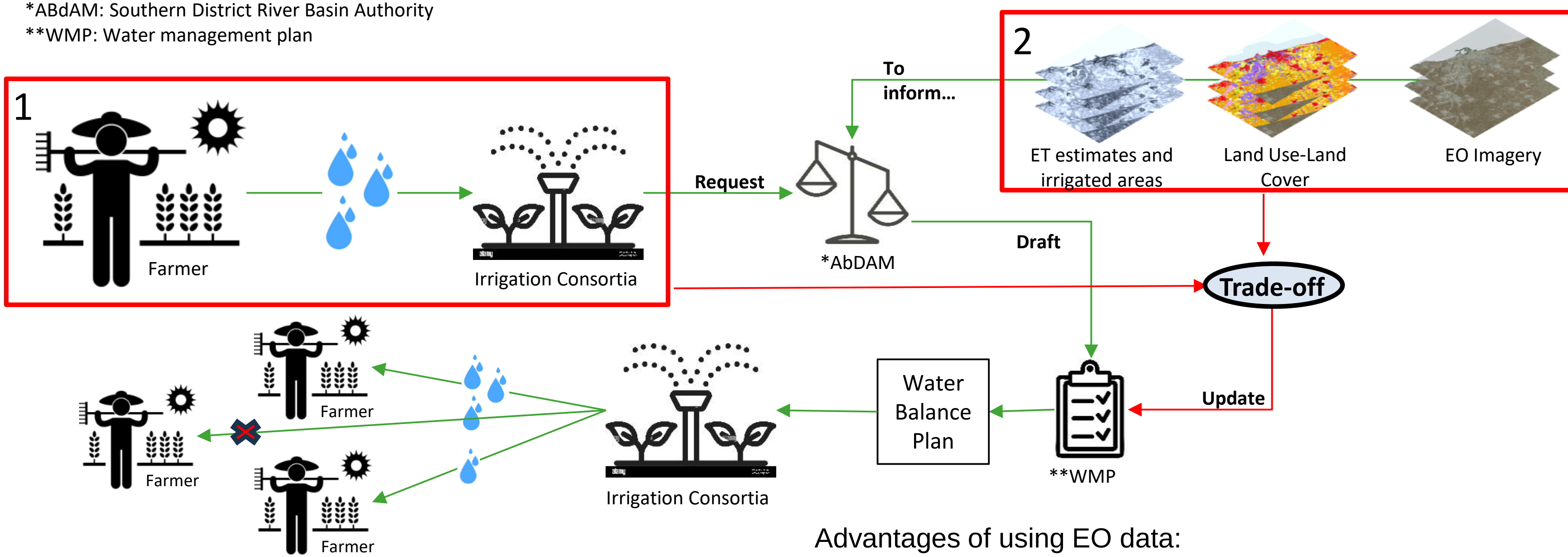


What does all this have to do with **Remote Sensing for EO**?

*ABdAM: Southern District River Basin Authority
**WMP: Water management plan

Water Needs Estimation for Agricultural Land Management

*ABdAM: Southern District River Basin Authority
**WMP: Water management plan



Advantages of using EO data:

- Large spatial coverage;
- Near real-time information;
- Time series analysis (aka backwards);
- High accuracy in water needs estimation;
- Support to decisions for future planning (aka land use change).

Water Needs Estimation for Agricultural Land Management

Why the estimation of ET (for Planetek)?

1. **IRIDE Service Segment project**: Water needs and used mapping Service Value Chain ← On-going
2. **RIPARTI project (I)**: Upgrade of IRMAT model to IRMAT+ (integration with EO data)
3. **RIPARTI project (II)**: Detection of crop rotations and estimation of crop water needs in Northen Apulia Region
4. **Crop water needs in Tunisia**: Quantification of utilizede agricultural areas for investments in agriculture
5. **Water Digital Twin (WADIT) project**: Digital twin for crop water used estimation in Apulia region ← On-going
6. **EOAfrica project**: Crop water needs estimation in Egypt ← On-going
7. **UNIVERSWATER project**: Universal agri/water management platform (Italian UC: water salinity) ← On-going
8. Other proposals…

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EO for ET estimation:
take-away from RIPARTI project (II)

Overarching Goal

To estimate crop evapotranspiration (ETc) using a combined approach of FAO-56 – EO.

Objectives

- (i) Mapping crops and crop rotation: high level & crop rotation classifications;
- (ii) Estimating crop coefficients (Kc): EO-based Kc estimation;
- (iii) Estimating ETc: Estimates of ETc using both standard (i.e., FAO-56) and EO methods.

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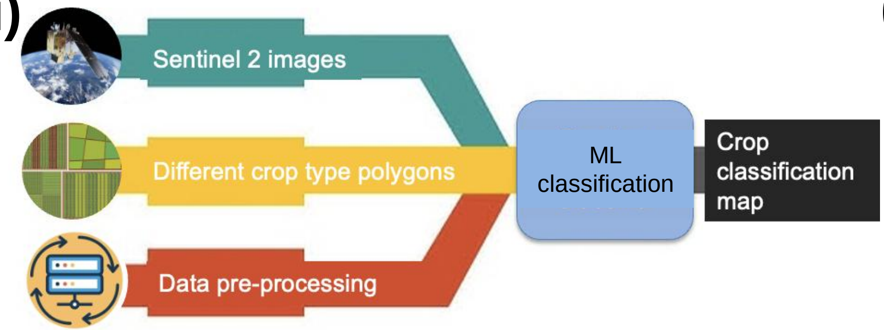
EO for ET estimation: take-away from projects

(i)



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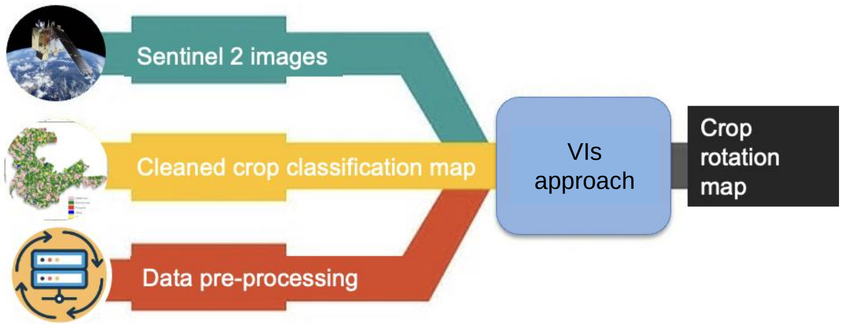

