

# INTEL-IRRIS

Intelligent Irrigation System for Low-cost Autonomous Water Control  
in Small-scale Agriculture



# The INTEL-IRRIS approach for low-cost sensing and Edge-AI in optimized irrigation for smallholder farmers communities



June 28th, 2023  
EAISA 2023 – Workshop on Edge AI for Smart Agriculture

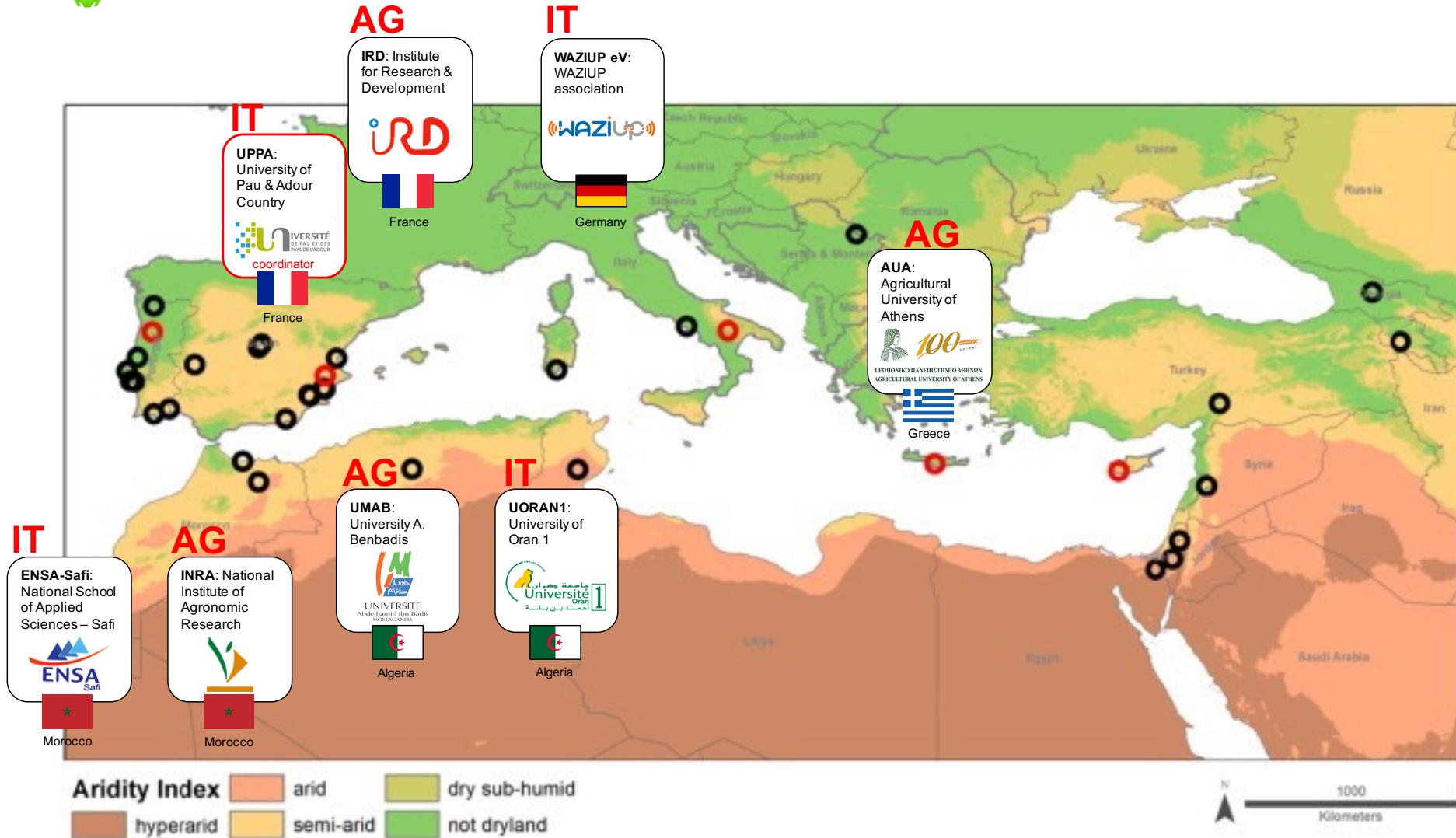
Prof. Congduc Pham  
<http://www.univ-pau.fr/~cpham>  
Université de Pau, France



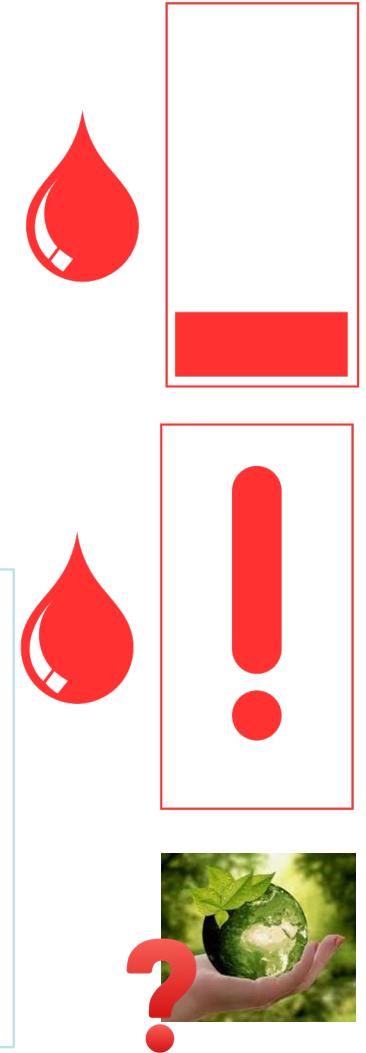
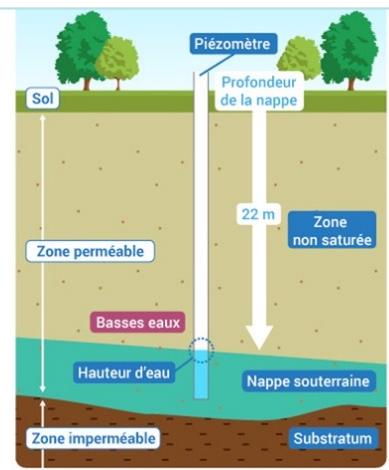
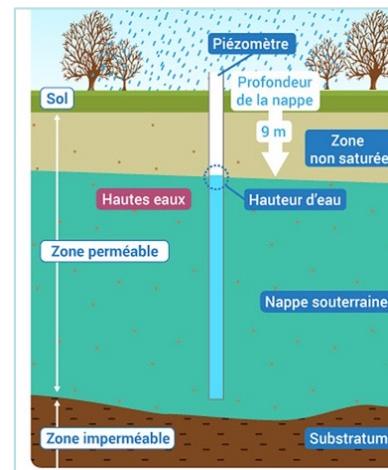
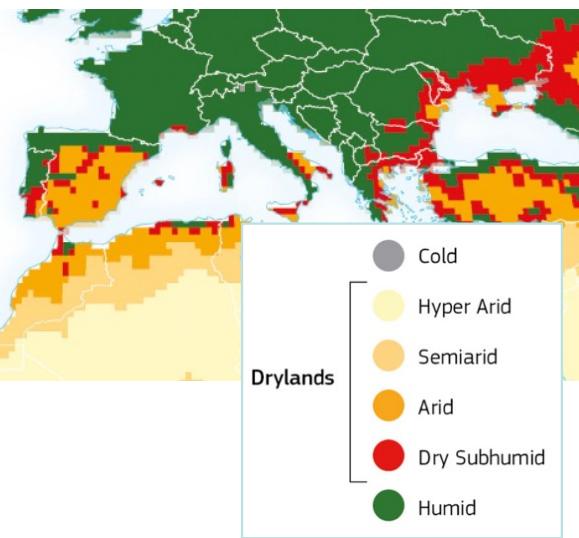
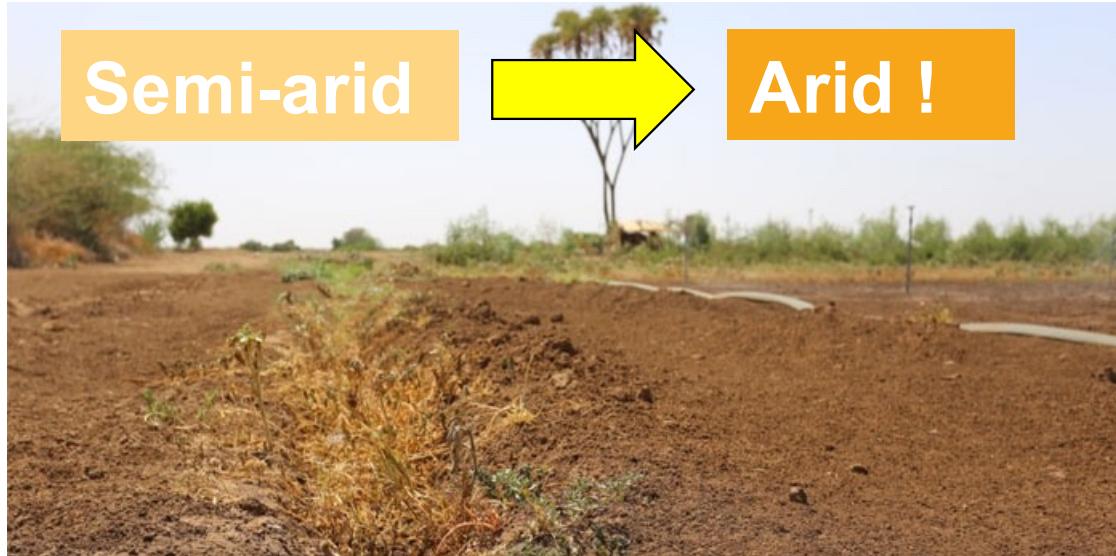
# Where am I now?



# Focus on Mediterranean Area



# Water resource is precious!



# Ideal smart agriculture scenario



# Where can we save water?

- More than 70% of water is used for agriculture activities
- Digital technologies can help reducing and optimizing usage of water, **but...**



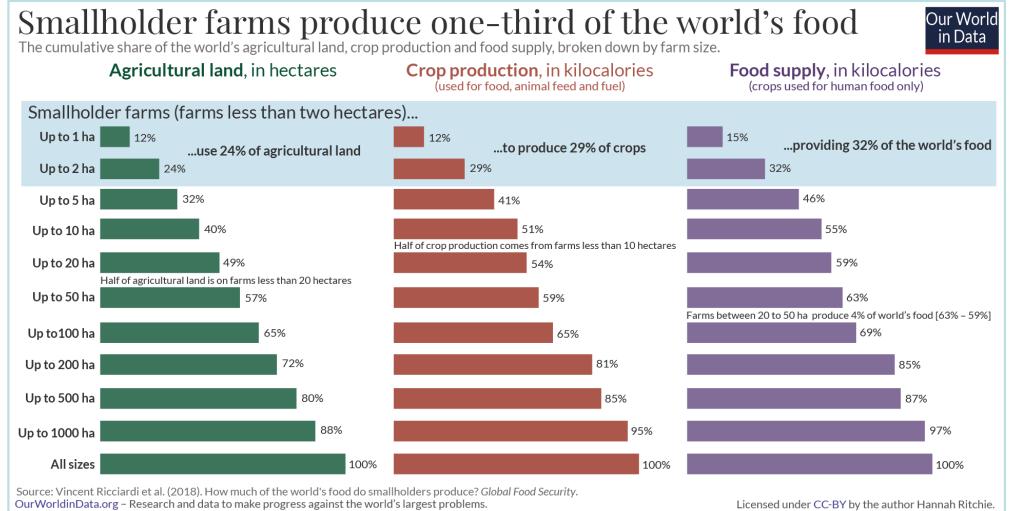
Possible for large farms



Out of reach for  
smallholders!

# Smallholders – up to 2ha

- Most (84%) of the world's 570 million farms are smallholdings
- Provide about 32% of world food supply, on about 24% of agriculture land

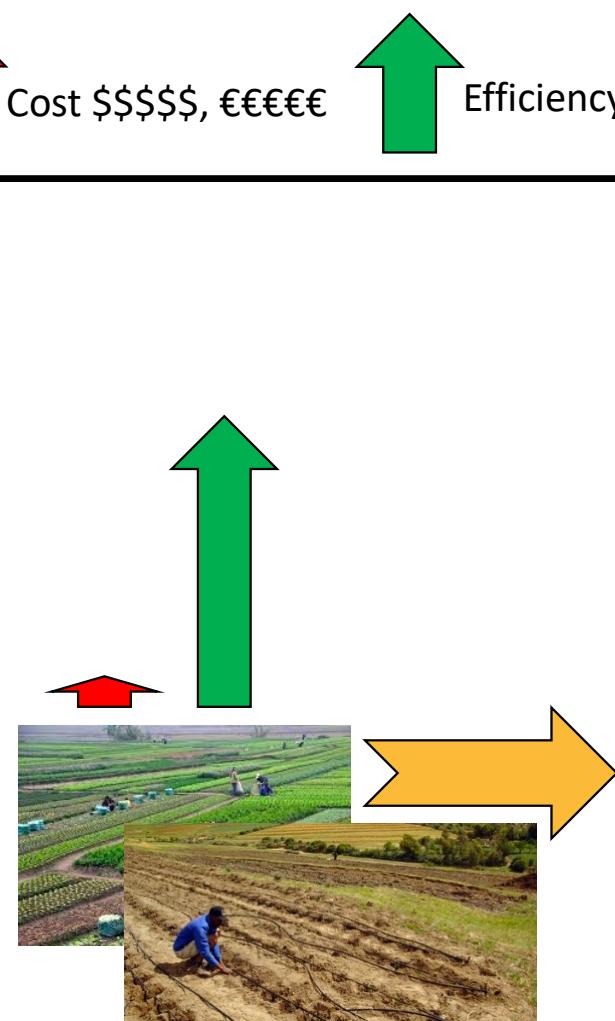
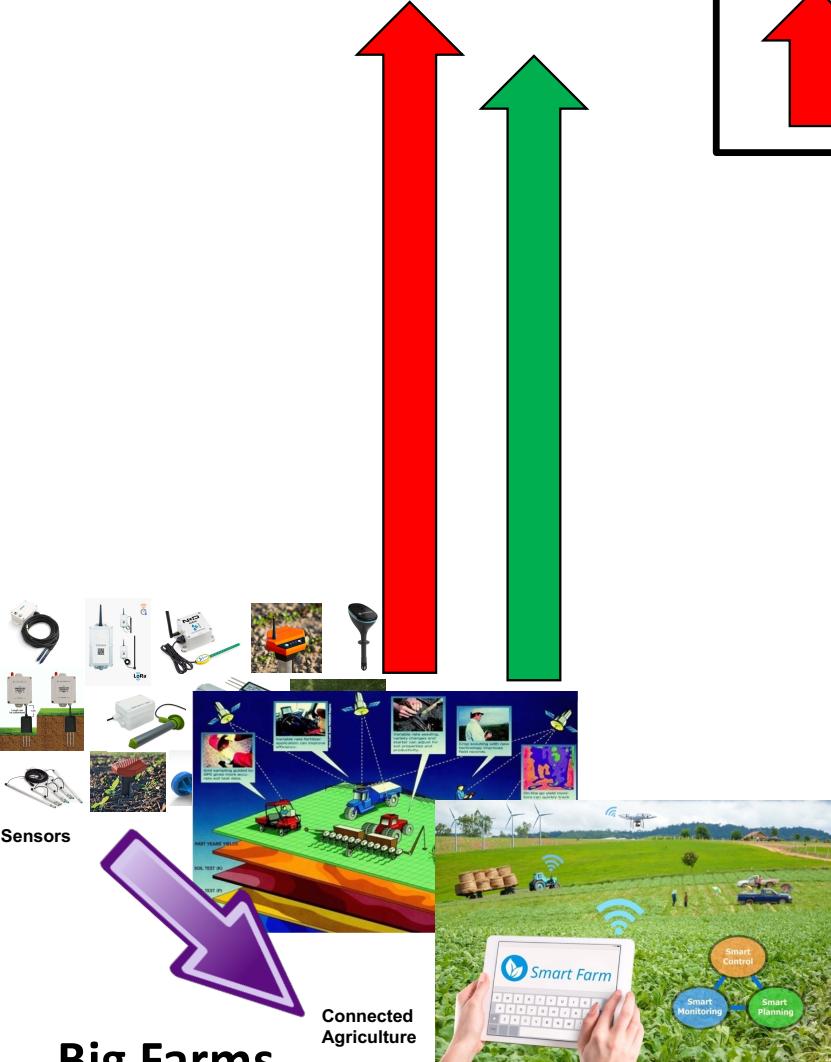


<https://ourworldindata.org/smallholder-food-production>



Too expensive  
 Too integrated  
 Highly specialized  
 Difficult to customize  
 Difficult to upgrade

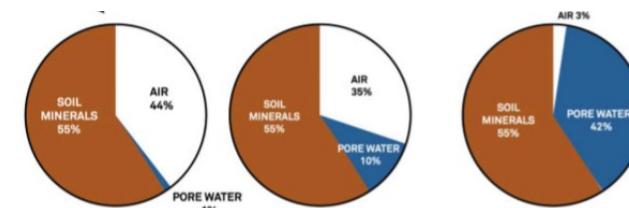
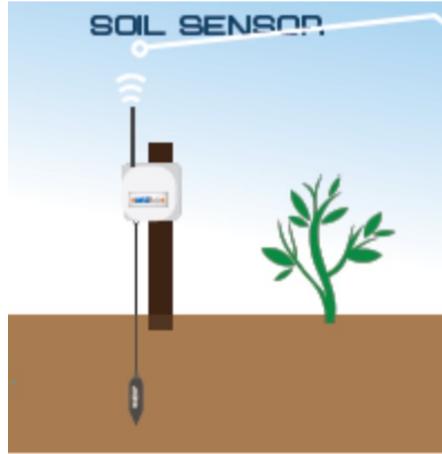
# It is always a tradeoff...



