

Innovative smart-farming and decision-support service for improving clingstone peach cultivation

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AgroNIT a smart-farming & decision-support platform for real-time irrigation management and assessment of its impact on pear and cherry tree crops' economy and nutrition in Thessaly, Greece

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Agro-NIT Smart Farming Framework

- Designed to incubate and evaluate innovative, eco-friendly, field-based solutions that aim to transform traditional farming to data-driven farming.
- Consists of three independent yet interconnected subsystems (layers) (Fig. 1):

- ✓ **Data Acquisition:** Custom-made, energy-autonomous, field-based Wireless Sensor Networks. Heterogenous data collection and transmittance to the Cloud, in real-time.
- ✓ **Data Management:** Cloud infrastructure, data storage and availability. Integrates: a) AI-enabled Early Warning System and b) Decision Support System
- ✓ **Application:** Connects users with data acquisition process, analysed field performance data, produced recommendations and alerts.

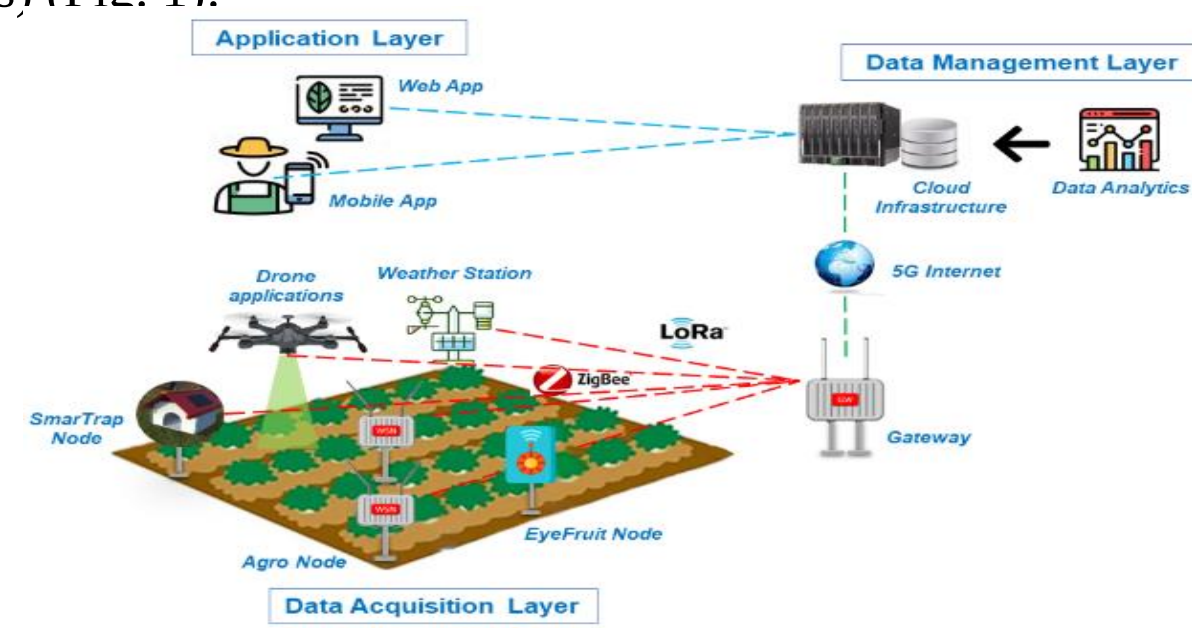


Fig. 1. The AgroNIT Platform Architecture

The Peach Use Case

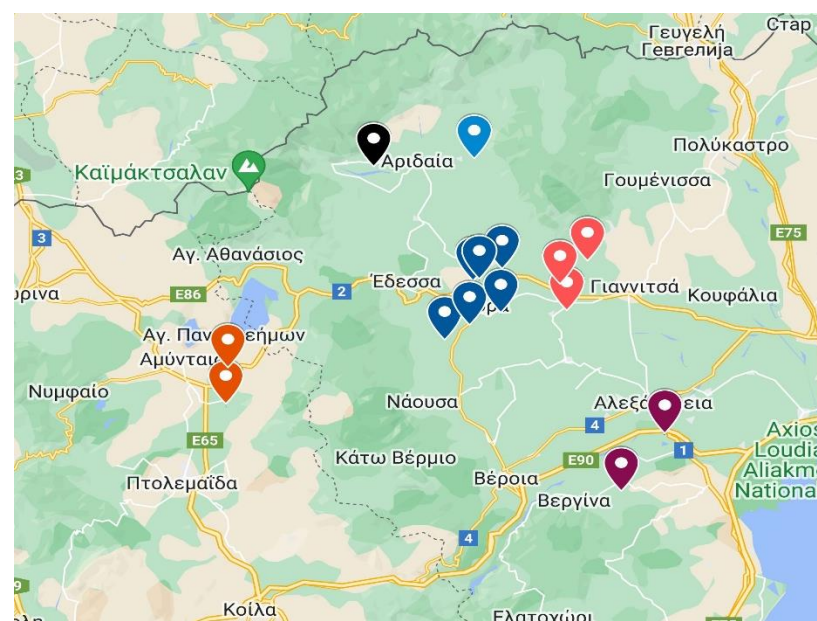


Fig. 2. Use Case's Deployment Map

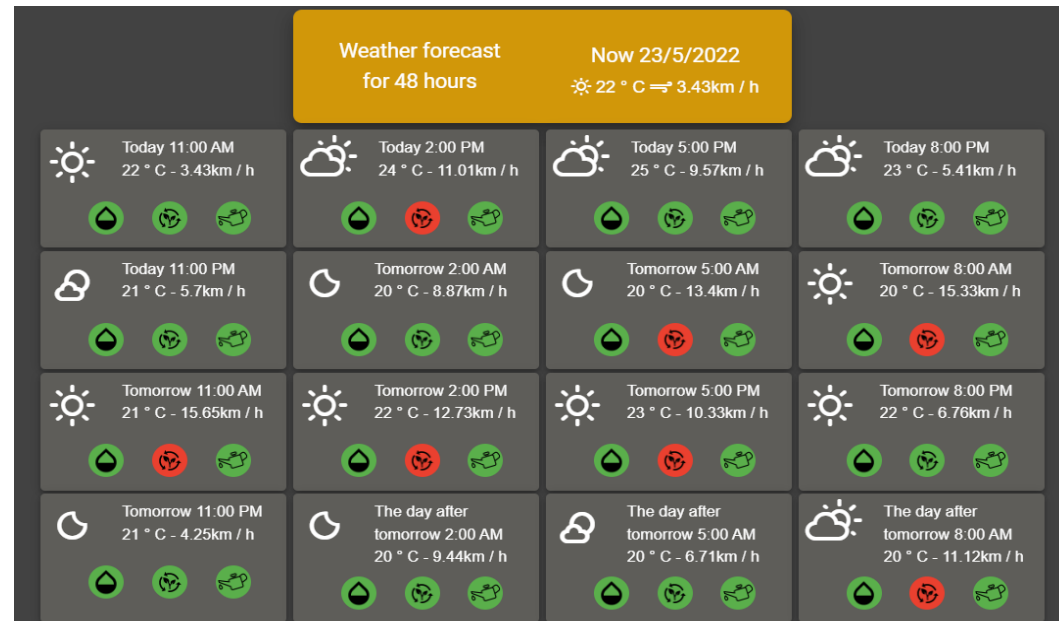


Fig. 3. Weather Forecast & Management Report

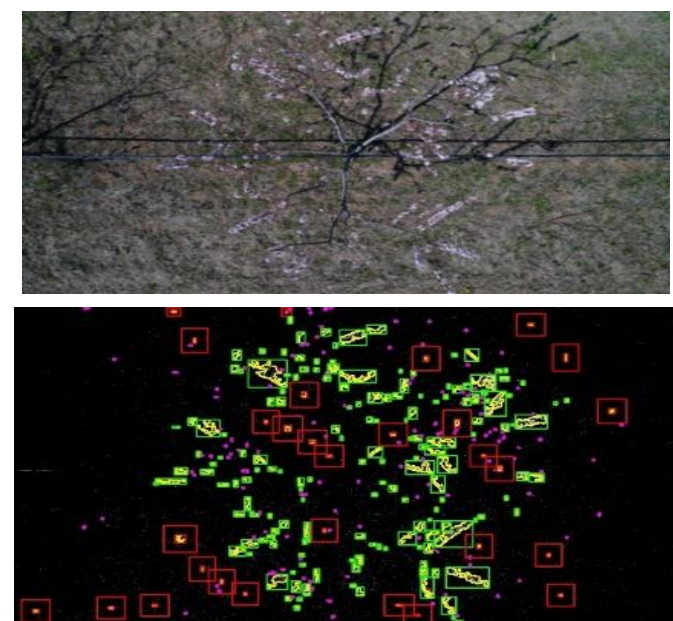


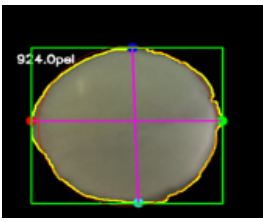
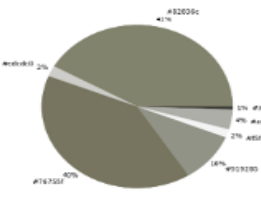
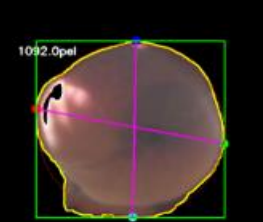
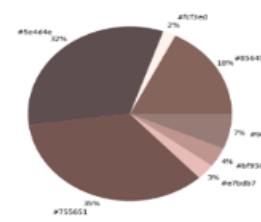
Fig. 4. Raw perpendicular tree image and final image processing output