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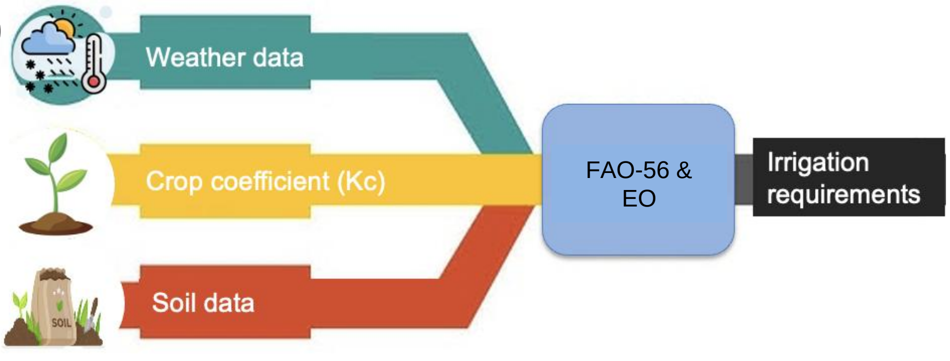
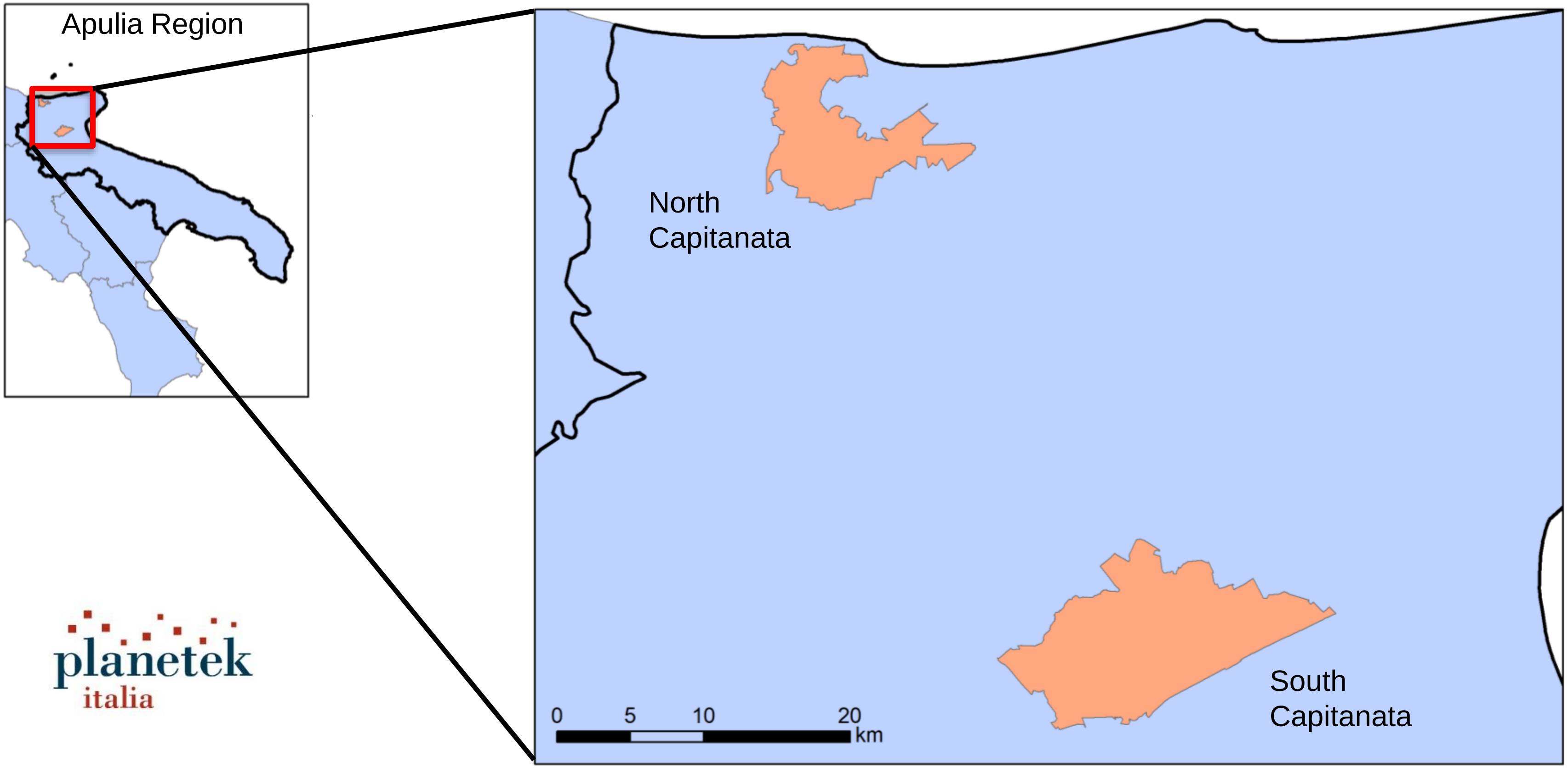


EO for ET estimation: take-away from projects



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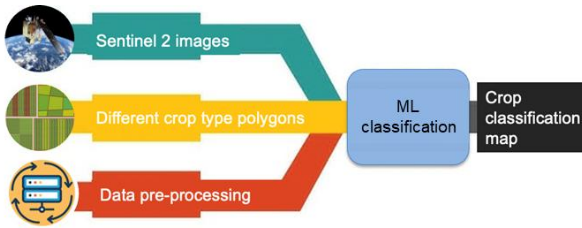
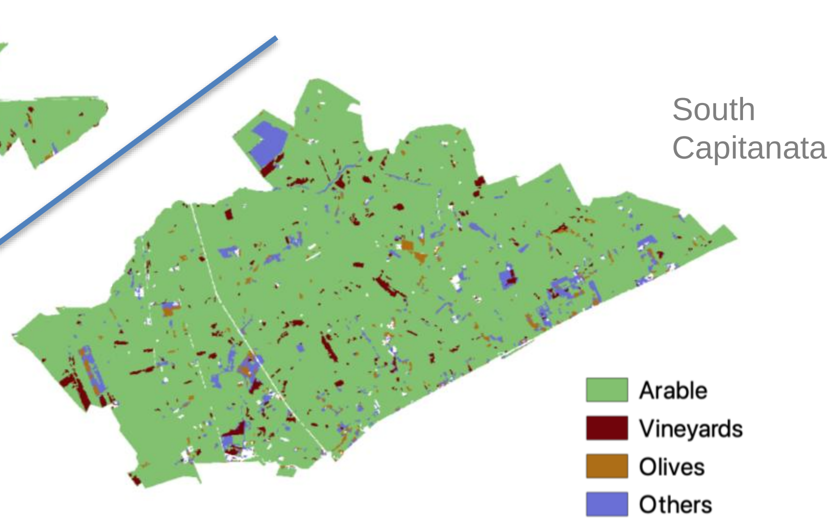
EO for ET estimation: take-away from projects