**Small-scale farms,  
Smallholder Farmers**

**What can  
research &  
innovation  
bring to smart  
agriculture?**

# Irrigation with soil moisture sensing



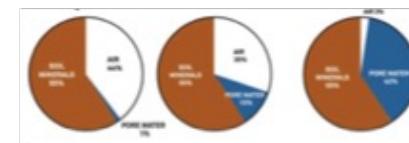
# Not as simple as it seems 😞

**Sense**



Volumetric Water Content,  
Water Potential, Water  
Tension,....

TDR, FDR, capacitance,  
resistance, ....



Soil characteristics: bulk  
density, soil salinity, soil  
texture & soil type

Evapotranspiration, soil-  
plant-atmosphere  
continuum,....



Irrigation type: drip,  
furrow, sprinkler,...

Plant/Crop varieties

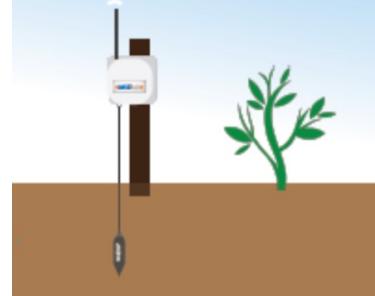
Relationship with other  
agriculture inputs

# INTEL-IRRIS's main objectives

## Low-cost

1

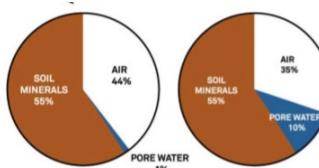
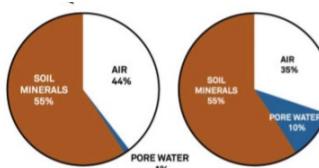
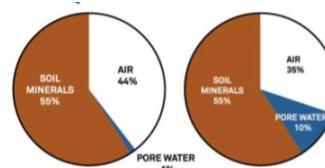
Propose low cost but highly efficient water control systems for irrigation optimization



## Advanced technologies

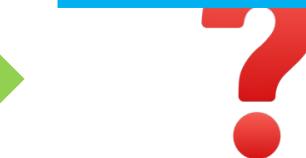
2

Use cutting-edge technologies to propose highly innovative systems yet simple to deploy and adapted to smallholders



3

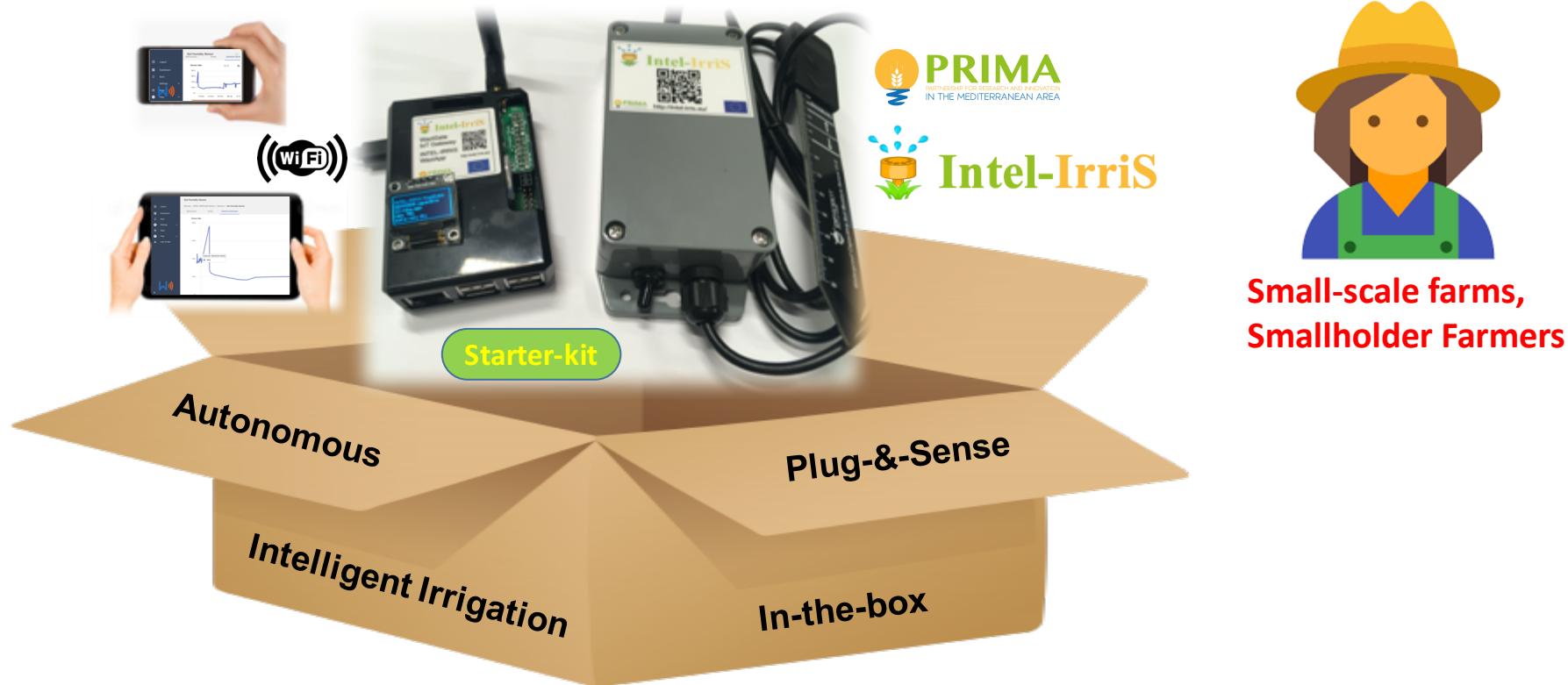
Seamless integration into existing irrigation system and/or local customs and practices



## Autonomous Plug-&-Sense

# INTEL-IRRIS's starter-kit

- At the beginning: **an idea...**
- Very simple, "Intelligent Irrigation in-the-box", "plug-&-sense"



# INTEL-IRRIS's starter-kit

○ From idea to reality!



# 2 versions of the soil device



A soil temperature sensor can be added

Especially for tensiometer

# Technology components

Sensor part



**SEN0308**  
capacitive  
sensor

**Irrometer WM200**  
**Water tension sensor**

Control part



Embedded  
Database



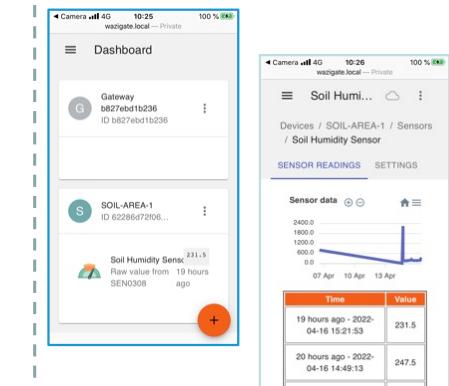
Software  
updates

Embedded  
User Interface



**LoRa**  
**LoRaWAN®**

LPWAN



**WiFi**

# Low-cost sensors

Sensor part



SEN0308  
capacitive  
sensor

< 30€

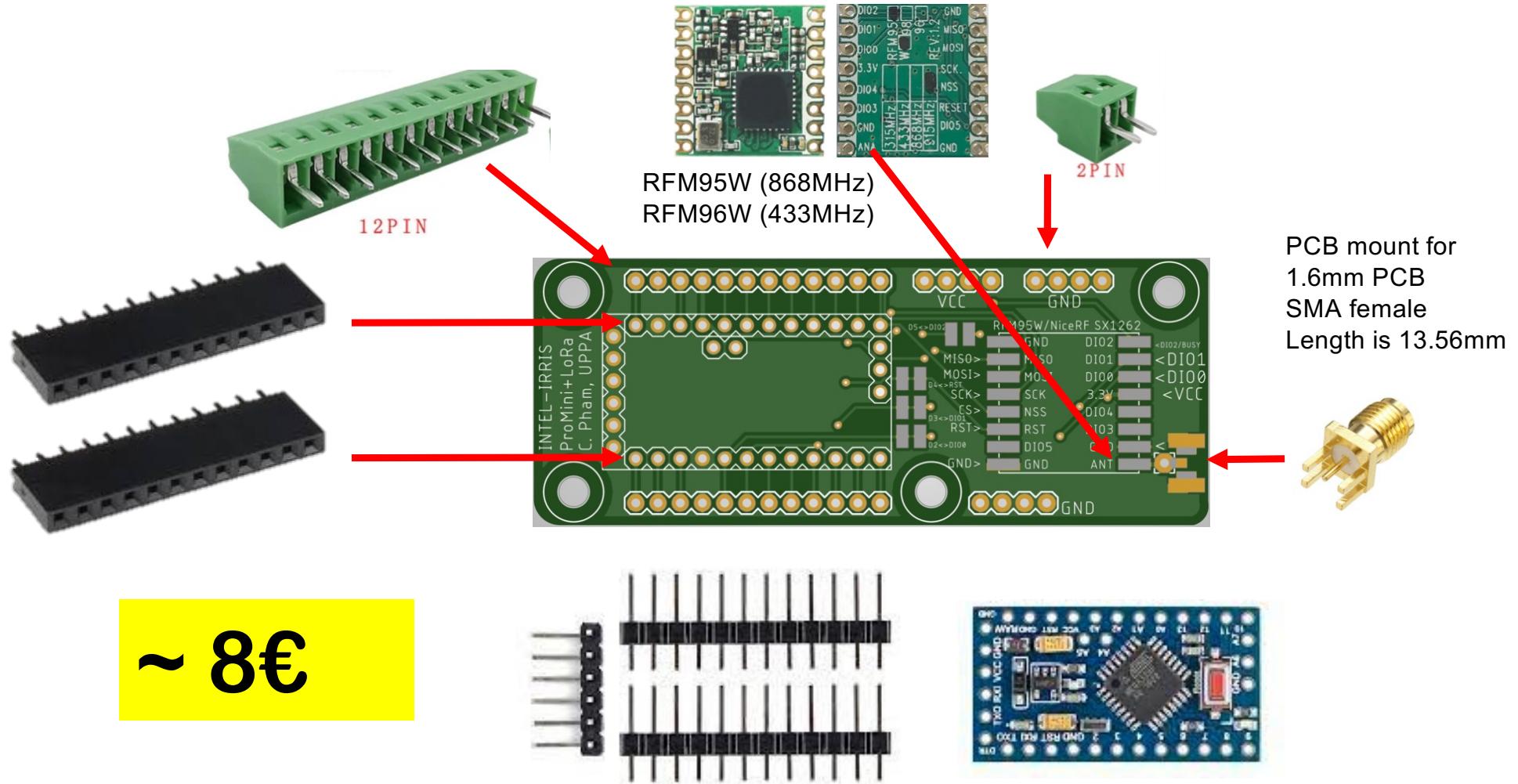
Irrrometer WM200  
Water tension sensor

< 60€

- Build on low-cost, low-power IoT expertise
- Enable deployment of several complementary low-cost sensors
- Several versions can be designed to meet cost constraints
- Increase accuracy of low-cost sensors by advanced calibration procedures



# Soil sensor: electronic parts



# Soil sensor: integration

~ 12€

~ 38€



~ 10€

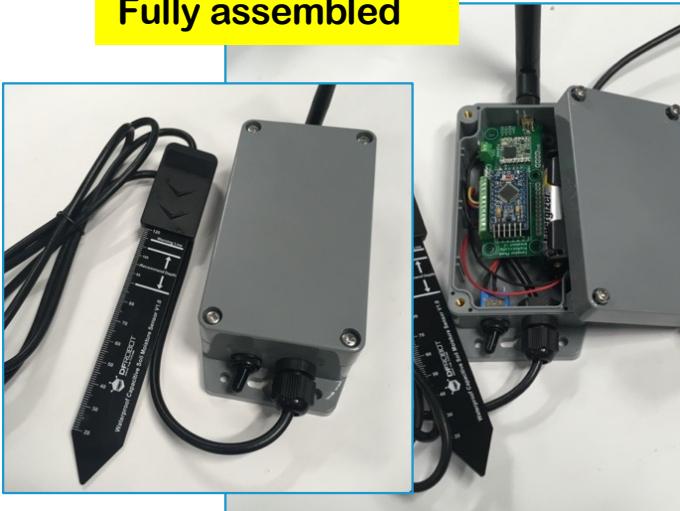


~ 2€



# Soil sensor...in kit!

Fully assembled



Packaging in enclosure



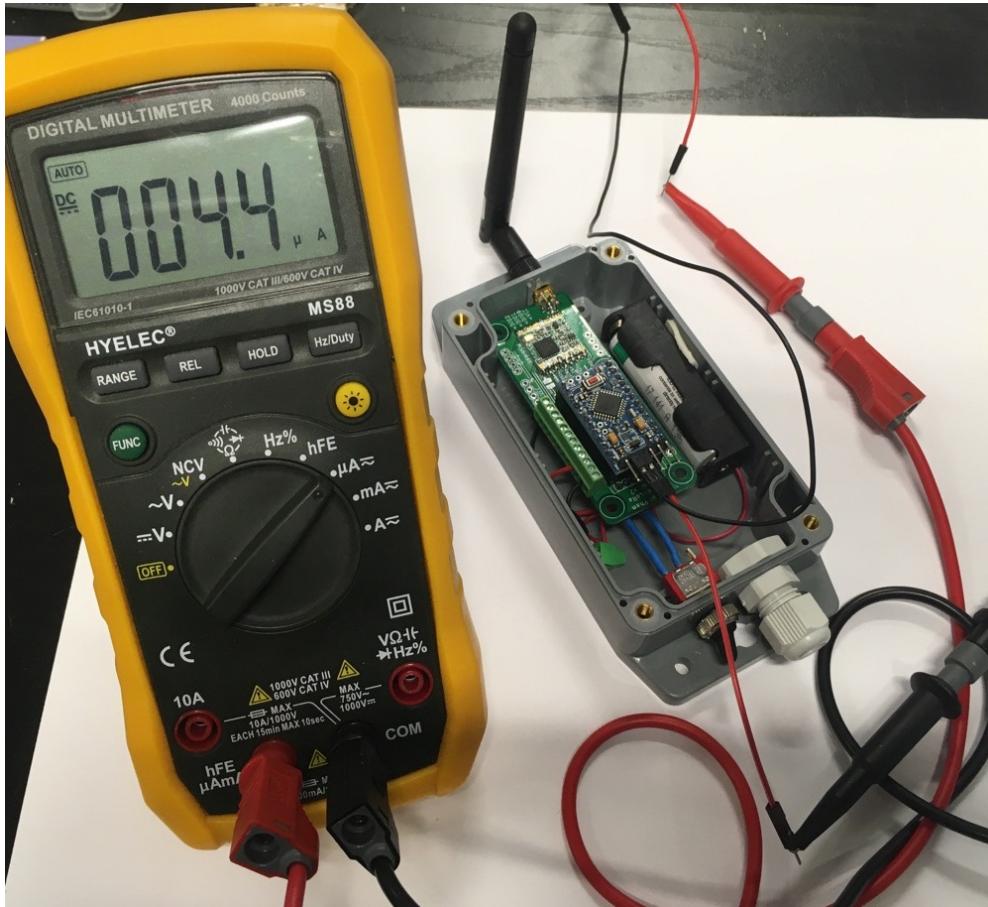
To be assembled

# A generic hardware platform

- Low-cost: < 20€
- Off-the-shelves components
- Easily duplicated
- Assembling by local partners
- Can connect several sensors
- Can be adapted by local partners



# Power consumption in deep sleep



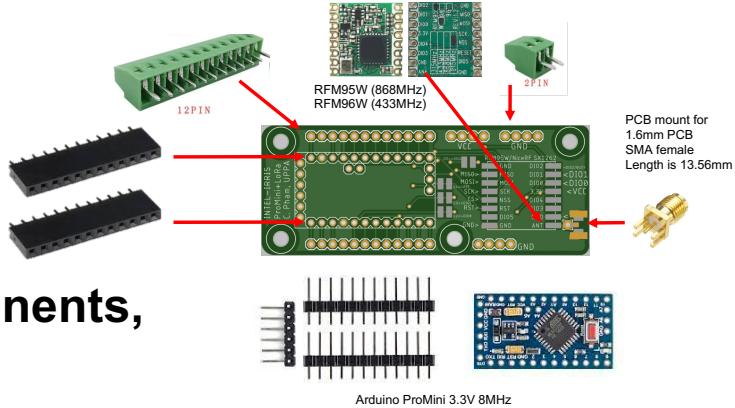
Measured below 5 $\mu$ A in deep sleep, between 2 active periods with transmissions

Expected autonomy with 1 transmission / hour is over 2 years with either 2 AA batteries or 1 AA 3.6V Lithium battery