- **Deployment:** 15 pilot fields, 15 agro, 5 meteo, 8 camera nodes, 13 GW (Fig. 2)
- **Decision support:** Irrigation (Table 1), Fertilization, Harvesting (Table 2), Plant Protection, Plant Phenology, Weather Forecasting & Management (Fig. 3), Yield Prediction (Fig. 4)

Table 1. Weekly sums of crop evapotranspiration (ET_c), total irrigation requirements (Idt) & duration (It) per dose for cv 'Catherina' during June 2021

Date	ET _c (mm)	Idt (mm)	It per dose (min)
8/6/21	10,05	11,82	92,36
15/6/21	12,84	15,10	117,98
22/6/21	13,08	15,39	120,23
29/6/21	9,97	11,73	91,68

Table 2. Estimation of fruit size and colour of cv 'Catherina', based on the image processing applied on raw field-based fruit images

Date	Raw image	Size measurement	Colour palette
08/07/21			
23/08/21			

Conclusions

- ✓ AgroNIT is an integrated, highly modular smart farming tool that is fully adapted to clingstone peaches
- ✓ It improves informed decision-making by the avg. peach grower or agriculturist
- ✓ It accommodates extensions and adaptations to various crops and environments without significant restrictions

- ✓ Designed to incubate and evaluate innovative, field-based solutions that aim to transform traditional farming to digital data-driven farming.
- ✓ Consists of three independent yet interconnected subsystems (layers) (Fig. 1):
 - **Data Acquisition:** Custom-made, energy-autonomous, field-based Wireless Sensor Networks. Real-time data collection from heterogeneous sensors and transmission to the Cloud
 - **Data Management:** Cloud infrastructure - Data Storage and Analysis: a) AI-enabled Early Warning System and b) Decision Support System
 - **Application:** Connects users with data acquisition process, analyses field performance data, creates recommendations and alerts

Materials & Methods

- **Deployment:**
 - 25 pilot fields across the plain of Thessaly, Central Greece
 - 21 agrometeorological, 6 cameras, and 11 GW nodes (Fig. 2)
- **Use cases (UC):**
 - UC1: *Pyrus communis*, cv. Krystali, Tyrnavos - UC2: *Prunus avium*, cv. Regina, Agia
- **Irrigation treatments:**
 - Model-based / smart irrigation (SI)
 - Rational with growth stage-based deficit irrigation (DI)
 - Conventional irrigation (CI)
- **Key Performance Indicators:**
 - Crop mineral nutrition
 - Cost-savings (irrigation, N-fertilization)
 - Crop water productivity (CWP)