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EO for ET estimation: take-away from projects

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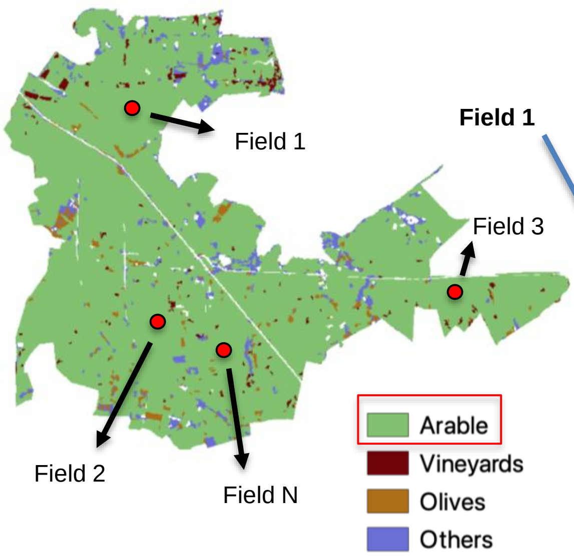

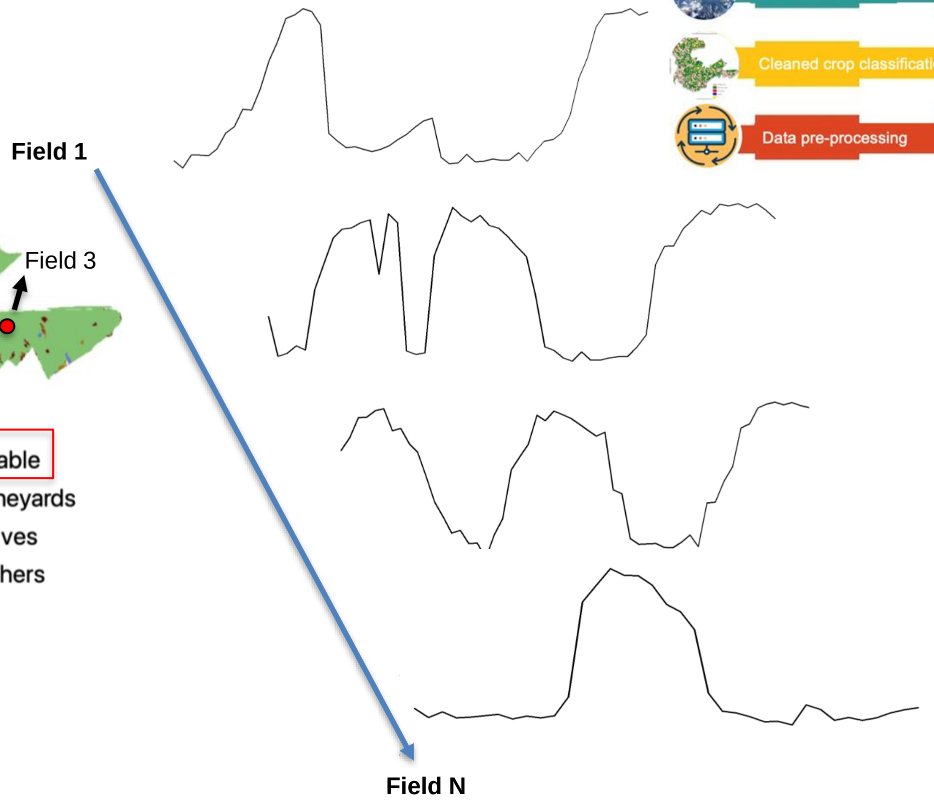