# Low-cost design space

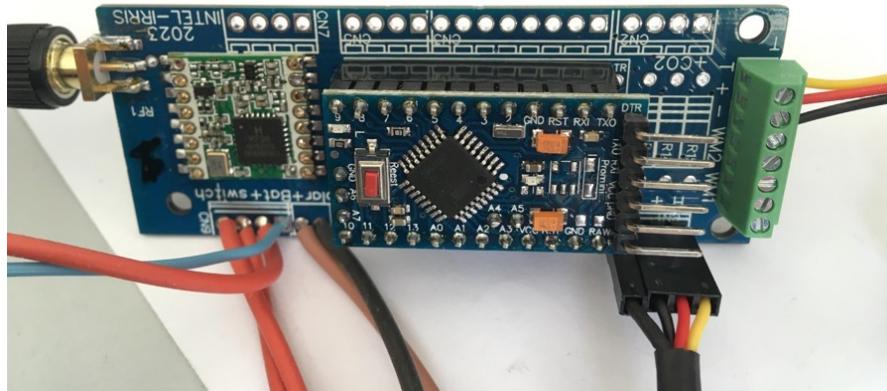
1

Simple design, off-the-shelves components, 100% DIY



Simple design, off-the-shelves components, low-cost support for solar panel, some components already soldered, mixed-DIY

2

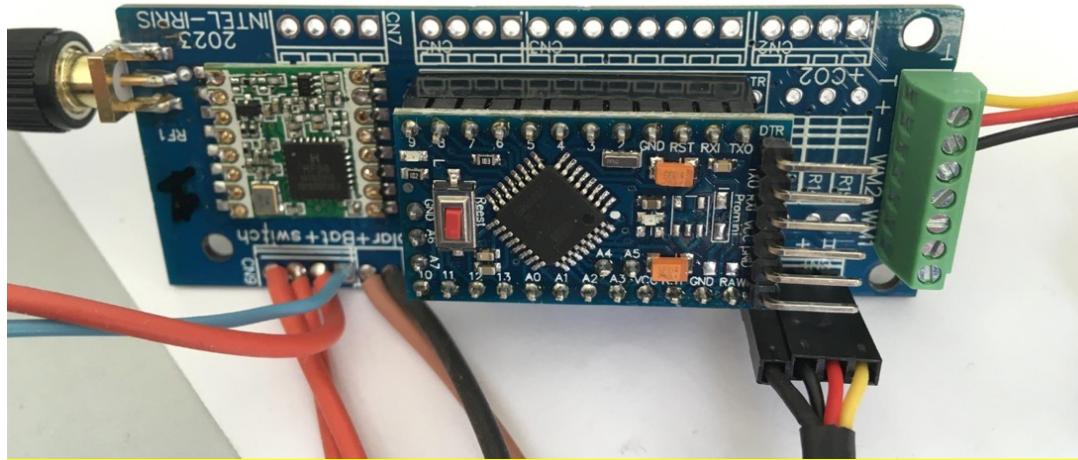


3

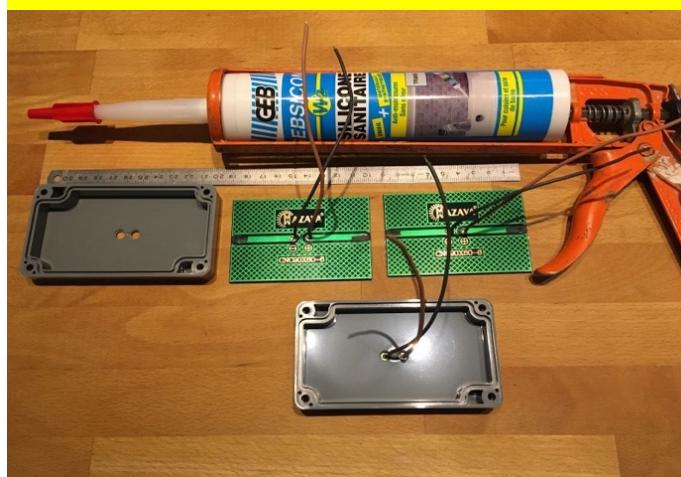
Integrated design, off-the-shelves components, full support for solar panel, all components already soldered

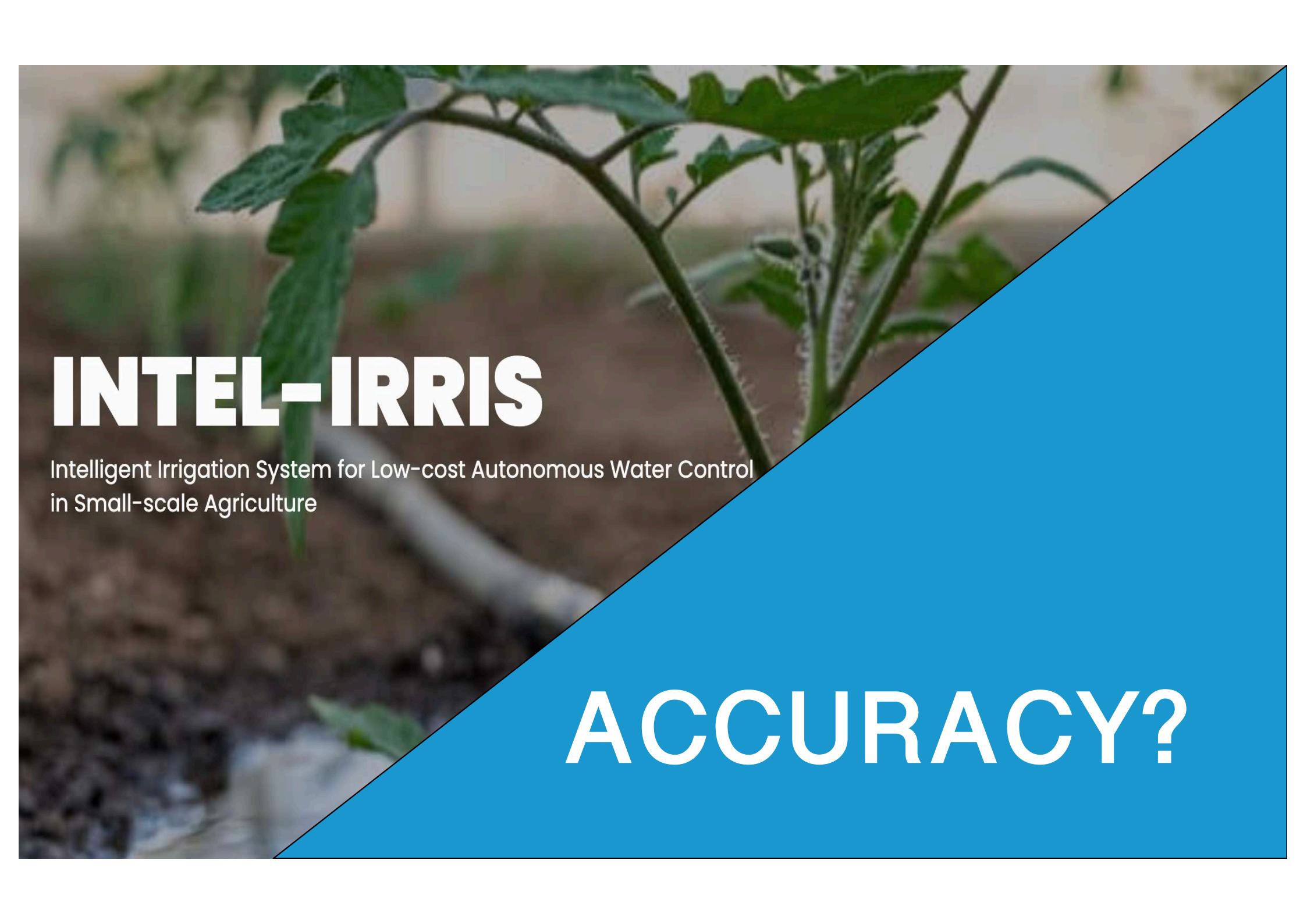


# Low-cost solar variant



Add about 5€ only



A close-up photograph of a young green plant with several leaves and a thin stem, growing out of dark brown soil. The background is slightly blurred.

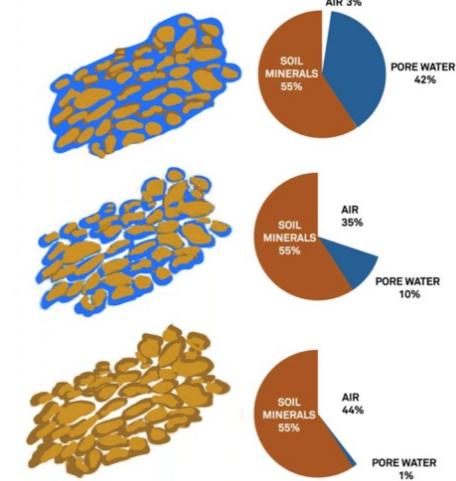
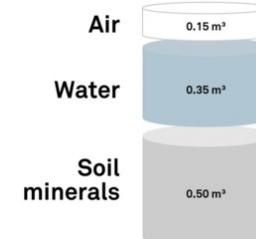
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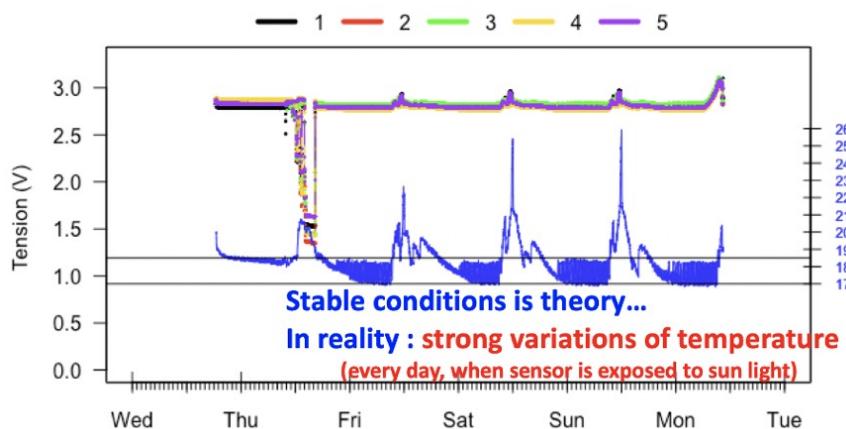
# ACCURACY?

# Capacitive sensor

- Capacitive soil moisture sensors usually measure volumetric water content
- Soil density & soil texture are important parameters



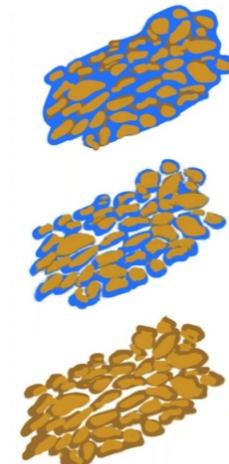
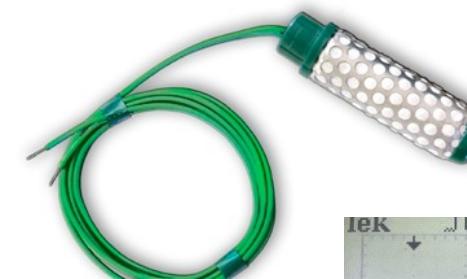
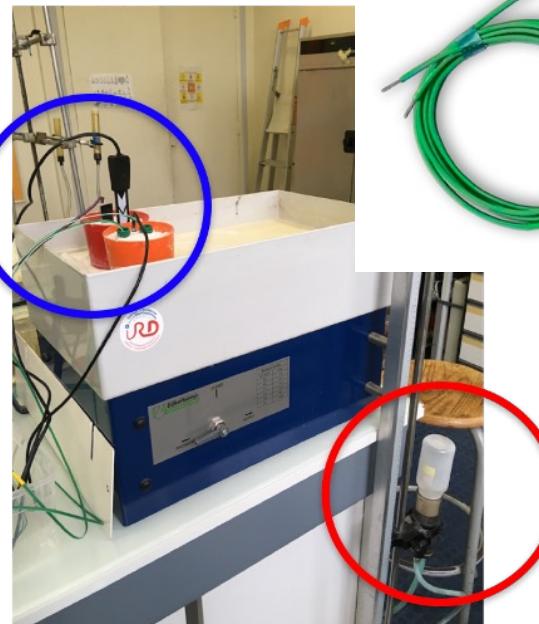
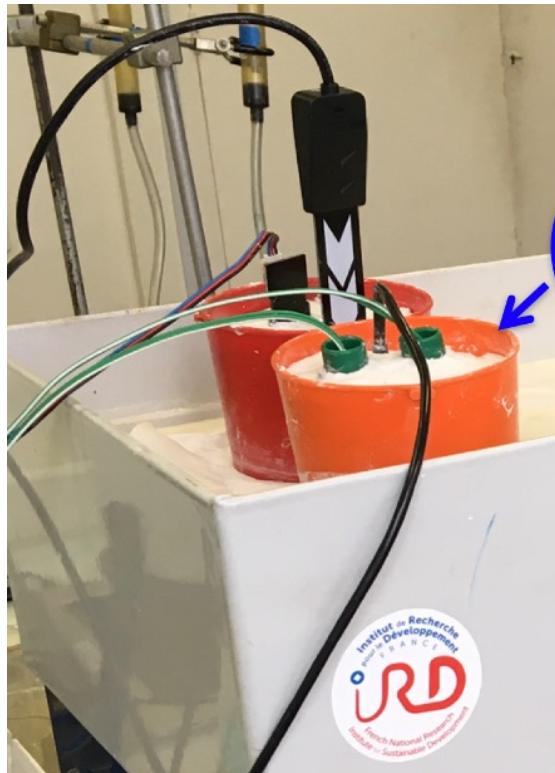
From METER group



IRD in conducting extentise test on the accucary and the stability of the low-cost SEN0308 capacitive sensor    26

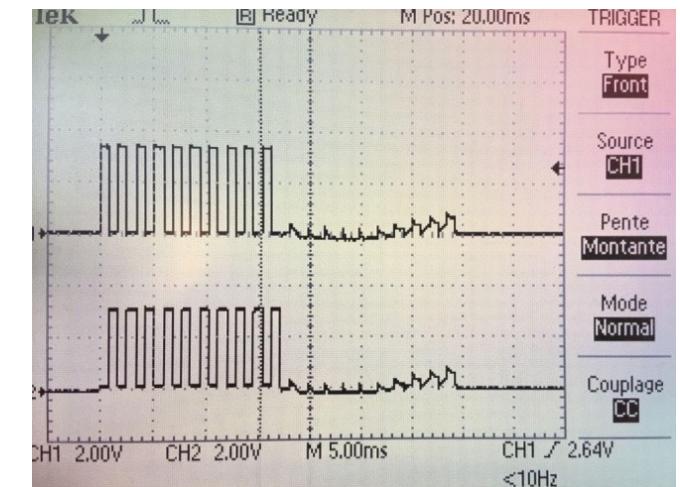
# Water tension sensor

- Water tension sensor measures the amount of force required to extract water from soil's pores



comparison

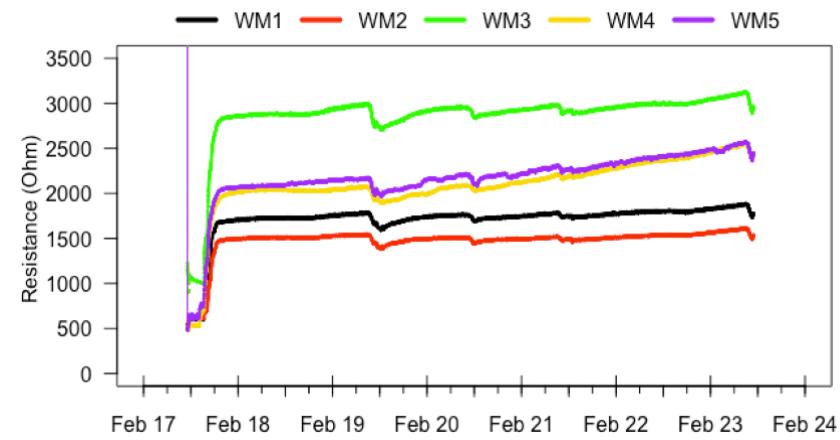
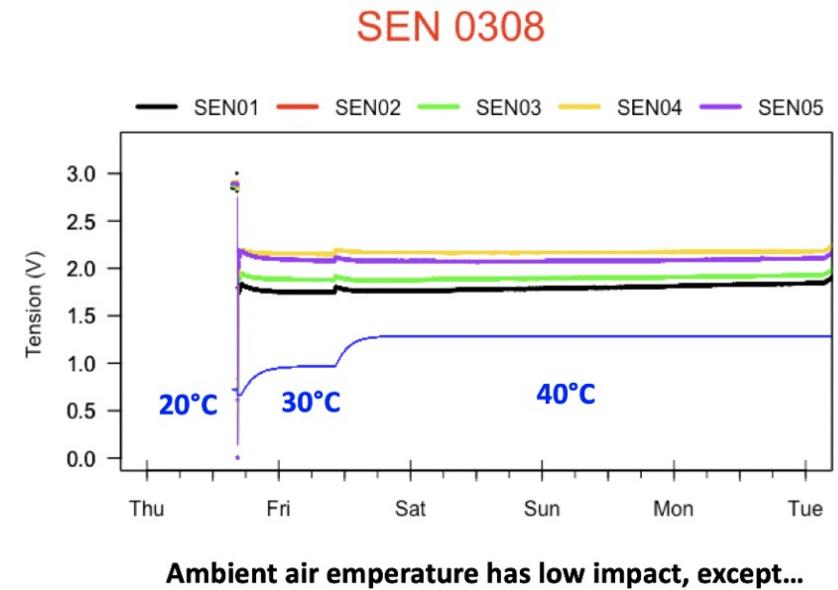
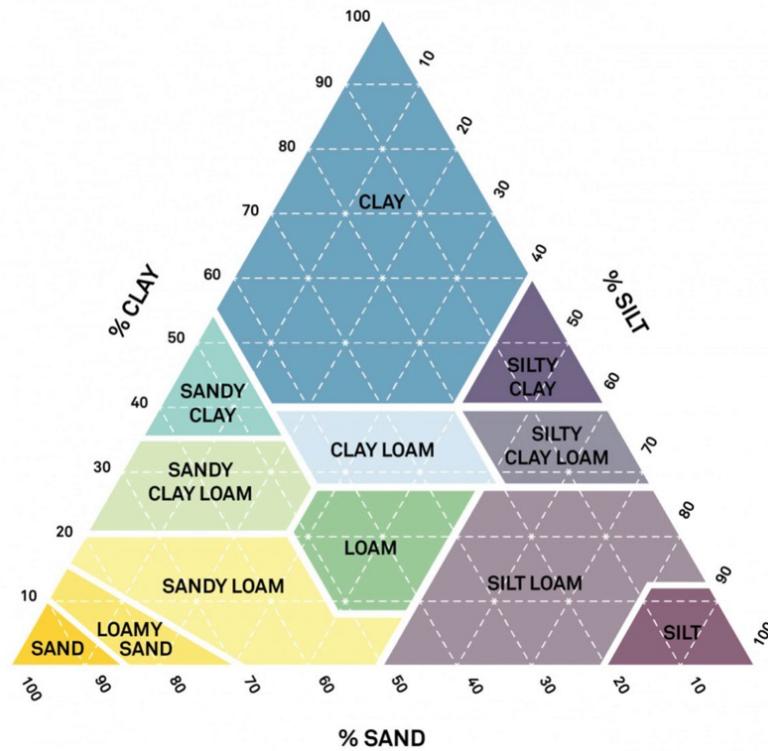
From METER group