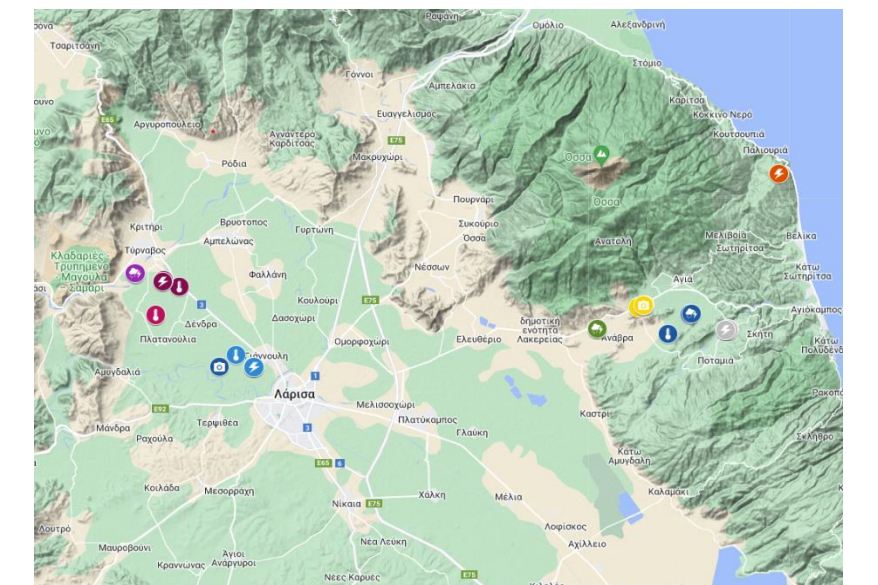


Fig. 2. AgroNIT Deployment Map

Conclusions

- **Crop mineral nutrition:** CI overcovered crop nutritional requirements in N, Ca, Mg on many cases in both years (N: 58-247%; Ca: 445-14,673%; Mg: 518-9,114%; K: 8.6-39.3%)
- **Cost-savings:**
 - Irrigation: SI & DI generated significant water-savings (10-46%) and cost-savings (158-767 €/ha), accordingly. SI scored best in almost all cases, except for UC2 in 2020 in which CI consumed less water and scored slightly better in the related cost-savings (30 €/ha).
 - N-fertilization: CI scored highest in UC1 and UC2 (2021) (206-390 €/ha). SI and DI generated between 120-286 €/ha cost-savings.
 - Trade-off: SI was found to be the best method cost-wise.
- **Crop Water Productivity:** SI & DI performed better, compared to CI, ranging between 1.3-4.8 kg/m³ per tree.
- **AgroNIT:**
 - ✓ Enables the real-time quantification and assessment of (a) real crop water needs, and (b) nutrient concentrations applied through irrigation
 - ✓ Empowers user to dynamically (1) devise, schedule and apply alternative irrigation regimes, and (2) assess and quantify their impact on crop nutrition, economy, and productivity
 - ✓ Facilitates the application of holistic crop management to (i) improve water & nutrient use efficiency, and (ii) minimize irrigation & fertilization costs and environmental footprint

Demonstration Results

Table 1. Nutrients applied (kg/ha) through different irrigation volumes (m³/ha) at different treatments in UC1 and UC2. DI was not applied in 2020.

Use case	Year	Treatment	Irrigated water	N	Ca	Mg	K
1	2020	CI	5,406.7	69.5	519.6	111.4	8.7
		SI	2,910.1	37.4	279.7	59.9	4.7
	2021	CI	5,007.0	64.4	481.2	103.1	8.0
		SI	3,174.5	40.8	305.1	65.4	5.1
2	2020	CI	4,479.2	57.6	430.5	92.3	7.2
		SI	5,712.0	81.8	851.1	209.6	10.9
	2021	CI	5,812.4	83.3	866.0	213.3	11.0
		SI	6,240.0	89.4	929.8	229.0	11.9

Table 2. Nutrients applied in irrigated water as a percentage (%) of nutrient removed (kg/ha) in harvested fruits and pruned biomass (kg/ha) in UC1 & UC2 for 2021 and 2020, respectively.

		Crop produce		N		Ca		Mg		K	
UC	Year	Pruned	Fruit	Removed	Applied	Removed	Applied	Removed	Applied	Removed	Applied
1	2021	8,970	39,490	110.3	58.4	108.1	445.1	19.9	518.3	92.9	8.6
2	2020	314	16,070	33.2	246.5	5.8	14,673.9	2.3	9,114.4	27.6	39.3

Table 3. The trade-off between irrigation and N-fertilization cost savings (€ per ha) and the water savings (%) recorded for the different irrigation treatments compared to conventional method in UC1 and UC2. The average water cost was 0.3 €/m³; N-fertilization cost was 3.2 €/kg N; DI was not applied in 2020.

Use case	Year	Treatment	Water-savings	Irrigation cost savings	N-fertilization cost savings	Trade-off*
1	2020	CI	-	-	-	-
		SI	46.2	749.0	-102.7	646.3
	2021	CI	-	-	-	-
		SI	36.6	549.8	-75.4	474.4
2	2020	CI	-	-	-	-
		SI	-1.8	-30.1	4.6	-25.5
	2021	CI	-	-	-	-
		SI	30.1	767.3	-117.3	650.0
		DI	26.6	678.0	-103.6	574.4

*The difference between the irrigation and N-fertilization cost-savings.

Table 4. Computed CWP (kg/m³) per tree at different irrigation volumes (m³/tree) compared to the conventional method in UC1 and UC2 during the year 2021. Yield measurements (kg/tree) were not carried out in 2020. Yield for the SI and CI treatments were assumed to be the same.

Use case	Treatment	Yield	Irrigated water	CWP	CWP (diff)*
1	CI	46.3	5.7	8.1	-
	SI	46.3	3.6	12.9	4.8
	DI	49.5	5.1	9.7	1.6
2	CI	29.9	10.2	2.9	-
	SI	29.9	7.2	4.2	1.3
	DI	34.8	7.5	4.6	1.7

*The difference between the SI and DI values from the values of CI treatment.