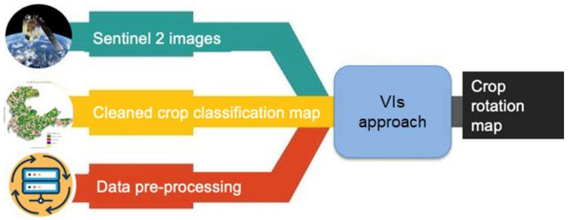

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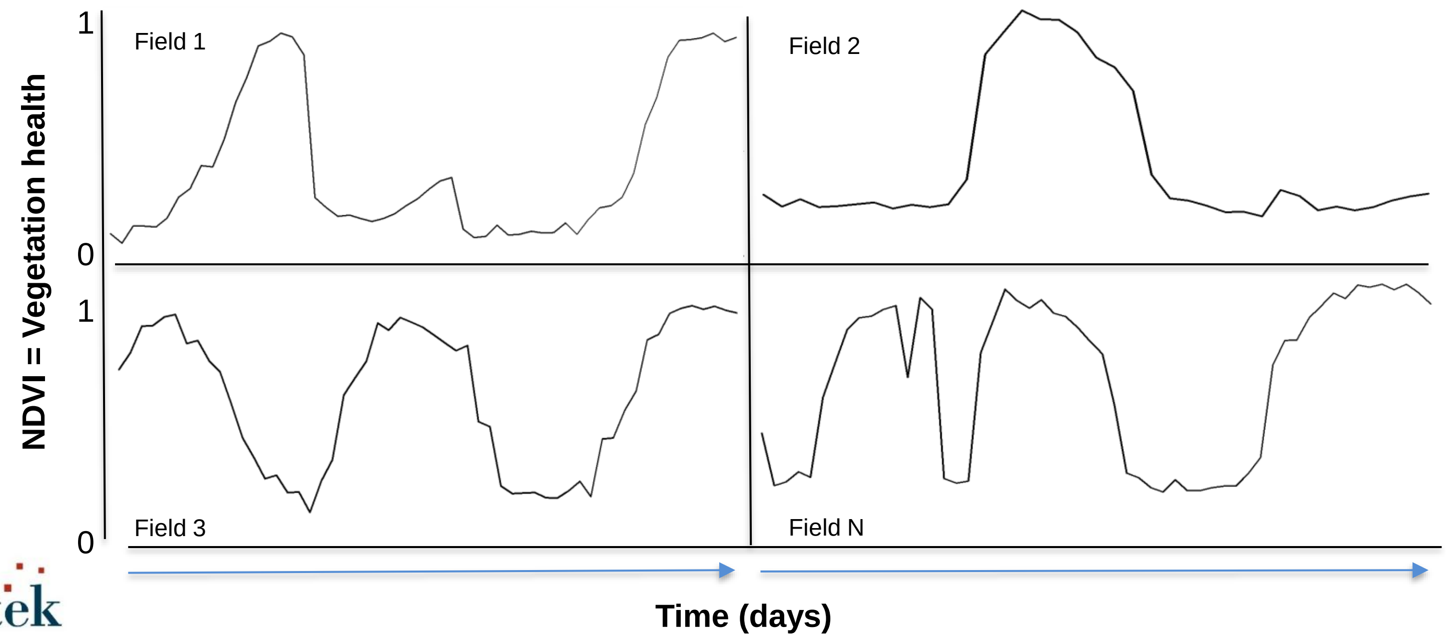

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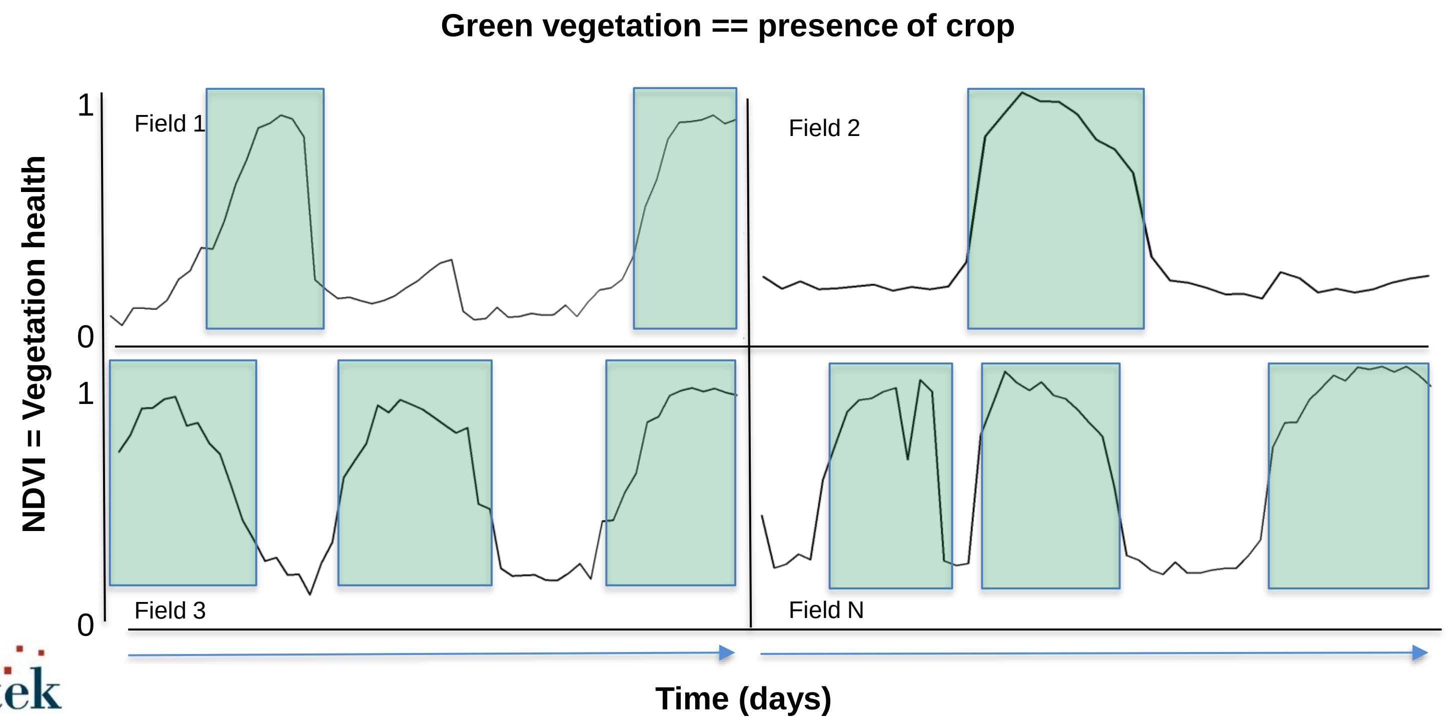
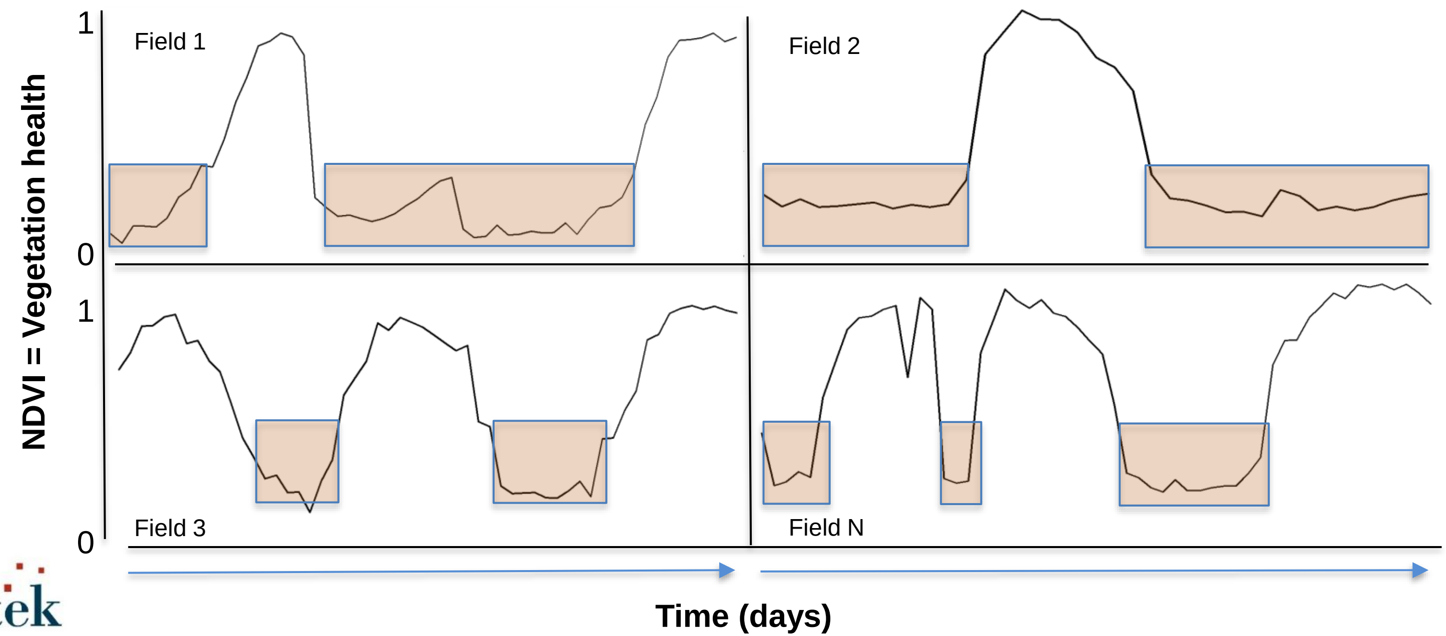