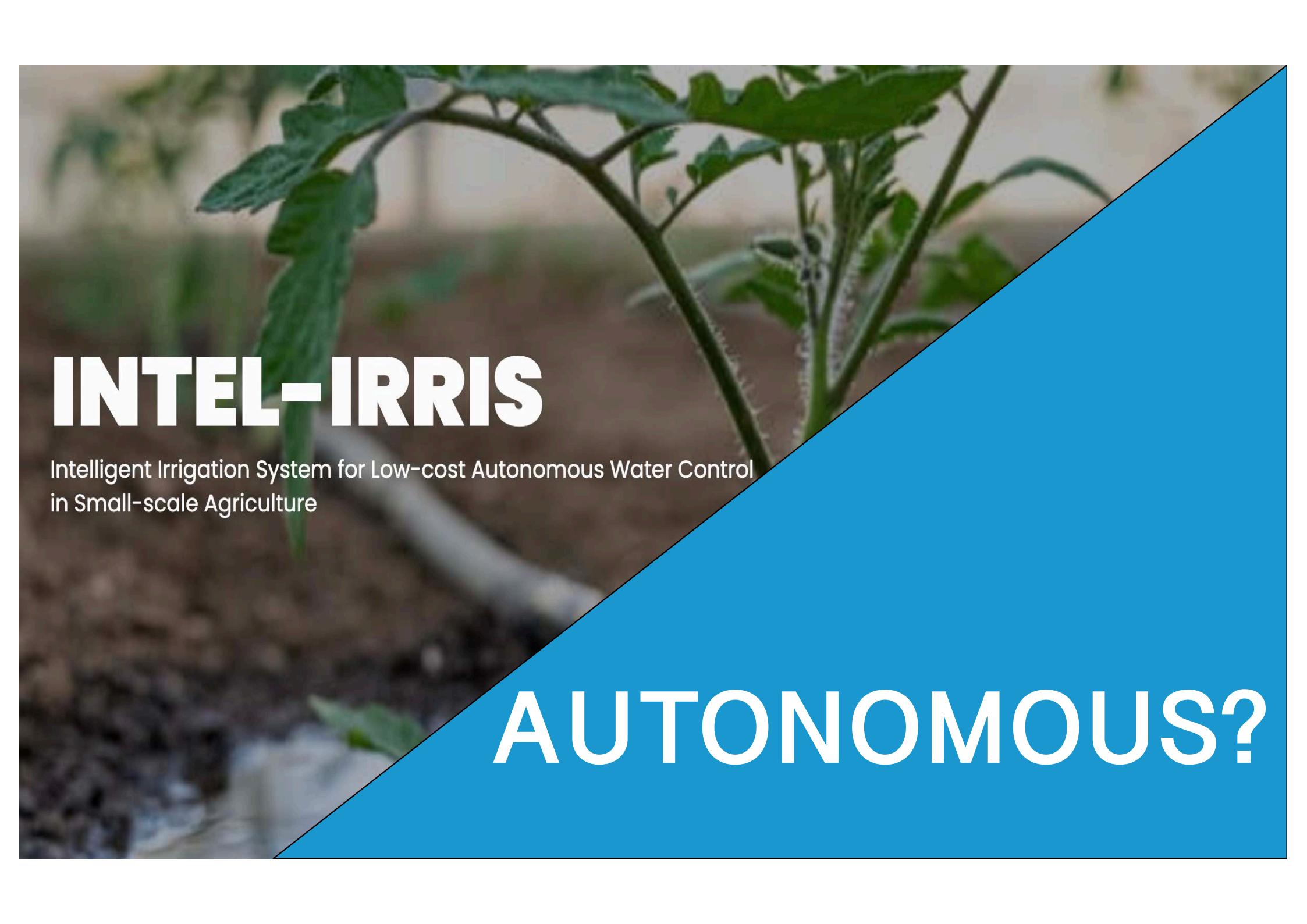


IRD in conducting extensive tests on the stability & suitability of microcontroller-based usage of the Watermark water tension sensor

# Calibration

- Soil-specific calibration
- Impact of external "noise"



A close-up photograph of a green plant with serrated leaves growing in dark brown soil. The plant has several thin stems and small leaves. The background is slightly blurred.

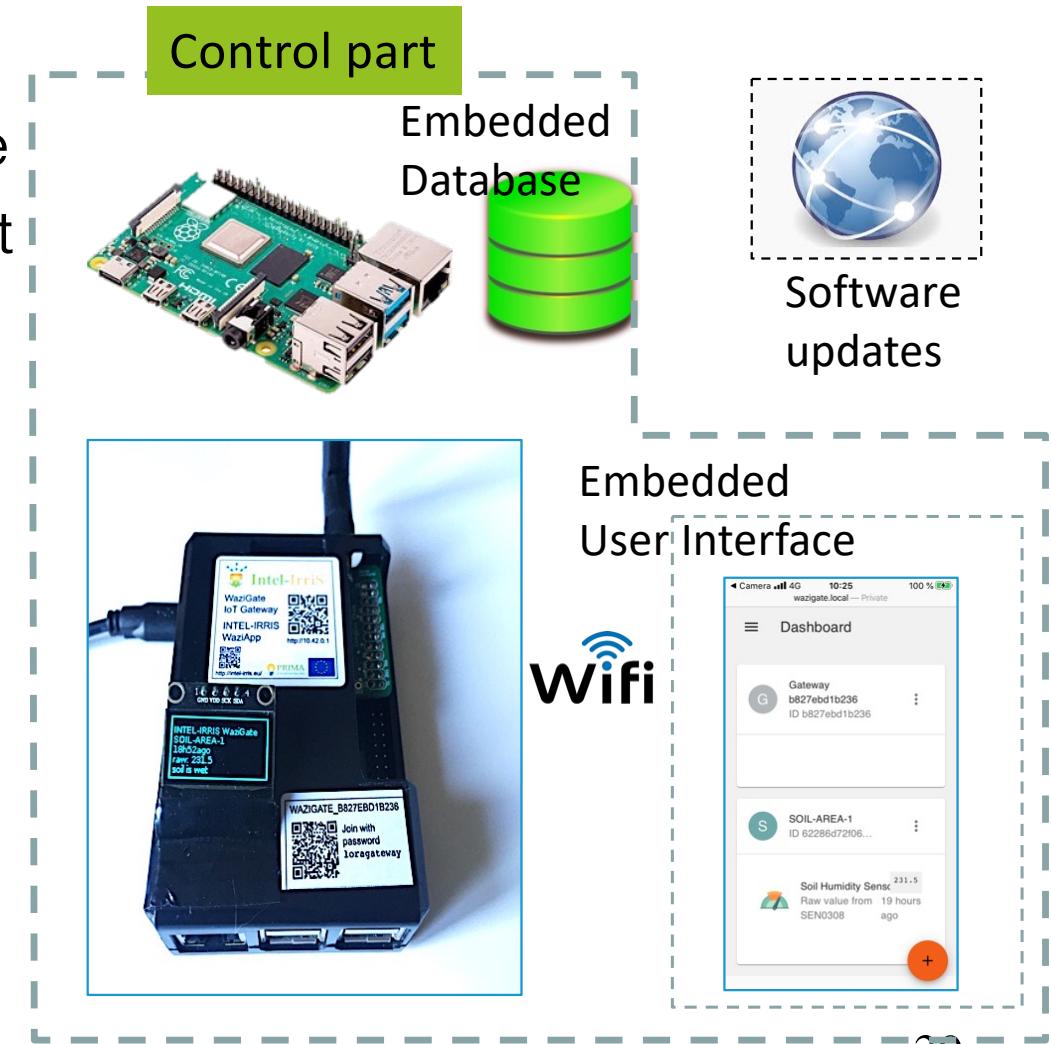
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# AUTONOMOUS?

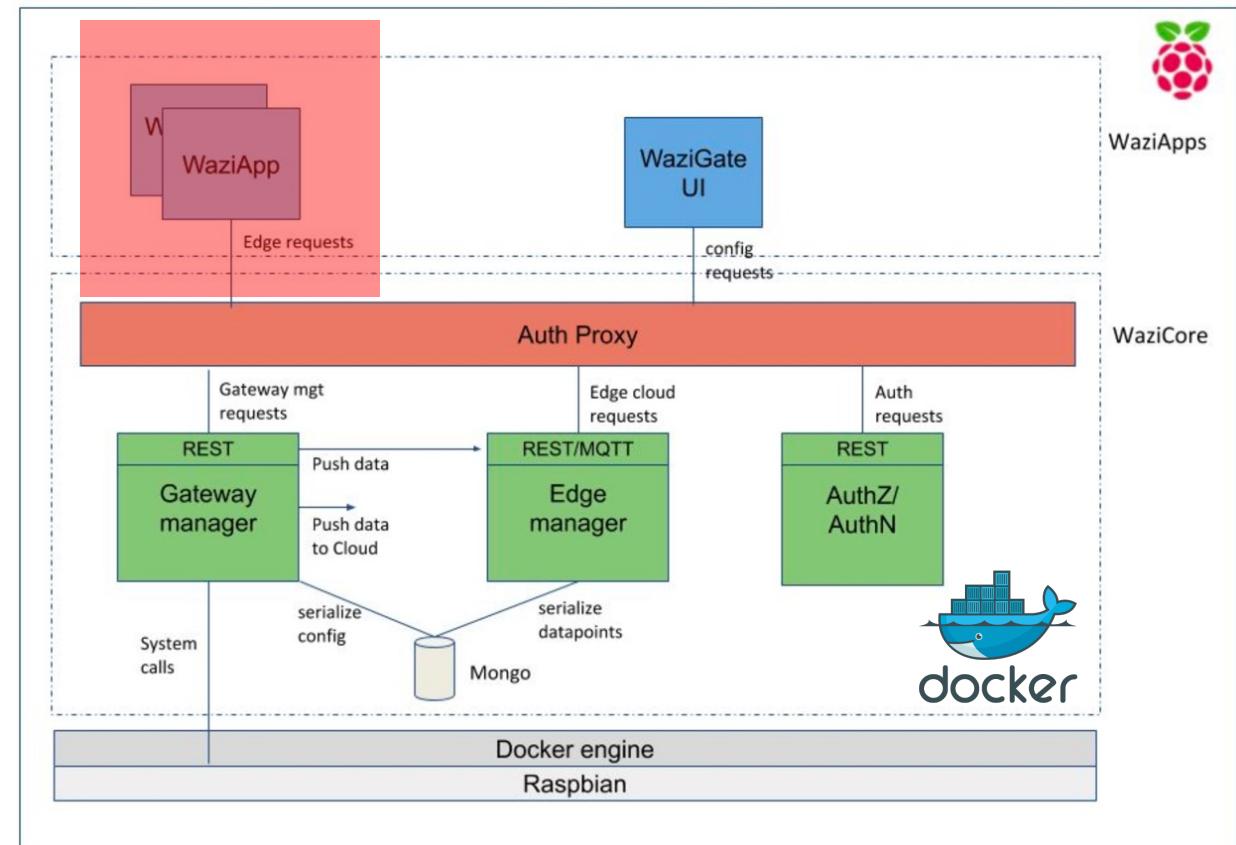
# Smart embedded control

- Build on low-cost embedded & open IoT gateway expertise
- Fully autonomous, no Internet
- Implement the “Intelligent Irrigation in-the-box” with "plug-&-sense" approach
- Embed dedicated irrigation-oriented application
- Model complex water-soil-plant-weather interaction
- Integration of various knowledge streams



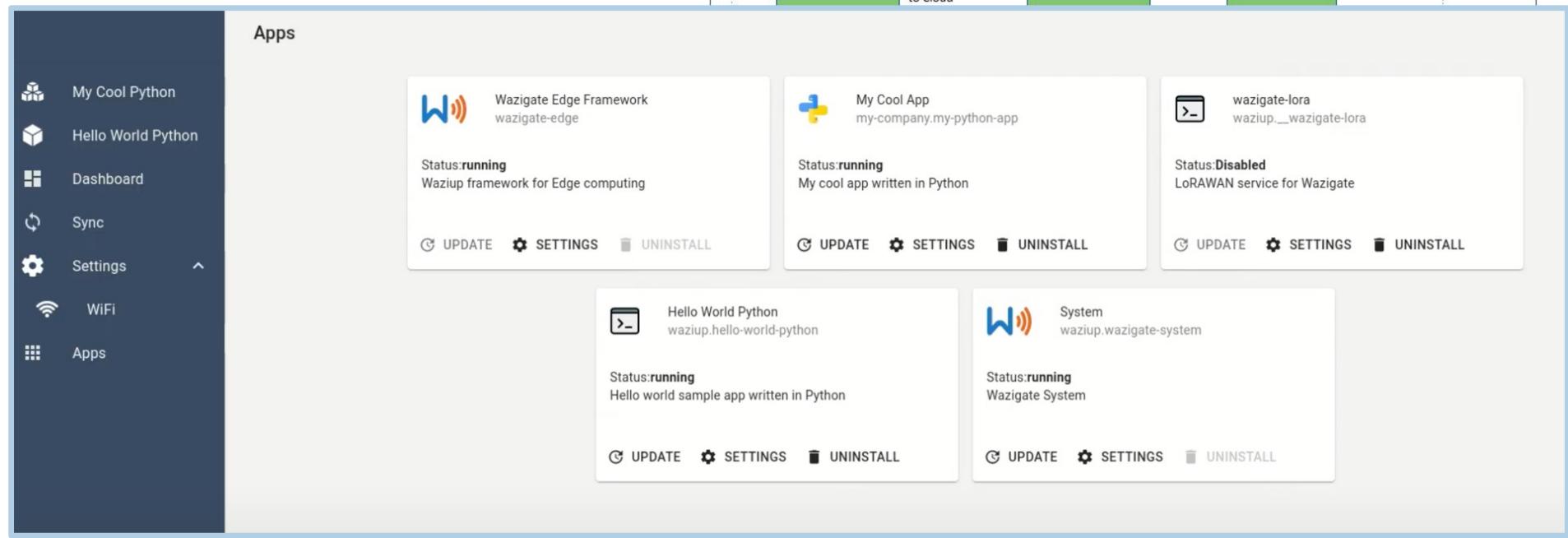
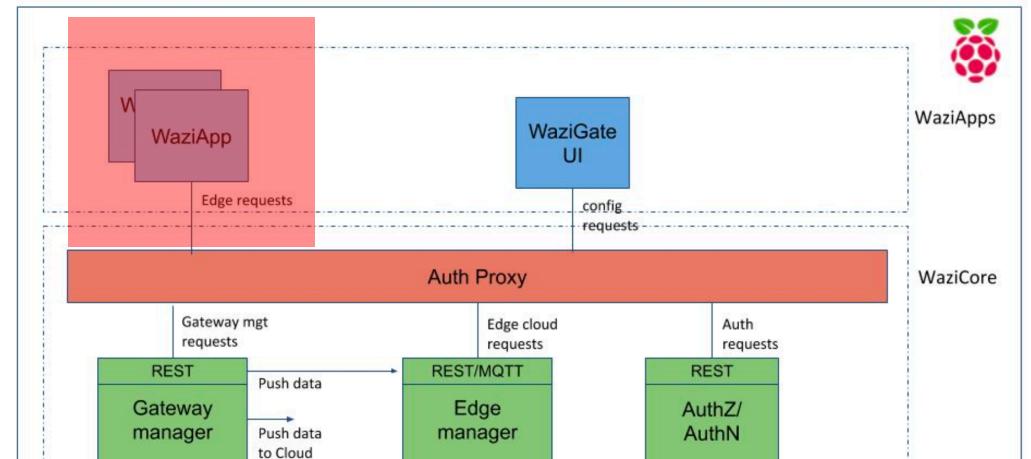
# WaziGate: the versatile IoT gateway

- Raspberry Pi
- Micro-service architecture
- System & User APIs
- Docker-based user apps
- LoRa & LoRaWAN



# WaziApps

- WaziGate supports user-developed applications



# Towards Plug-&-Sense



# Gateway: collect sensor data

WAZIGATE GATEWAY

FULL EDGE-COMPUTING  
 (NO INTERNET)

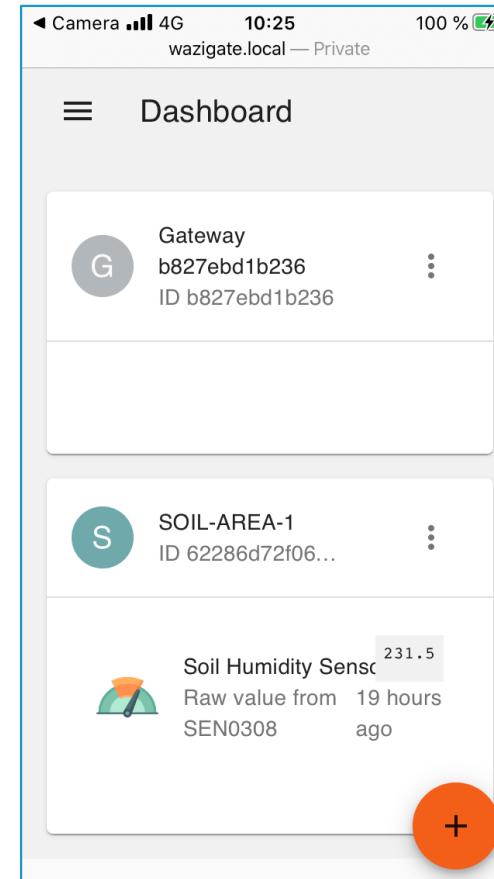
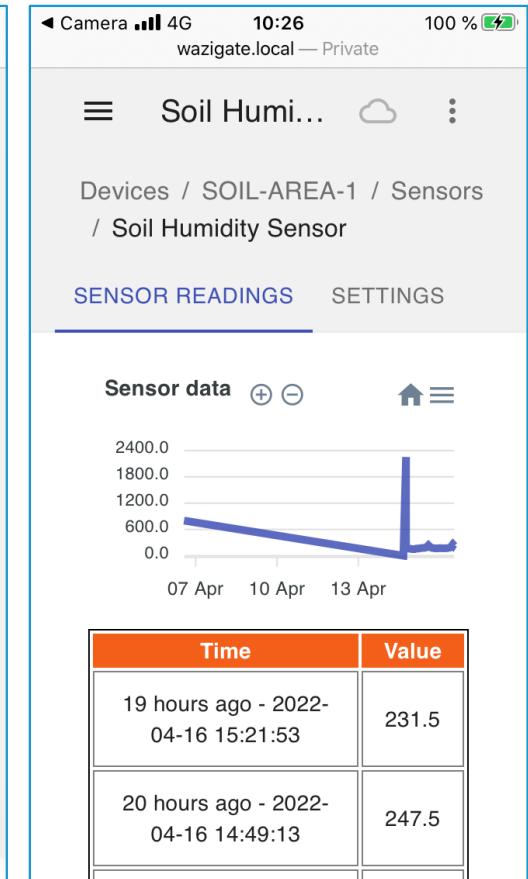
ALL DATA PROCESSING  
 CAN BE DONE LOCALLY



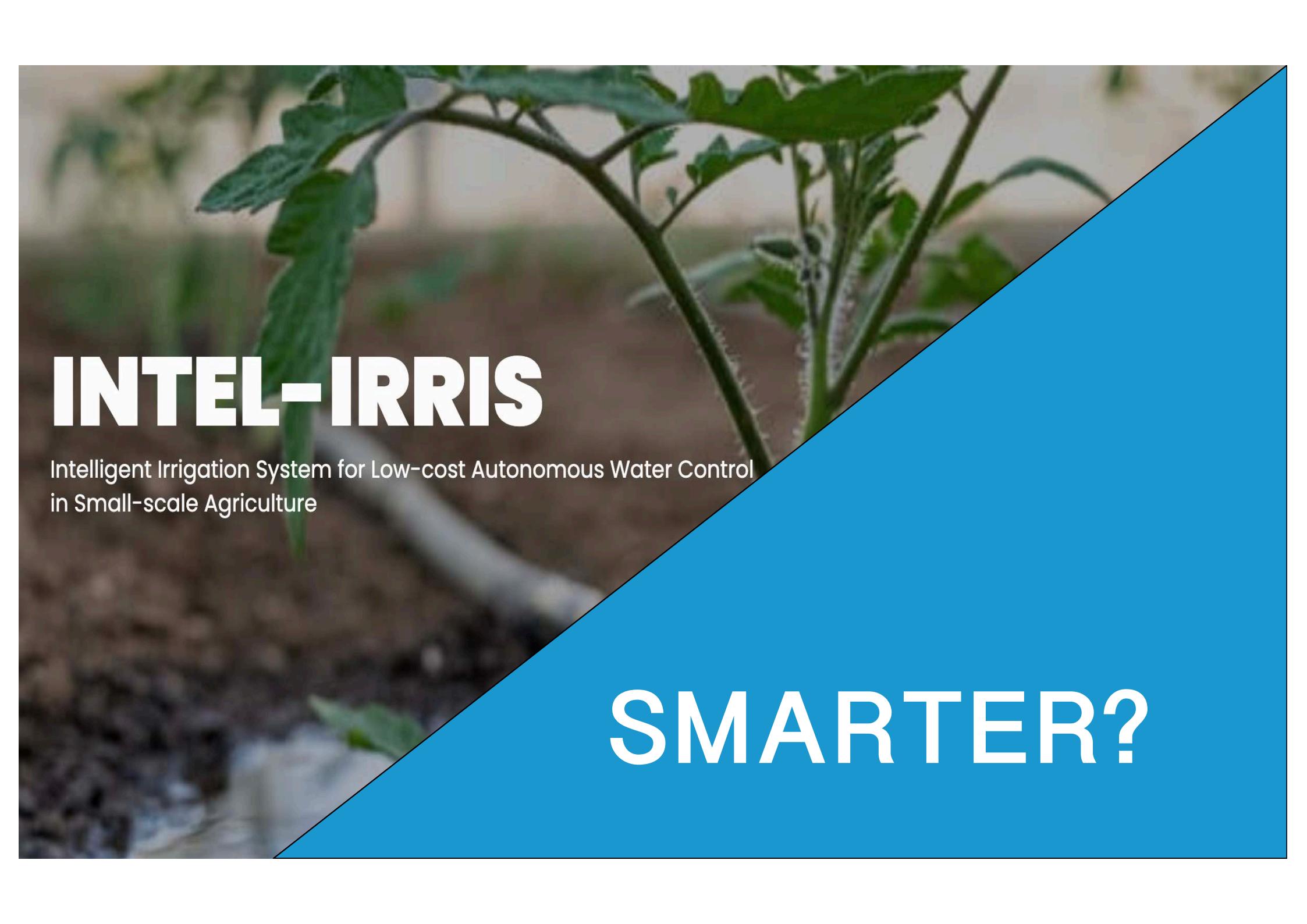
1 GATEWAY HANDLES  
 SEVERAL DEVICES

< 50€

EMBEDDED WEB INTERFACE

EASILY ACCESSED FROM A SMARTPHONE

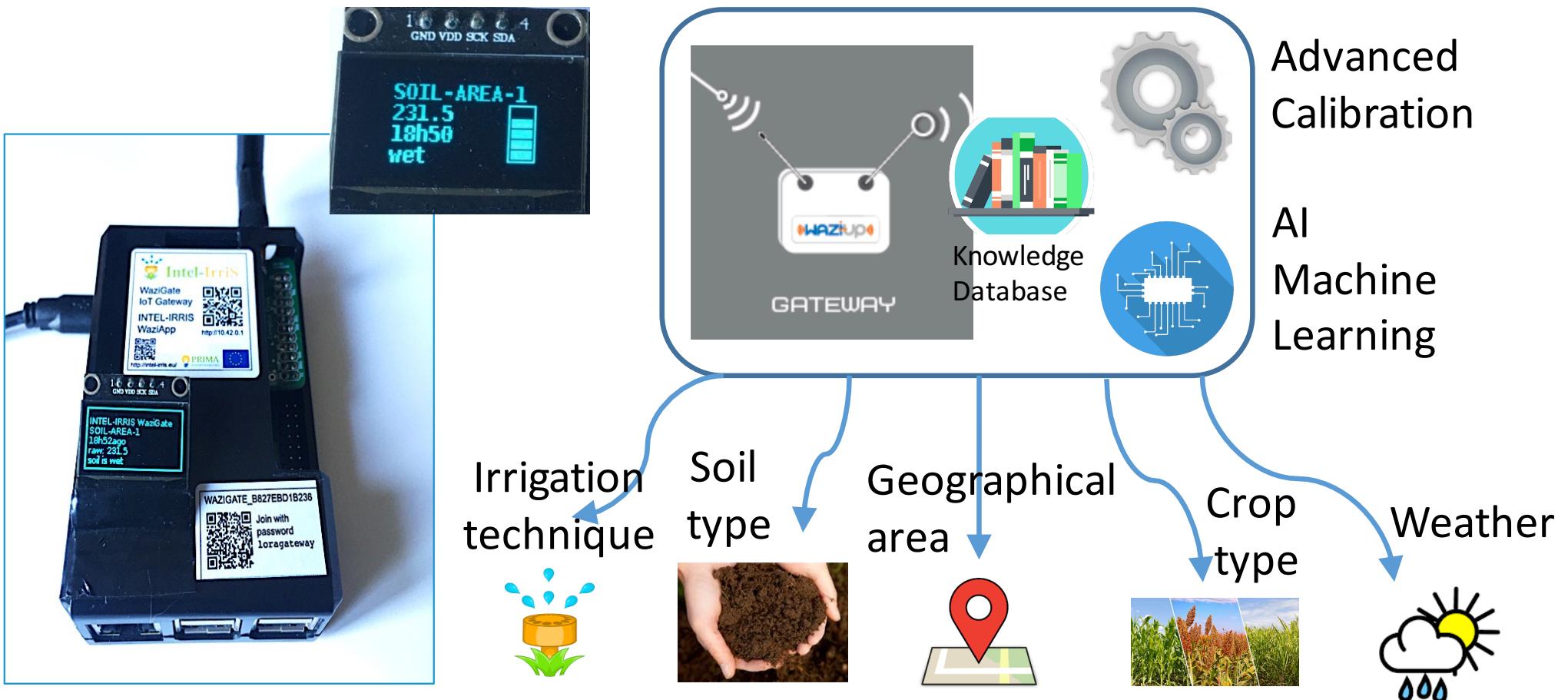
A close-up photograph of a green plant, likely a tomato or similar leafy vegetable, growing in soil. A white, flexible irrigation tube is visible, connected to the plant's stem, suggesting a smart irrigation system. The background is slightly blurred.

# INTEL-IRRIS

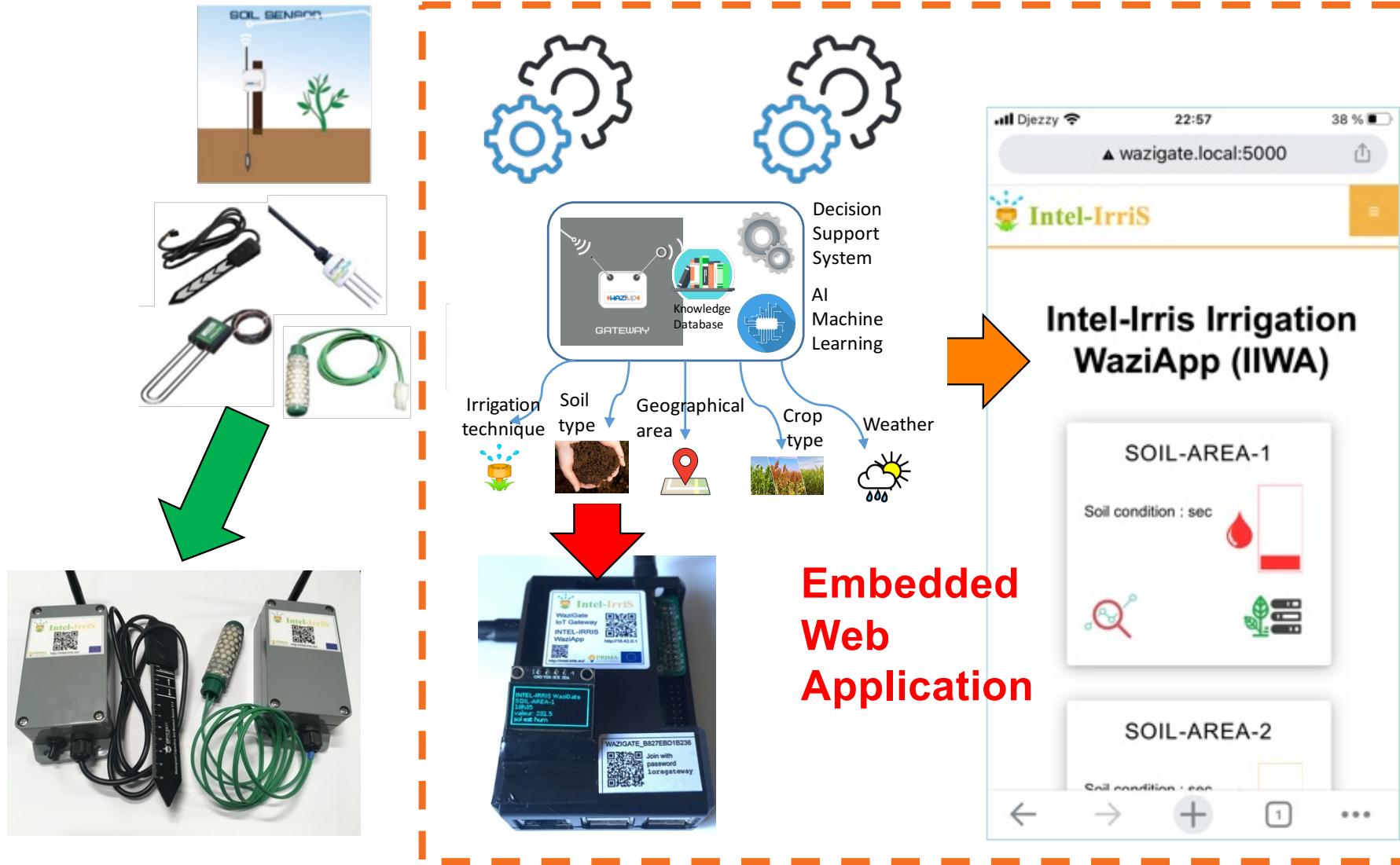
Intelligent Irrigation System for Low-cost Autonomous Water Control  
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SMARTER?