EO for ET estimation: take-away from projects

Senescence / bare soil == absence of crop



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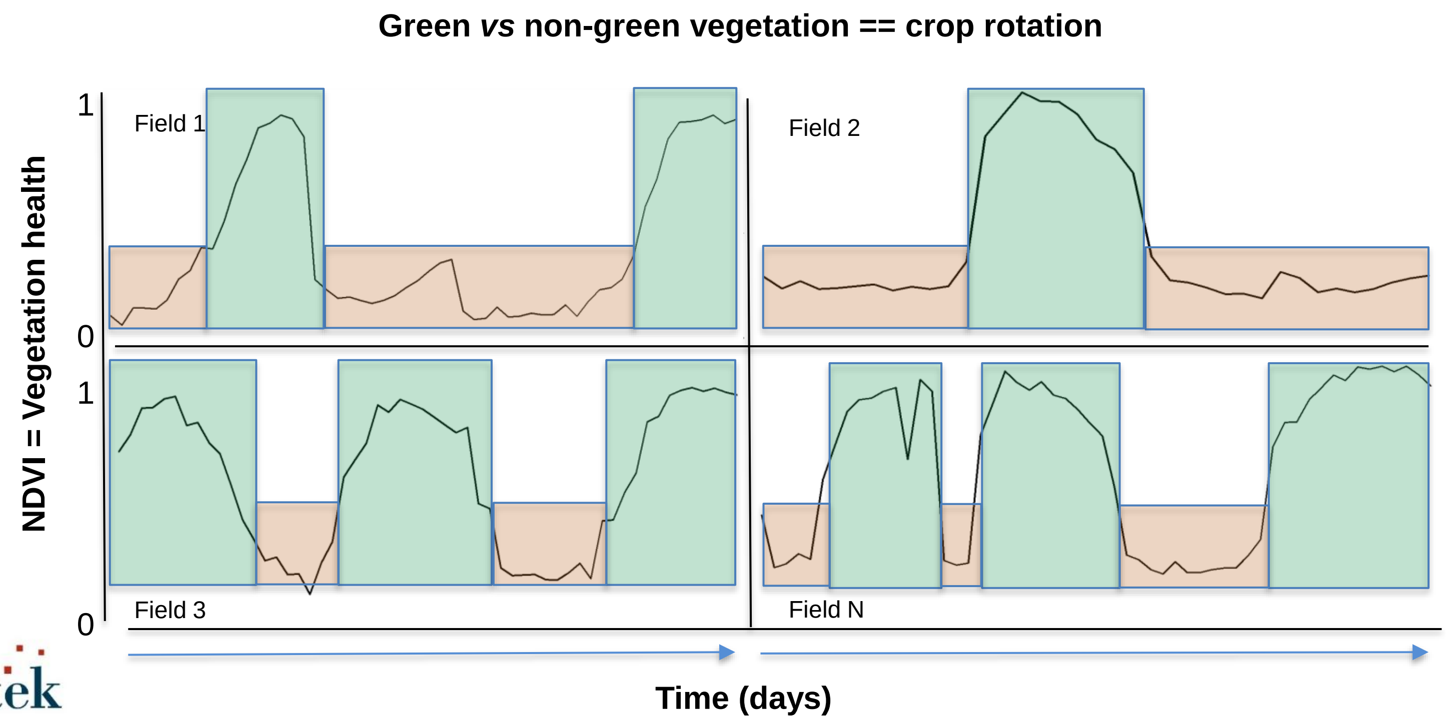
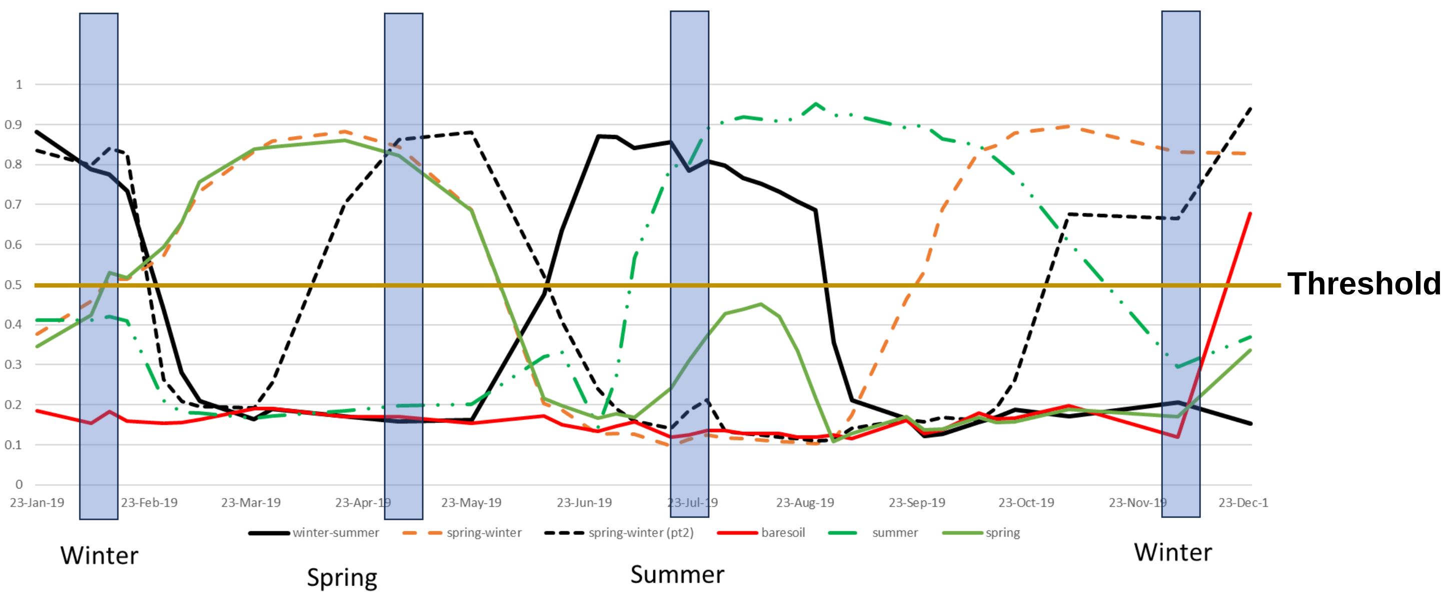
EO for ET estimation: take-away from projects