# Added value: embedded intelligence!

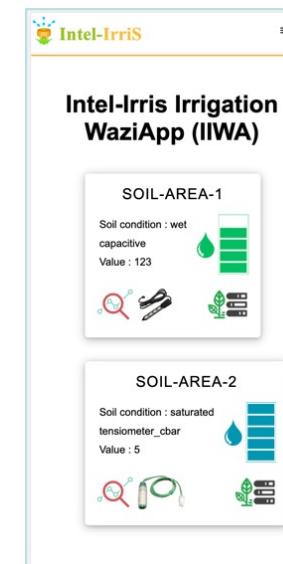


# INTEL-IRRIS: add intelligence



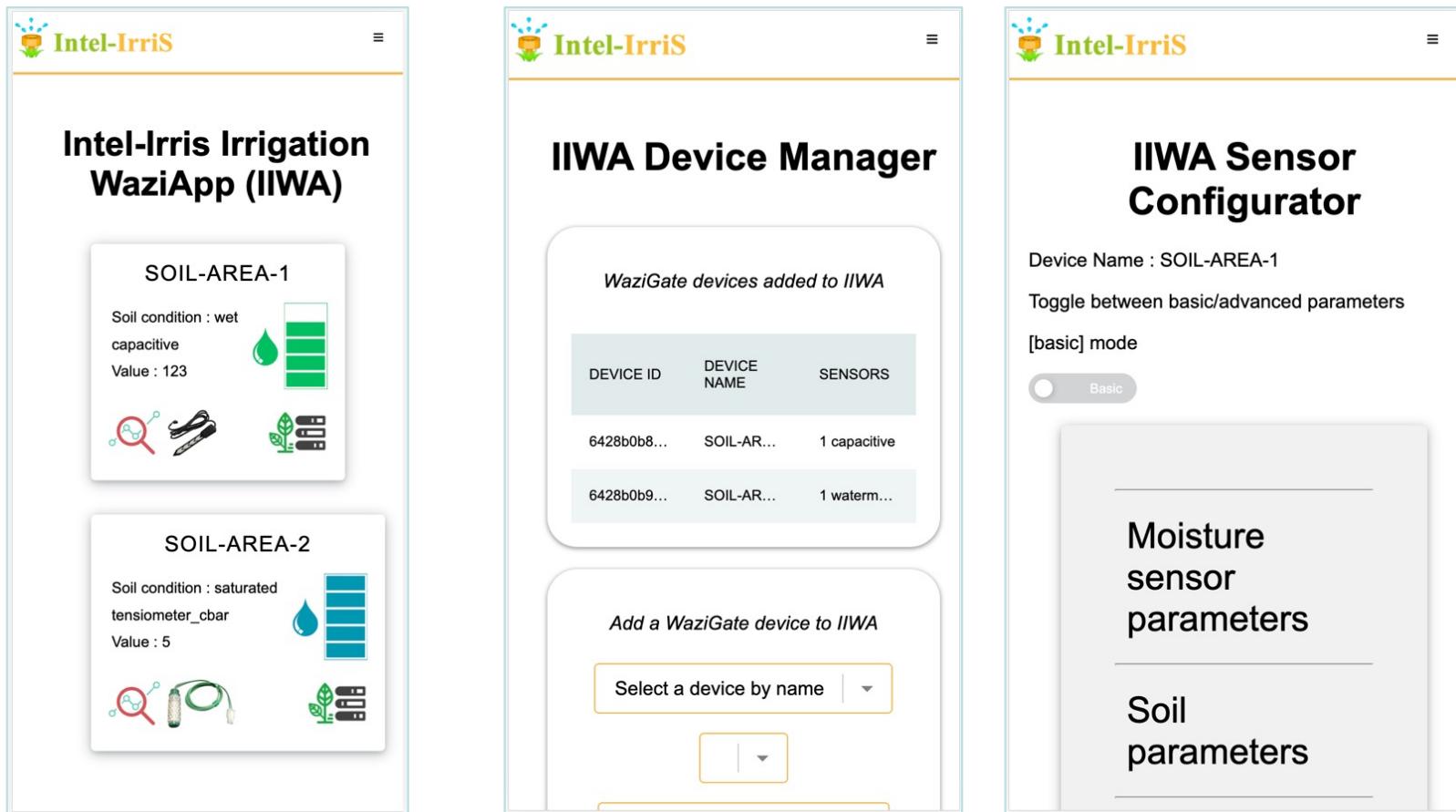
# INTEL-IRRIS Irrigation WaziApp

- The INTEL-IRRIS Irrigation WaziApp (IIWA) is an embedded application running on the INTEL-IRRIS WaziGate itself
- It is included in the starter-kit to implement the "**intelligent Irrigation in-the-box**" & "**plug-&-sense**" approach
- Its objective is to enhance the irrigation indication by applying sensor calibration models with soil/plant/weather parameters



# IIWA main screens

- Dashboard, Device Manager and Sensor Configuration



The figure displays three screenshots of the IIWA mobile application interface:

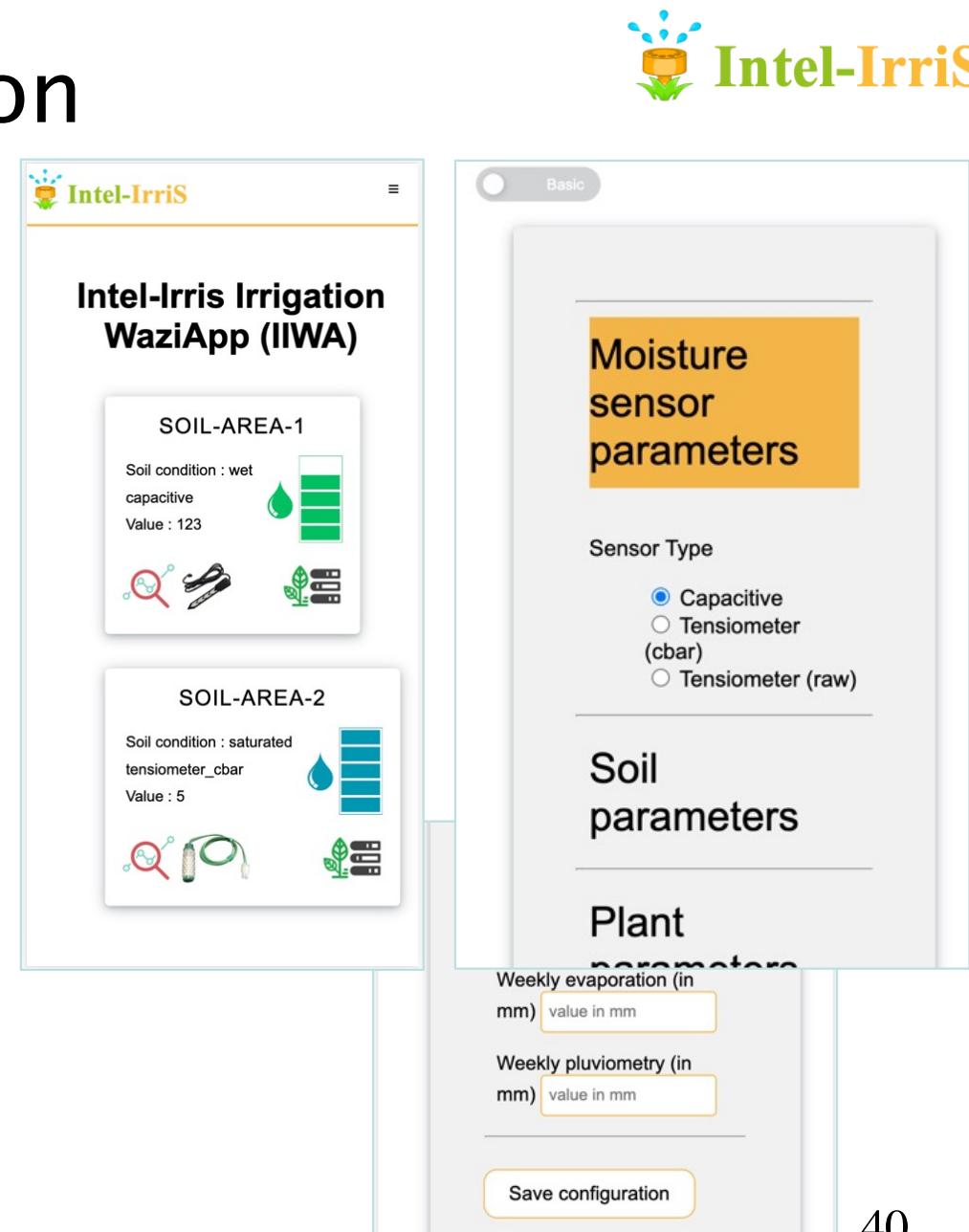
- Dashboard:** Shows two soil moisture monitoring stations.   
 - **SOIL-AREA-1:** Soil condition: wet, capacitive sensor, Value: 123. Icons: magnifying glass over soil, scissor-like tool, water drop, soil block.  
 - **SOIL-AREA-2:** Soil condition: saturated, tensiometer\_cbar, Value: 5. Icons: magnifying glass over soil, green tube, water drop, soil block.
- Device Manager:** Lists WaziGate devices added to IIWA.   

DEVICE ID	DEVICE NAME	SENSORS
6428b0b8...	SOIL-AR...	1 capacitive
6428b0b9...	SOIL-AR...	1 waterm...

 A button at the bottom says "Add a WaziGate device to IIWA".
- IIWA Sensor Configurator:** For Device Name: SOIL-AREA-1.   
 - A toggle switch between "basic" and "advanced" modes is set to "Basic".  
 - A section titled "Moisture sensor parameters" is visible.  
 - A section titled "Soil parameters" is visible.

# Sensor configuration

- To enable IIWA to calibrate the sensor, the minimum information is to provide the sensor type
- From the Dashboard, go to Sensor Configuration (  ) and select the Moisture Sensor Parameter menu
- Then, select "Capacitive" for instance
- Scroll to the bottom and click on "Save configuration"



The screenshot shows the Intel-Irris Irrigation WaziApp (IIWA) interface. At the top, there's a header with the Intel-Irris logo and a 'Basic' button. Below the header, there are two sections for 'SOIL-AREA-1' and 'SOIL-AREA-2'. Each section displays the soil condition, sensor type, value, and icons for edit and save. A large orange box labeled 'Moisture sensor parameters' covers the bottom right. It includes a 'Sensor Type' section with three radio buttons: 'Capacitive' (selected), 'Tensiometer (cbar)', and 'Tensiometer (raw)'. Below this are sections for 'Soil parameters' and 'Plant parameters', each with input fields for 'Weekly evaporation (in mm)' and 'Weekly pluviometry (in mm)'. A 'Save configuration' button is at the bottom.

# Advanced parameters

Basic

More parameters will be integrated in IIWA during the project

## Moisture sensor parameters

### Sensor Type

- Capacitive
- Tensiometer (cbar)
- Tensiometer (raw)

## Soil parameters

## Plant parameters

## Moisture sensor parameters

## Soil parameters

### Soil Type

### Soil Irrigation Type

- Submersion
- Furrow
- Sprinkler
- Drip
- Subirrigation

## Moisture sensor parameters

## Plant parameters

### Plant type

### Planting Date

## Moisture sensor parameters

## Weather parameters

### Region



Advanced

## Moisture sensor parameters

### Sensor age

### Maximum sensor value

### Minimum sensor value

## Soil parameters

## Moisture sensor parameters

## Soil parameters

### Soil Salinity

### Soil Bulk Density

### Soil Field Capacity

## Moisture sensor parameters

## Plant parameters

### Plant category

### Plant Variety

## Moisture sensor parameters

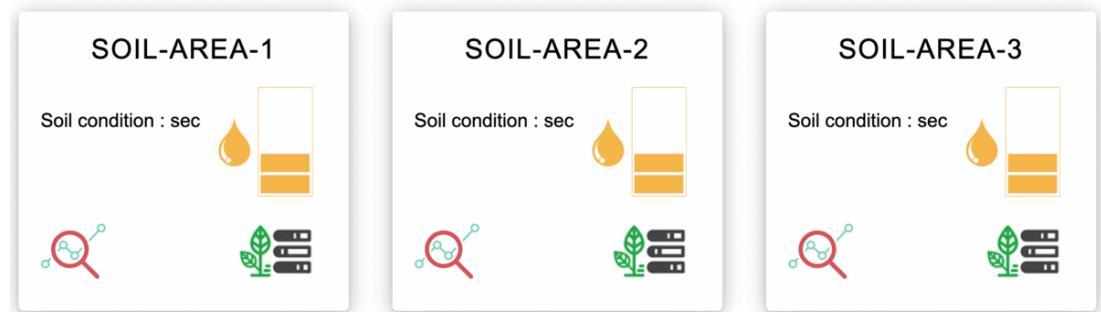
## Weather parameters

### Weekly evaporation (in mm) value in mm

### Weekly pluviometry (in mm) value in mm

# First IIWA demo at Mostaganem event

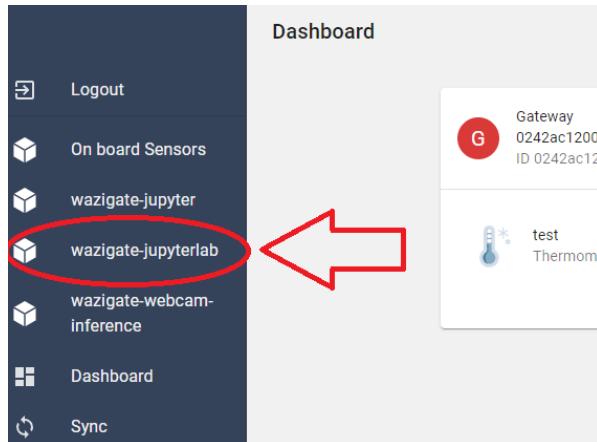
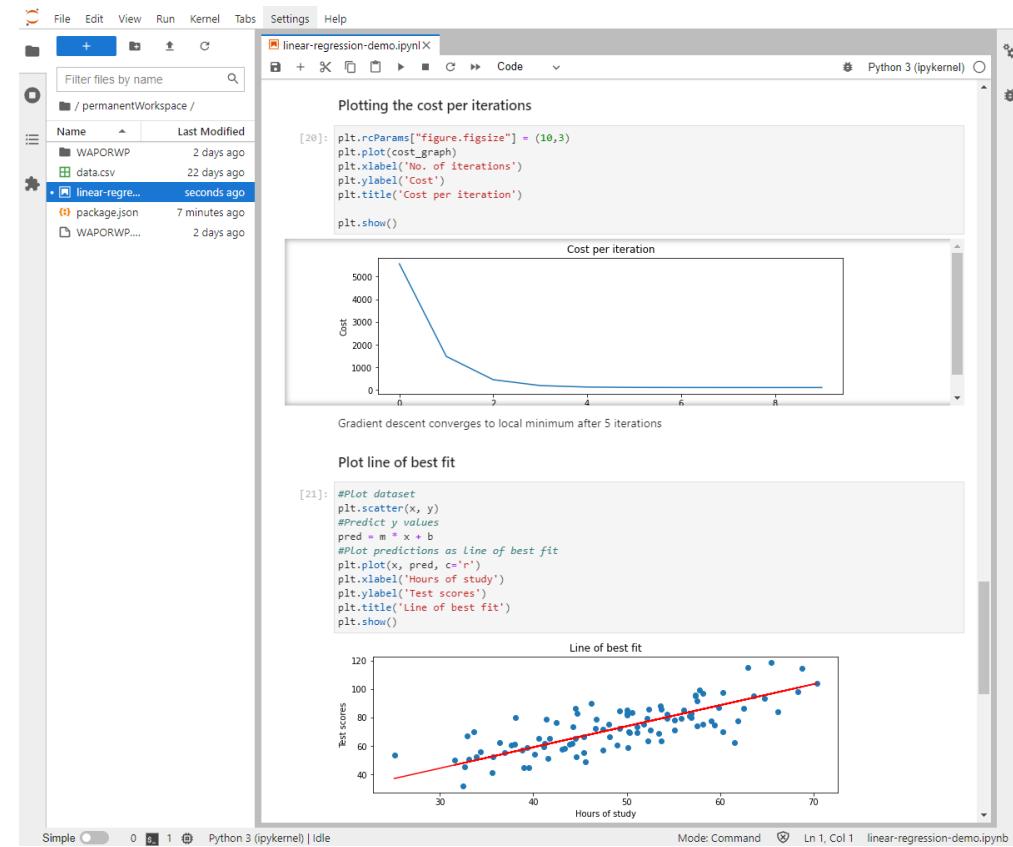
- March 7th, 2023
- Real-time demo of soil sensor + IIWA



<https://intel-irris.eu/presentation-of-intel-irris-starter-kit-for-smallholder-farmers-in-mostaganem-algerie>

# AI, Machine Learning

- WaziApps – Jupyterlab
- Available languages: Markdown, Python, R, LaTeX, ...

The screenshot shows a JupyterLab session with two code cells and their corresponding plots.

```
[20]: plt.rcParams["figure.figsize"] = (10,3)
plt.plot(cost_graph)
plt.xlabel('No. of iterations')
plt.ylabel('Cost')
plt.title('Cost per iteration')

plt.show()
```

Plotting the cost per iterations

Cost per iteration

Gradient descent converges to local minimum after 5 iterations

```
[21]: #Plot dataset
plt.scatter(x, y)
#Predict y values
pred = m * x + b
#Plot predictions as line of best fit
plt.plot(x, pred, c='r')
plt.xlabel('Hours of study')
plt.ylabel('Test scores')
plt.title('Line of best fit')
plt.show()
```

Plot line of best fit

Line of best fit

Hours of study

Test scores

Mode: Command

Ln 1, Col 1 linear-regression-demo.ipynb

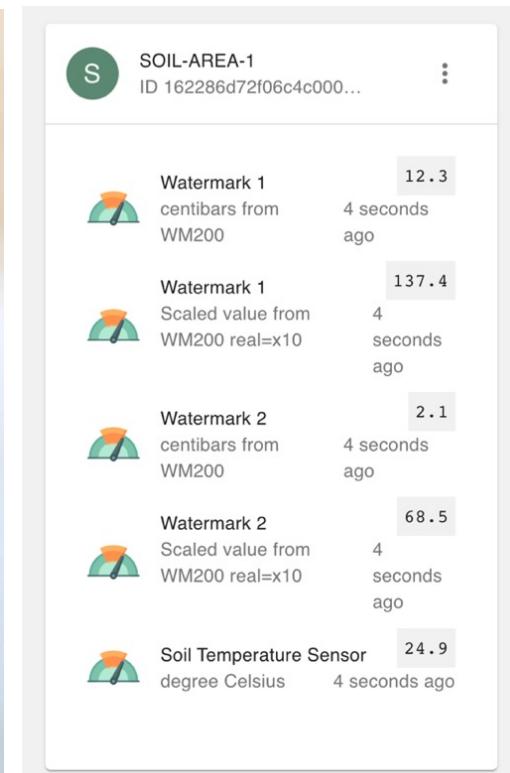
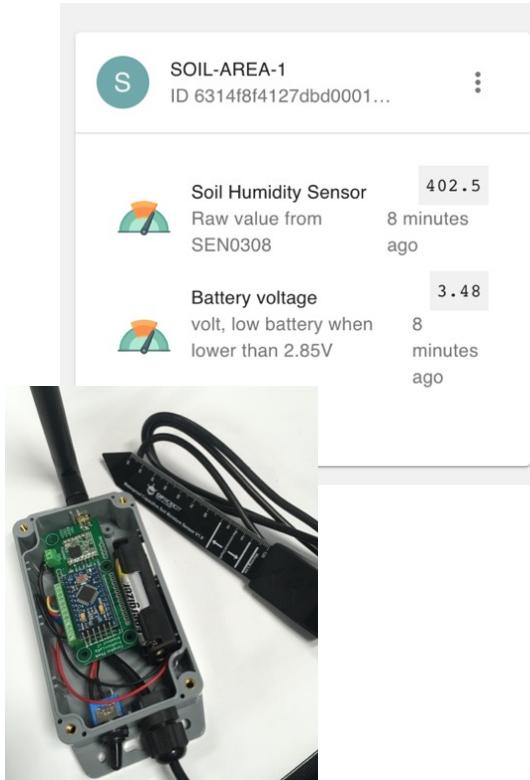
# And dataset?