EO for ET estimation: take-away from projects

Green *vs* non-green vegetation == crop rotation



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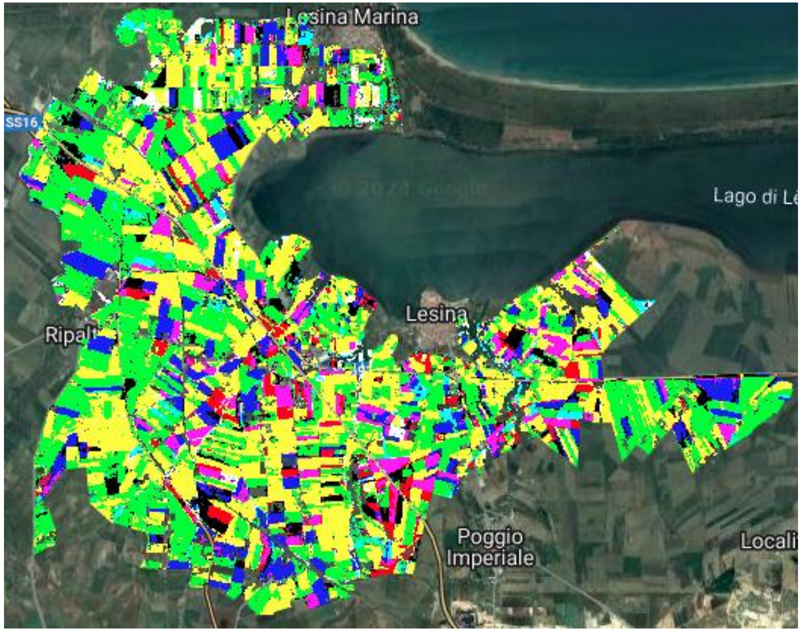
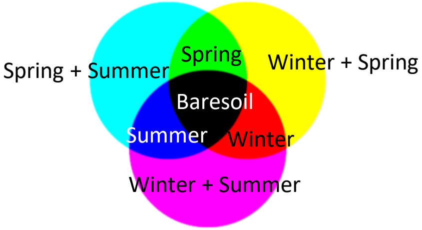
EO for ET estimation: take-away from projects

Green *vs* non-green vegetation == crop rotation





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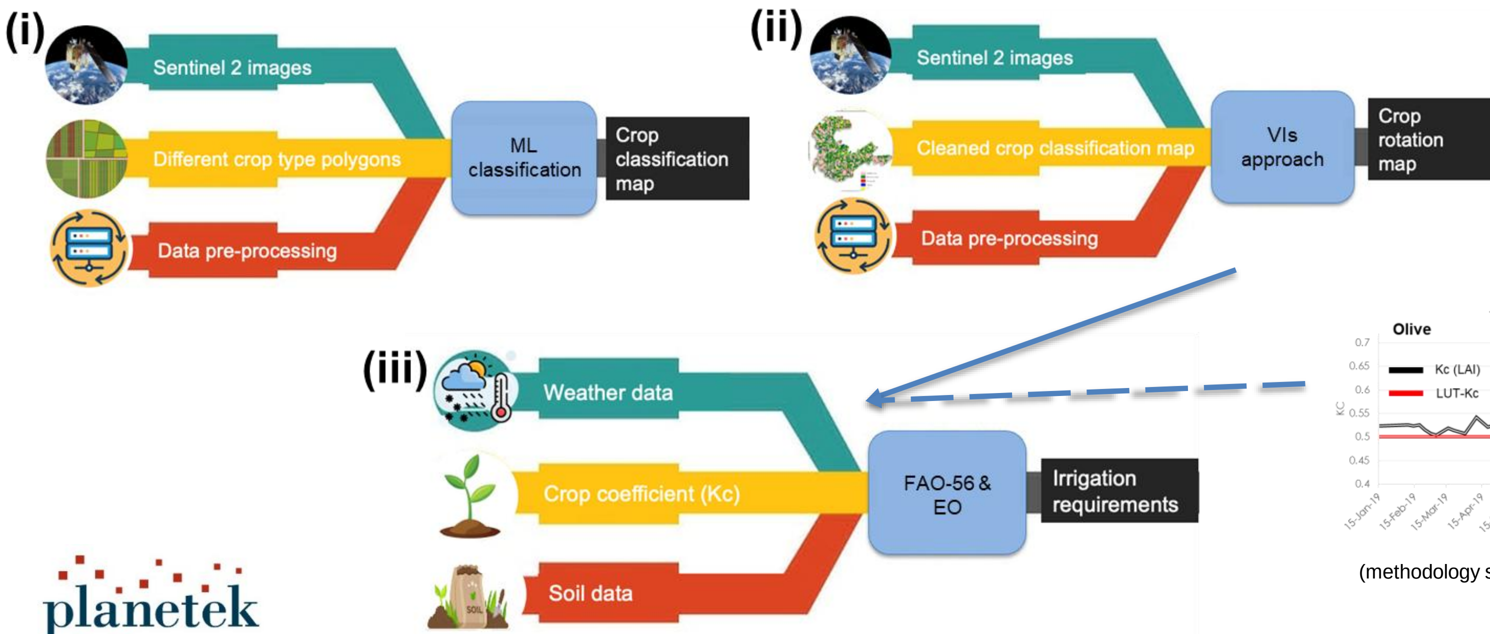

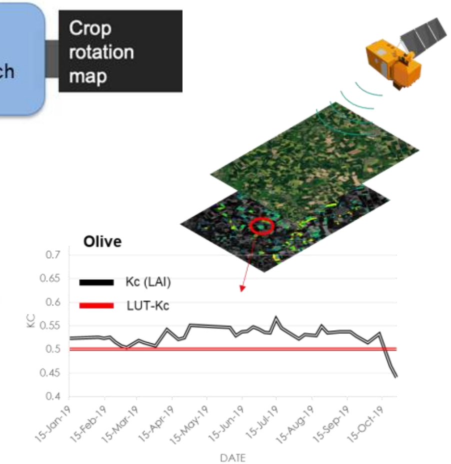

(methodology shown in the next slide)

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EO for ET estimation: take-away from projects

$$ET_c = ET_{ref} \cdot K_c$$

ET_{ref} → Reference ET

K_c → Relative fraction of ETref, governed by the amount, type, and condition of vegetation

Estimating Kc from fraction of ground cover

$$K_c = K_{c\,min} + K_d \cdot (K_{c\,full} - K_{c\,min})$$

$K_{c\,min}$ → Minimum basal Kc for bare soil (about 0.15 under typical agricultural conditions)

K_d → **Density coefficient** → **Leaf area index (LAI)**, **Fraction of vegetation cover (FVC)**

$K_{c\,full}$ → Estimated basal Kc during peak growth (LAI>3)

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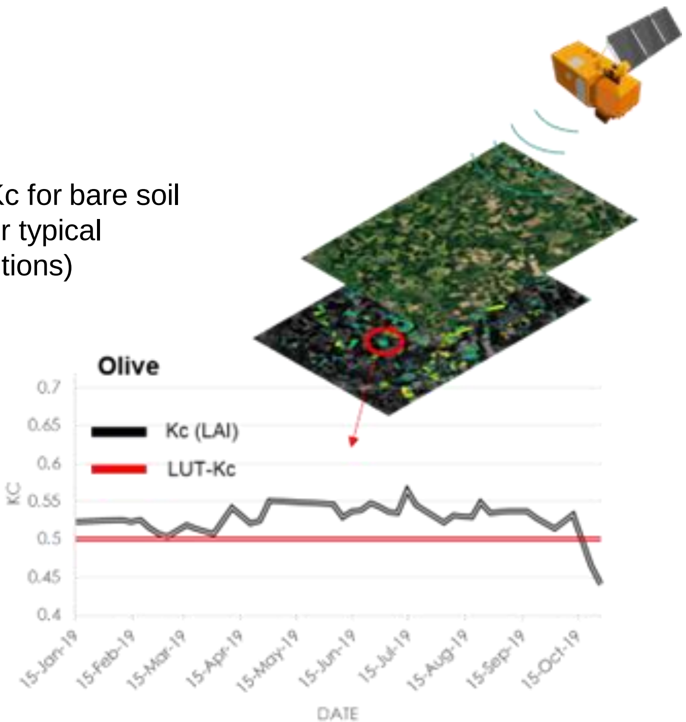
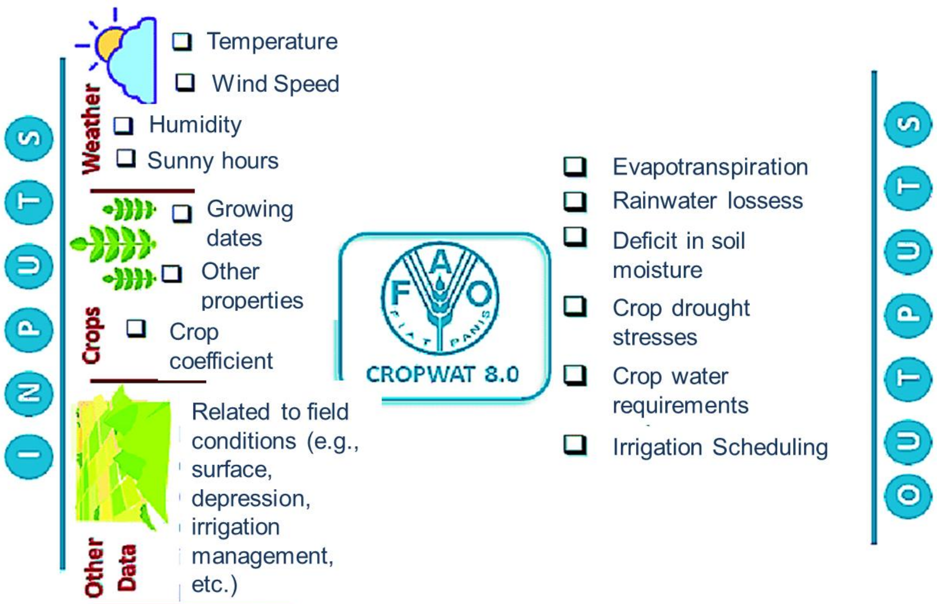
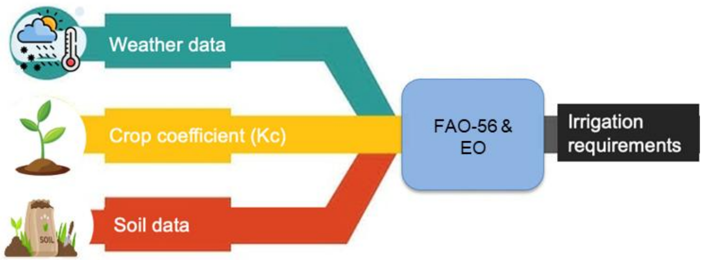


EO for ET estimation: take-away from projects





$$ET_o = \frac{0.408\,\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)} \qquad (6)$$

where

ET_o	reference evapotranspiration [mm day^{-1}],
R_n	net radiation at the crop surface [MJ m^{-2} day^{-1}],
G	soil heat flux density [MJ m^{-2} day^{-1}],
T	mean daily air temperature at 2 m height [°C],
u_2	wind speed at 2 m height [m s^{-1}],
e_s	saturation vapour pressure [kPa],
e_a	actual vapour pressure [kPa],
e_s-e_a	saturation vapour pressure deficit [kPa],
Δ	slope vapour pressure curve [kPa °C^{-1}],
γ	psychrometric constant [kPa °C^{-1}].