- AI and Machine Learning need datasets!
- The INTEL-IRRIS starter-kit will be installed in "promiscuous" mode to build datasets
- Controlled environments
  - tests campaign with INTEL-IRRIS agricultural partners
  - AUA, INRA, IRD, UMAB
- Smallholder Piloting Program
  - Test campaign with pilot farms & smallholders
  - Participatory approach to co-design & test the innovative solutions in fields
  - Take into account region-dependent technical, agricultural, social, climatic and environmental aspects



# Experimental devices for datasets

- The datasets campaign will use 2 soil device versions
  - A soil device with 1 capacitive sensor
  - A soil device with 2 watermark sensors + 1 temperature sensor



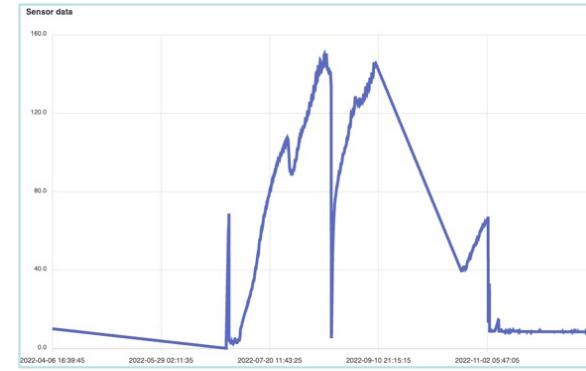
# From raw data to dataset (1)

**S** SOIL-AREA-1  
 ID 63a7191a68f3190886...

- Soil Humidity Sensor 106  
 Raw value from SEN0308 6 months ago
- Soil Temperature Sensor -99  
 degree Celsius 14 hours ago
- Battery voltage 3.35  
 volt, low battery when lower than 2.85V 6 months ago

**S** SOIL-AREA-2  
 ID 63a71aa368f3190886...

- Soil Humidity Sensor 8.4  
 centibars from WM200 6 months ago
- Soil Humidity Sensor 104.4  
 scaled value from WM200 real=x10 6 months ago
- Soil Temperature Sensor 9.2  
 degree Celsius 6 months ago
- Battery voltage 2.82  
 volt, low battery when lower than 2.85V 6 months ago



# From raw data to dataset (2)

	A	B	C	D	E	F
1	63a7191a68f3190886639cc7	temperatureSensor_0	63a7191a68f3190886639cc7	temperatureSensor_5	63a7191a68f3190886639cc7	analogInput_6
2	SOIL-AREA-1	Soil Humidity Sensor / Raw value	SOIL-AREA-1	Soil Temperature Sensor / degree	SOIL-AREA-1	Battery voltage / volt, low battery
3	2022-04-06T16:39:45+02:00	800	2023-06-27T08:00:00+02:00	-99	2022-08-20T15:25:37+02:00	3.27
4	2022-06-29T11:40:04+02:00	0			2022-08-20T15:26:57+02:00	3.54
5	2022-06-29T11:46:49+02:00	64.5			2022-08-20T15:40:39+02:00	3.26
6	2022-06-29T12:19:20+02:00	66			2022-08-20T15:41:42+02:00	3.37
7	2022-06-29T12:51:48+02:00	67.5			2022-08-20T15:42:03+02:00	3.66
8	2022-06-29T13:24:18+02:00	67.5			2022-08-20T16:47:24+02:00	3.68
9	2022-06-29T13:56:47+02:00	68			2022-08-20T17:53:18+02:00	3.68
10	2022-06-29T14:29:17+02:00	67			2022-08-20T18:58:49+02:00	3.67
11	2022-06-29T15:01:47+02:00	68			2022-08-20T20:04:03+02:00	3.67
12	2022-06-29T15:34:17+02:00	70			2022-08-20T21:09:13+02:00	3.67
13	2022-06-29T16:06:47+02:00	70			2022-08-20T22:14:19+02:00	3.66
14	2022-06-29T16:39:16+02:00	70			2022-08-20T23:19:21+02:00	3.66
15	2022-06-29T17:11:45+02:00	68			2022-08-21T00:24:19+02:00	3.66
16	2022-06-29T17:44:15+02:00	68			2022-08-21T01:29:14+02:00	3.66
17	2022-06-29T18:16:46+02:00	67			2022-08-21T02:34:09+02:00	3.65
18	2022-06-29T18:49:14+02:00	65			2022-08-21T03:39:02+02:00	3.65
19	2022-06-29T19:21:41+02:00	63.5			2022-08-21T04:43:57+02:00	3.65
20	2022-06-29T19:54:08+02:00	62			2022-08-21T05:48:52+02:00	3.65
21	2022-06-29T20:26:36+02:00	61			2022-08-21T06:53:47+02:00	3.65
22	2022-06-29T20:59:00+02:00	60			2022-08-21T07:58:43+02:00	3.65
23	2022-06-29T21:31:25+02:00	59.5			2022-08-21T09:03:41+02:00	3.65
24	2022-06-29T22:03:50+02:00	57			2022-08-21T10:08:41+02:00	3.66
25	2022-06-29T22:36:13+02:00	56			2022-08-21T11:13:44+02:00	3.66
26	2022-06-29T23:08:36+02:00	43			2022-08-21T12:18:55+02:00	3.67
27	2022-06-29T23:40:58+02:00	24			2022-08-21T13:24:07+02:00	3.67
28	2022-06-30T01:13:21+02:00	22.5			2022-08-21T14:29:18+02:00	3.67
29	2022-06-30T00:45:43+02:00	23.5			2022-08-21T15:34:32+02:00	3.67
30	2022-06-30T01:18:04+02:00	23.5			2022-08-21T16:39:51+02:00	3.67
31	2022-06-30T01:50:26+02:00	23.5			2022-08-21T17:45:28+02:00	3.68
32	2022-06-30T02:55:09+02:00	18			2022-08-21T18:50:46+02:00	3.67
33	2022-06-30T03:27:31+02:00	16			2022-08-21T19:55:54+02:00	3.66
34	2022-06-30T03:59:51+02:00	15			2022-08-21T21:00:57+02:00	3.66
35	2022-06-30T05:04:33+02:00	16			2022-08-21T22:05:56+02:00	3.66
36	2022-06-30T05:36:53+02:00	14			2022-08-21T23:10:54+02:00	3.65
37	2022-06-30T06:09:14+02:00	9			2022-08-22T00:15:48+02:00	3.65
38	2022-06-30T06:41:34+02:00	9.5			2022-08-22T01:20:40+02:00	3.65



The screenshot shows the WaziGate software interface with a navigation bar at the top. The 'Maintenance' tab is selected. Below it, there are several options: 'Ethernet Network', 'Containers', 'SSH', 'Logs', and 'Export gateway data'. The 'IP address' field is highlighted with the value '192.168.3.11'. A 'Gateway Clock' section is also visible.

WaziGate can export data of all devices & sensors into one global .csv file or into a tree of .csv files

# From raw data to dataset (3)

	G	H	I	J	K	L	M	N
1	63a71aa368f319088663dc85	temperatureSensor_0	63a71aa368f319088663dc85	temperatureSensor_1	63a71aa368f319088663dc85	temperatureSensor_5	63a71aa368f319088663dc85	analogInput_6
2	SOIL-AREA-2	Soil Humidity Sensor / centibars f SOIL-AREA-2		Soil Humidity Sensor / scaled valu SOIL-AREA-2		Soil Temperature Sensor / degree SOIL-AREA-2		Battery voltage / volt, low battery
3	2022-04-06T16:39:45+02:00		10	2022-04-06T16:39:45+02:00	550	2022-04-06T16:39:45+02:00	24	2022-08-20T15:27:20+02:00
4	2022-06-29T11:40:05+02:00		0	2022-06-29T11:40:05+02:00	0	2022-06-29T11:42:19+02:00	22.5	2022-08-20T15:27:48+02:00
5	2022-06-29T11:42:18+02:00		1.8	2022-06-29T11:42:18+02:00	67.1	2022-06-29T11:58:40+02:00	22.8	2022-08-20T15:39:42+02:00
6	2022-06-29T11:58:40+02:00		3.9	2022-06-29T11:58:40+02:00	76.1	2022-06-30T13:42:23+02:00	22.3	2022-08-20T15:40:22+02:00
7	2022-06-30T13:41:33+02:00		61.2	2022-06-30T13:41:33+02:00	874.4	2022-06-30T18:54:46+02:00	21.6	2022-08-20T16:43:08+02:00
8	2022-06-30T13:42:23+02:00		51.4	2022-06-30T13:42:23+02:00	873	2022-06-30T19:11:18+02:00	18	2022-08-20T17:45:18+02:00
9	2022-06-30T18:54:46+02:00		68.8	2022-06-30T18:54:46+02:00	1159.6	2022-06-30T20:12:42+02:00	17.9	2022-08-20T18:47:14+02:00
10	2022-06-30T19:11:18+02:00		9.5	2022-06-30T19:11:18+02:00	100	2022-06-30T21:14:02+02:00	17.8	2022-08-20T19:48:51+02:00
11	2022-06-30T20:12:42+02:00		3.9	2022-06-30T20:12:42+02:00	75.8	2022-06-30T22:15:22+02:00	17.7	2022-08-20T20:50:25+02:00
12	2022-06-30T21:14:02+02:00		4	2022-06-30T21:14:02+02:00	76.3	2022-06-30T23:16:37+02:00	17.5	2022-08-20T21:51:55+02:00
13	2022-06-30T22:15:21+02:00		3.9	2022-06-30T22:15:22+02:00	75.8	2022-07-01T00:17:53+02:00	17.3	2022-08-20T22:53:22+02:00
14	2022-06-30T23:16:37+02:00		3.9	2022-06-30T23:16:37+02:00	75.8	2022-07-01T01:19:08+02:00	17.1	2022-08-20T23:54:46+02:00
15	2022-07-01T00:17:53+02:00		3.9	2022-07-01T00:17:53+02:00	75.8	2022-07-01T02:20:22+02:00	16.9	2022-08-21T00:56:07+02:00
16	2022-07-01T01:19:08+02:00		3.9	2022-07-01T01:19:08+02:00	75.8	2022-07-01T03:21:34+02:00	16.7	2022-08-21T01:57:26+02:00
17	2022-07-01T02:20:22+02:00		3.9	2022-07-01T02:20:22+02:00	75.9	2022-07-01T04:22:45+02:00	16.5	2022-08-21T02:58:43+02:00
18	2022-07-01T03:21:34+02:00		3.9	2022-07-01T03:21:34+02:00	75.9	2022-07-01T05:23:56+02:00	16.2	2022-08-21T04:00:01+02:00
19	2022-07-01T04:22:45+02:00		3.7	2022-07-01T04:22:45+02:00	75	2022-07-01T06:25:07+02:00	16	2022-08-21T05:01:20+02:00
20	2022-07-01T05:23:56+02:00		3.7	2022-07-01T05:23:56+02:00	75	2022-07-01T07:26:18+02:00	15.8	2022-08-21T06:02:38+02:00
21	2022-07-01T06:25:07+02:00		3.7	2022-07-01T06:25:07+02:00	75	2022-07-01T08:27:33+02:00	15.8	2022-08-21T07:03:57+02:00
22	2022-07-01T07:26:18+02:00		3.8	2022-07-01T07:26:18+02:00	75.1	2022-07-01T09:28:51+02:00	15.9	2022-08-21T08:05:16+02:00
23	2022-07-01T08:27:33+02:00		3.2	2022-07-01T08:27:33+02:00	72.9	2022-07-01T10:30:15+02:00	16.2	2022-08-21T09:06:36+02:00
24	2022-07-01T09:28:51+02:00		3.5	2022-07-01T09:28:51+02:00	73.9	2022-07-01T11:31:43+02:00	16.5	2022-08-21T10:07:58+02:00
25	2022-07-01T10:30:14+02:00		3.5	2022-07-01T10:30:15+02:00	74	2022-07-01T12:33:15+02:00	17	2022-08-21T11:09:23+02:00
26	2022-07-01T11:31:43+02:00		3.5	2022-07-01T11:31:43+02:00	73.9	2022-07-01T13:34:51+02:00	17.3	2022-08-21T12:10:53+02:00
27	2022-07-01T12:33:16+02:00		3.2	2022-07-01T12:33:15+02:00	73	2022-07-01T14:36:30+02:00	17.7	2022-08-21T13:12:26+02:00
28	2022-07-01T13:34:51+02:00		3	2022-07-01T13:34:51+02:00	71.9	2022-07-01T15:38:12+02:00	18.5	2022-08-21T14:13:59+02:00
29	2022-07-01T14:36:30+02:00		3	2022-07-01T14:36:30+02:00	71.9	2022-07-01T16:39:57+02:00	18.9	2022-08-21T15:15:33+02:00
30	2022-07-01T15:38:12+02:00		2.9	2022-07-01T15:38:12+02:00	71.8	2022-07-01T17:41:48+02:00	19.6	2022-08-21T16:17:12+02:00
31	2022-07-01T16:39:57+02:00		2.9	2022-07-01T16:39:57+02:00	71.7	2022-07-01T18:43:32+02:00	20	2022-08-21T17:18:59+02:00
32	2022-07-01T17:41:48+02:00		2.7	2022-07-01T17:41:48+02:00	70.7	2022-07-01T20:46:39+02:00	19.3	2022-08-21T18:20:52+02:00
33	2022-07-01T18:43:32+02:00		2.7	2022-07-01T18:43:32+02:00	70.7	2022-07-01T21:48:08+02:00	19	2022-08-21T19:22:25+02:00
34	2022-07-01T20:46:39+02:00		2.9	2022-07-01T20:46:39+02:00	71.8	2022-07-01T22:49:33+02:00	18.7	2022-08-21T20:23:54+02:00
35	2022-07-01T21:48:08+02:00		2.9	2022-07-01T21:48:08+02:00	71.8	2022-07-01T23:50:54+02:00	18.5	2022-08-21T21:25:19+02:00
36	2022-07-01T22:49:33+02:00		2.9	2022-07-01T22:49:33+02:00	71.8	2022-07-02T00:52:13+02:00	18.2	2022-08-21T22:26:42+02:00
37	2022-07-01T23:50:54+02:00		3.1	2022-07-01T23:50:54+02:00	72.4	2022-07-02T01:53:31+02:00	18	2022-08-21T23:28:02+02:00
38	2022-07-02T00:52:13+02:00		3.2	2022-07-02T00:52:13+02:00	72.9	2022-07-02T02:54:47+02:00	17.8	2022-08-22T00:29:21+02:00



Converted in centibars

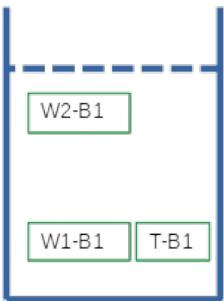


Raw resistance value



# Tests in controlled environment

2WT B1:  
SOIL-AREA-1



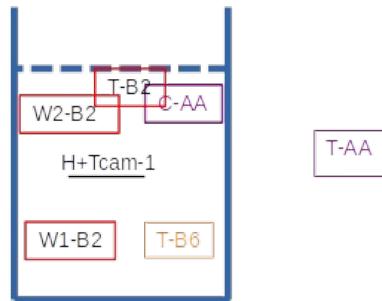
Bucket B1  
Soil S1

Soil S1: sand 100%  
Soil S2: AUA soil  
Soil S3: Mix AUA+sand

2WT B2:  
SOIL-AREA-2

Campbell 1

CT AA:  
SOIL-AREA-4



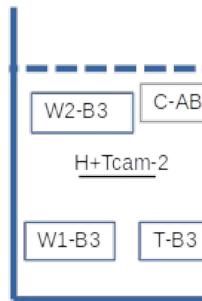
Bucket B2  
Soil S2

Greenhouse monitoring sensors:  
Ambient Temperature  
Ambient Humidity  
Ultra Violet