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Pereira, 1998

EO for ET estimation: take-away from projects

Reference Evapotranspiration (ET_0)

It is NOT crop-specific!

Month	Min Temp(°C)	Max Temp(°C)	Humidity(%)	Wind(km/day)	Sun(hours)	Rad(MJ/m^2/day)	ET_0(mm/day)
January	0.7	7.4	77	28	9.5	10.9	**0.44**
February	2.5	10.9	70	31	10.6	14.8	**0.99**
March	5.6	14.5	66	25	10.9	19.1	**1.94**
April	7.4	16.8	72	22	13.3	25.9	**3.21**
May	9.1	18.1	76	26	14.5	29.9	**3.95**
June	18.1	30.4	62	22	15.2	31.7	**5.51**
July	19.2	31	63	23	14.9	30.7	**5.62**
August	20.1	32.4	65	23	13.9	27.4	**5.11**
September	17.6	27.6	75	22	12.6	22.3	**3.71**
October	13.4	23.7	78	18	11.1	16.4	**2.12**
November	10.4	16.7	82	21	10.9	12.6	**0.95**
December	5.7	12.4	77	23	9.2	9.7	**0.45**
Average	**10.8**	**20.3**	**72**	**24**	**12.2**	**21**	**2.83**

Weather data source - https://www.visualcrossing.com

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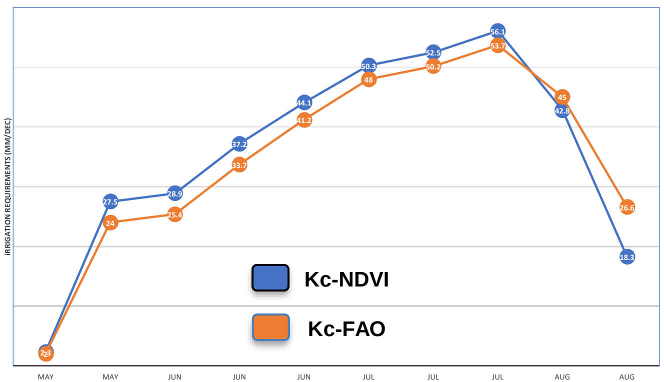
EO for ET estimation: take-away from projects

Kc-FAO *vs* Kc-NDVI for crop Evapotranspiration (ET_c)

	Month	Decade	Kc (NDVI)	Kc (FAO)	ETc – Kc-NDVI (mm/day)	ETc Kc-FAO (mm/day)	Effective rain (mm/dec)	Irrigation requirements Kc-NDVI (mm/dec)	Irrigation requirements Kc-FAO (mm/dec)
Zucchini	May	2	0.57	0.5	2.55	1.98	0.1	2.3	2
	May	3	0.57	0.5	2.55	2.23	0.6	27.5	24
	Jun	1	0.57	0.5	2.9	2.55	0.1	28.9	25.4
Start date 20/05	Jun	2	0.66	0.6	3.72	3.37	0	37.2	33.7
	Jun	3	0.79	0.73	4.42	4.13	0.1	44.1	41.2
	Jul	1	0.91	0.86	5.07	4.83	0.3	50.3	48
	Jul	2	0.94	0.9	5.29	5.07	0.5	52.5	50.2
	Jul	3	0.94	0.9	5.14	4.92	0.4	56.1	53.7
	Aug	1	0.81	0.85	4.3	4.52	0.2	42.8	45
	Aug	2	0.51	0.74	2.62	3.81	0	18.3	26.6
						Total	2.3	360	349.7

Irrigation requirement (mm/dec)



FAO	Initial	Dev	Mid	End	Total	Start
Zucchini	20	30	25	15	90	May/June
Kc	0.5		0.95	0.75		

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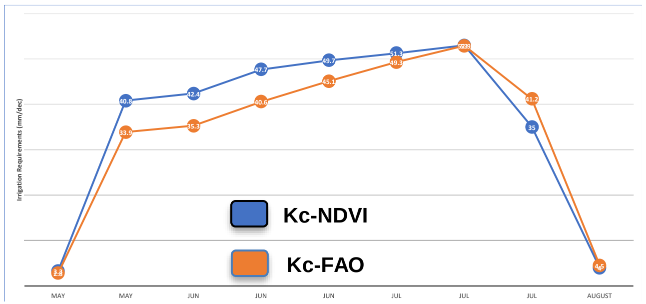
EO for ET estimation: take-away from projects

Kc-FAO *vs* Kc-NDVI for crop Evapotranspiration (ET_c)

	Month	Decade	Kc (NDVI)	Kc (FAO)	ETc Kc-NDVI (mm/day)	ETc Kc-FAO (mm/day)	Effective rain (mm/dec)	Irrigation requirements Kc-NDVI (mm/dec)	Irrigation requirements Kc-FAO (mm/dec)
Onion	May	2	0.84	0.7	3.32	2.77	0.1	3.3	2.8
	May	3	0.84	0.7	3.76	3.13	0.6	40.8	33.9
	Jun	1	0.84	0.7	4.25	3.54	0.1	42.4	35.3
Start date 20/05	Jun	2	0.85	0.72	4.77	4.06	0	47.7	40.6
	Jun	3	0.89	0.81	4.96	4.52	0.1	49.7	45.1
	Jul	1	0.92	0.89	5.16	49.6	0.3	51.3	49.3
	Jul	2	0.95	0.95	5.34	53.4	0.5	53	52.9
	Jul	3	0.81	0.95	4.41	41.5	0.3	35	41.2
						Total	2	323.1	301

Irrigation requirement (mm/dec)



FAO	Initial	Dev	Mid	End	Total	
Onion (green)	25	30	10	5	70	April/May
Kc	0.7		1	1		

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Extra

GEE UNIVERSWATER App

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End

Thank you! ☺

Q&A