2WT B3:  
SOIL-AREA-3

Campbell 2

C AB:  
SOIL-AREA-5

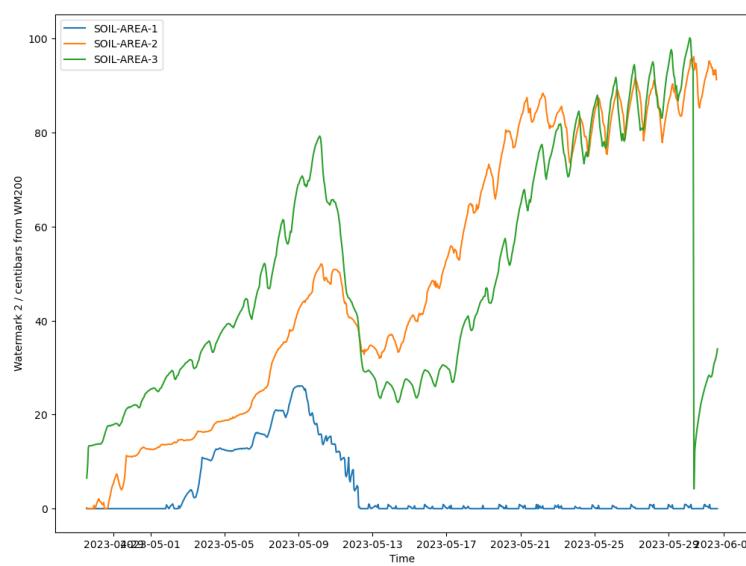
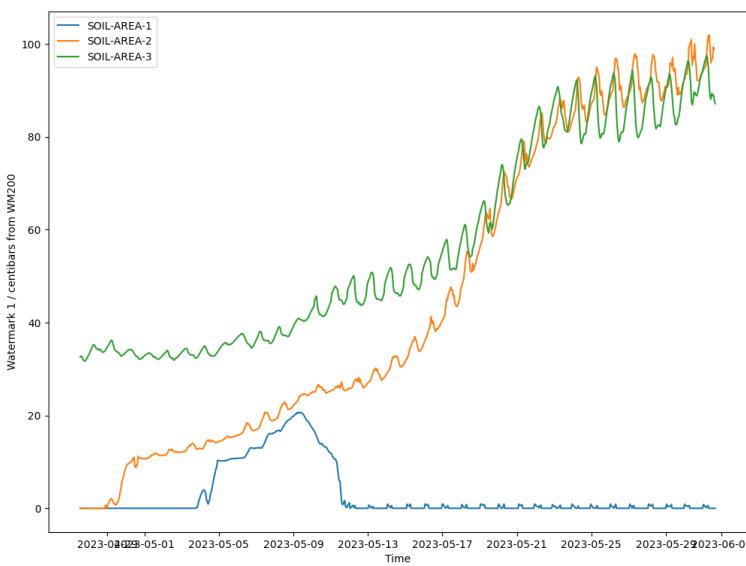
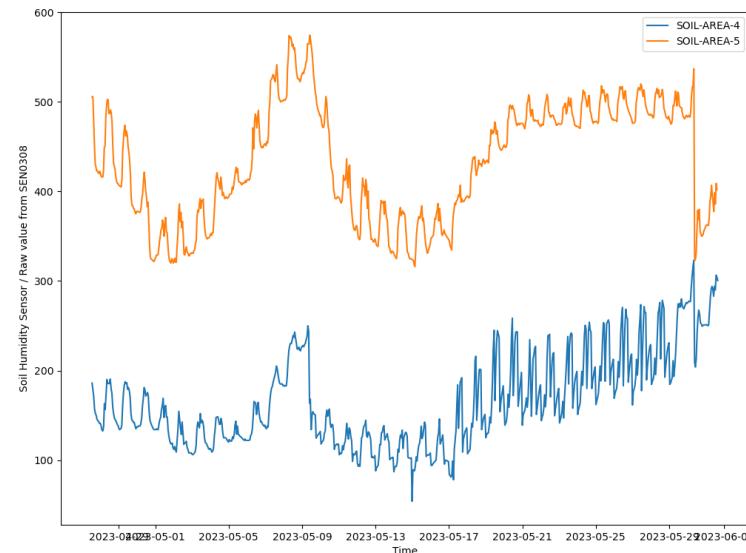
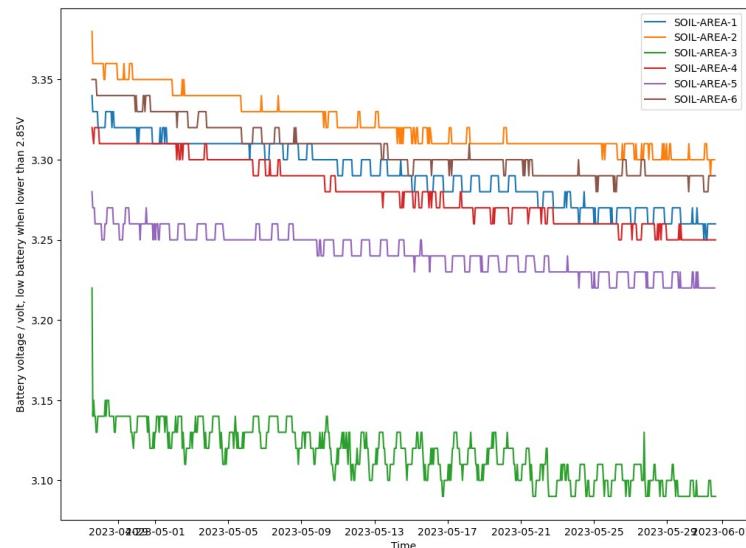


Bucket B3  
Soil S3

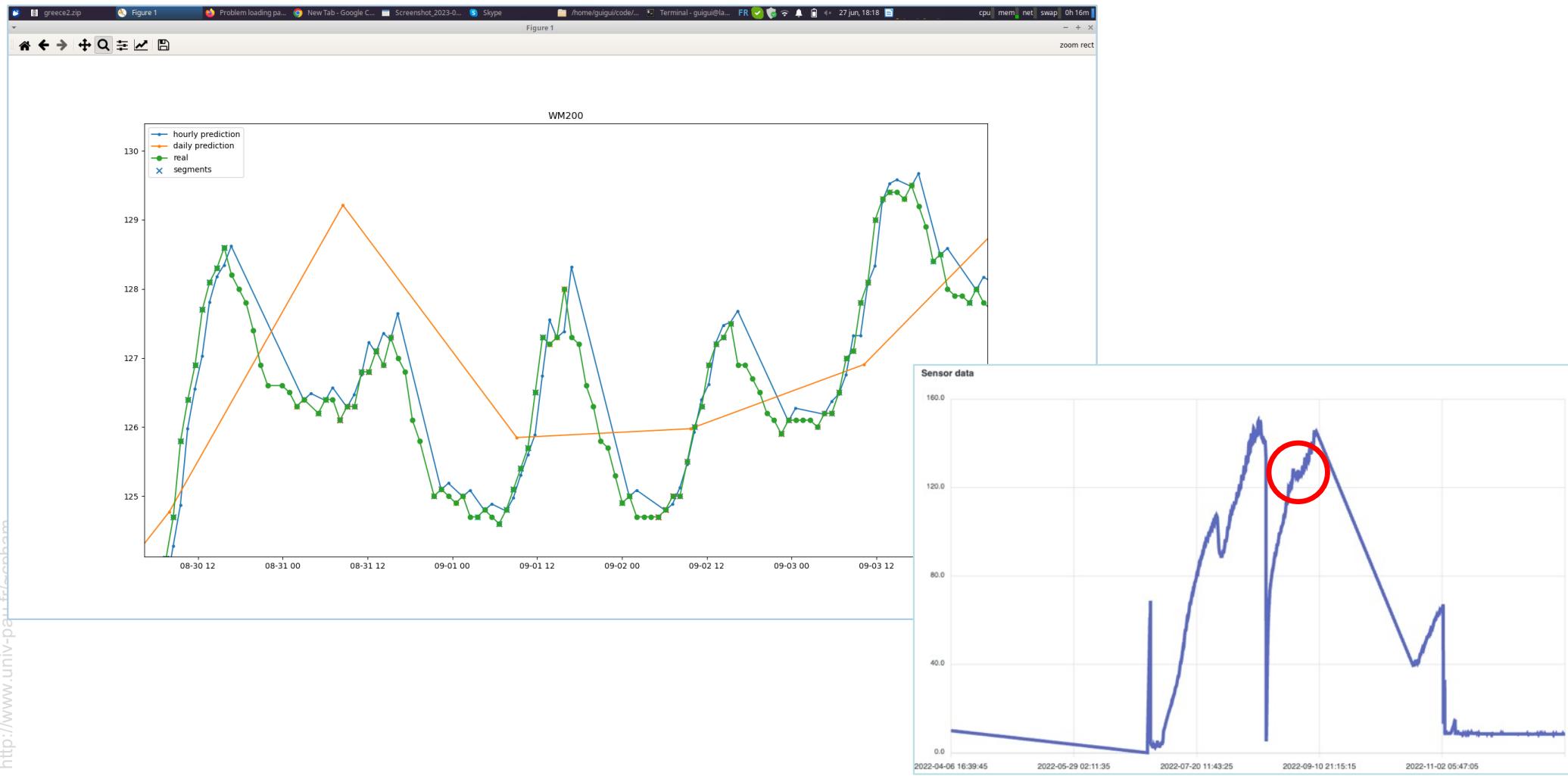
AUA is testing the INTEL-IRRIS starter-kit for monitoring soil evolution in controlled environment with known irrigation cycles



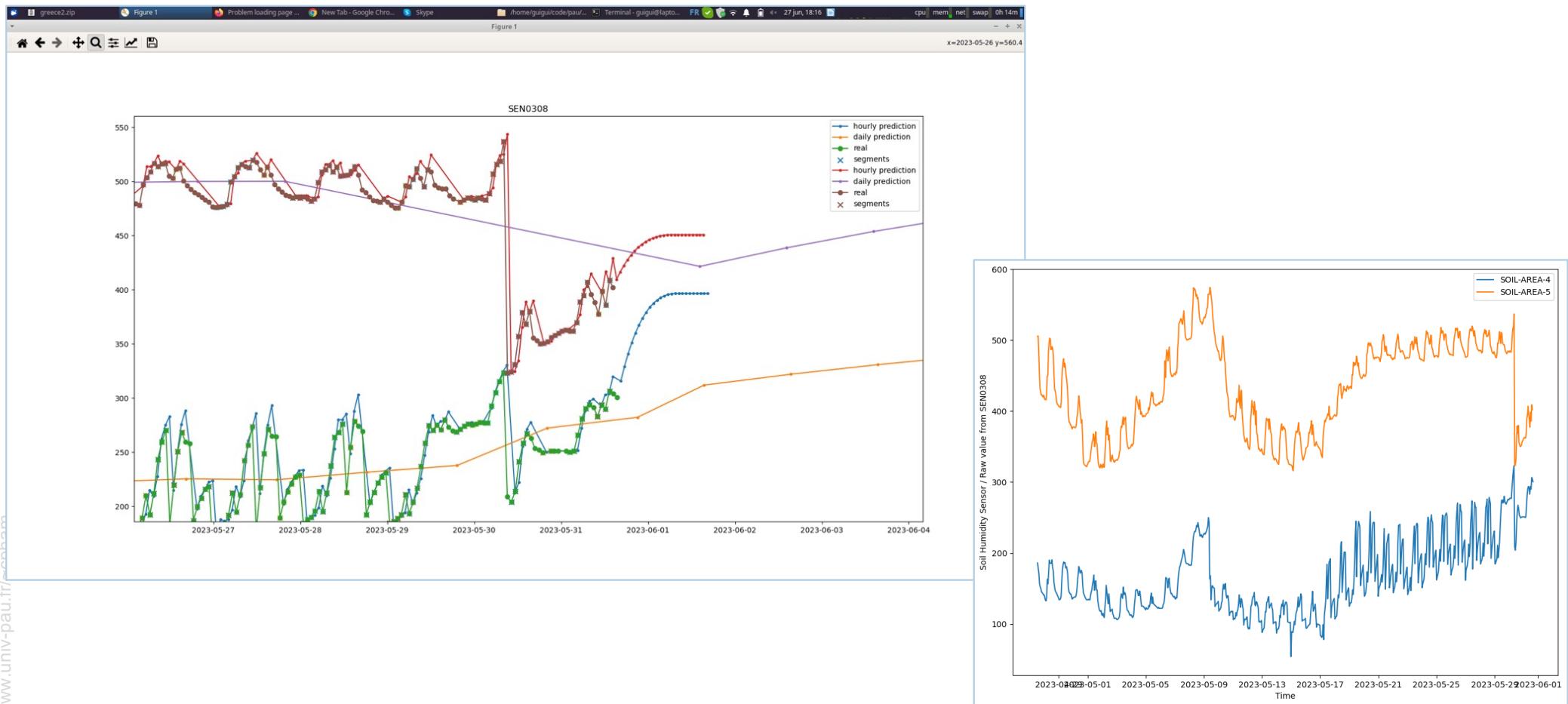
# Building graphs



# Prediction of soil humidity (1)?



# Prediction of soil humidity (2)?



# Going farther with AI?

- Digital platforms & AI for smart agriculture from AUA
  - SHERPA repository. SHERPA repository is a compilation of research outputs and findings from past and on-going projects related to rural areas. <https://sherpa-repository.eu/home>
  - FAIRshare. Digital Tools for Farm Advisors. Browse through the collection of Digital Advisory Tools and Services.  
<https://www.h2020fairshare.eu/>
  - EU FarmBook. A collection of vetted best practices for farmers & foresters. <https://www.eufarmbook.eu/>
  - Eden Library. Enabling AI in agrifood. <https://edenlibrary.ai/>

# Eden Library



- Spin-off company of the Agricultural University of Athens
  - Over 100K photos on the edenlibrary.ai platform with different infestation scenarios
  - Team of expert agronomists, engineers and developers
  - Specialized knowledge in precision agriculture and artificial intelligence applications
- Eden Library – datasets
  - An industry-leading platform, which hosts thousands of expert-annotated datasets for smart agriculture tasks
  - Collected under real field conditions
  - Annotated images with metadata about **diseases, weeds, pests or nutrition deficiencies**



# Not only the cost barrier...



**High acceptability  
of technologies,  
even complex ones**



**Very low acceptability  
of technologies  
because too complex!**

A close-up photograph of a young green plant with large, serrated leaves growing in dark brown soil. The plant has a central stem with several branches and leaves. The background is slightly blurred.

# INTEL-IRRIS

Intelligent Irrigation System for Low-cost Autonomous Water Control  
in Small-scale Agriculture

WHAT'S  
NEXT?

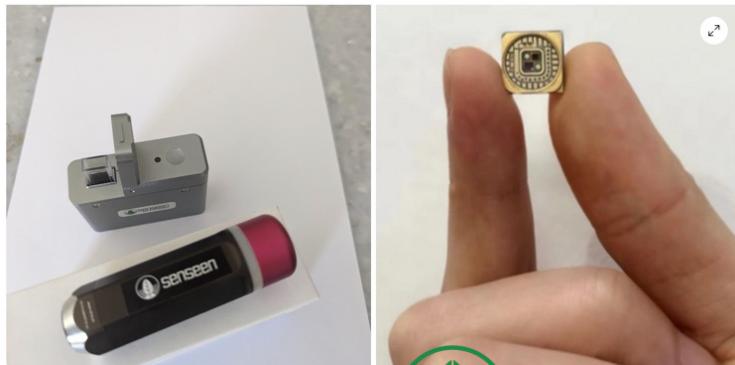
# Smart Agriculture as a whole

- Integration of multiple technologies solutions
  - Remote sensing, satellite data, knowledge base, ...
  - Artificial Intelligence for vertical application silos: rice, viticulture, ...
  - Advanced sensing system, spectrometer, hyperspectral, ...
  - ...
- **BUT**, to ensure wide dissemination, these technologies **MUST**
  - be open, be simple, be inclusive for smallholders
  - be accessible at lower cost
  - take into account weak connectivity areas
  - avoid vendor lock-ins
  - ensure interoperability of software & data
  - ...

# Some examples

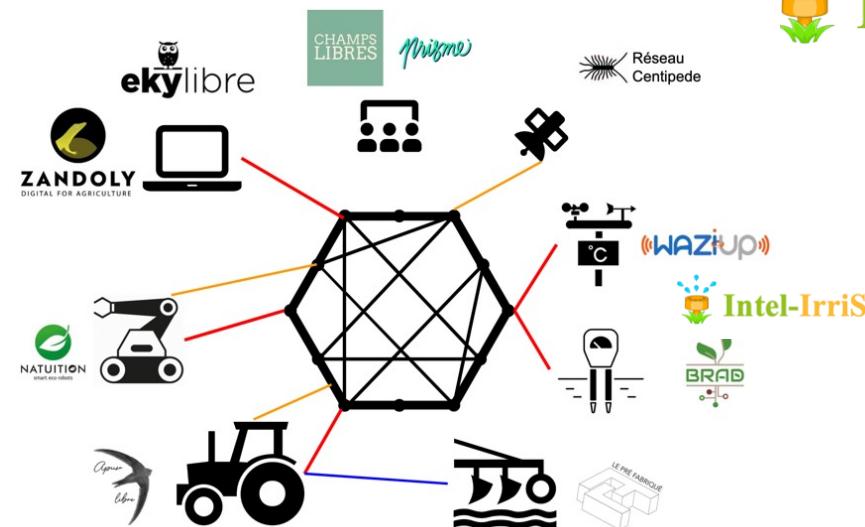


## Portable spectrometers



**SENSEEN**  
 Scanners for the planet

Diagram from ekylibre, draft project proposal

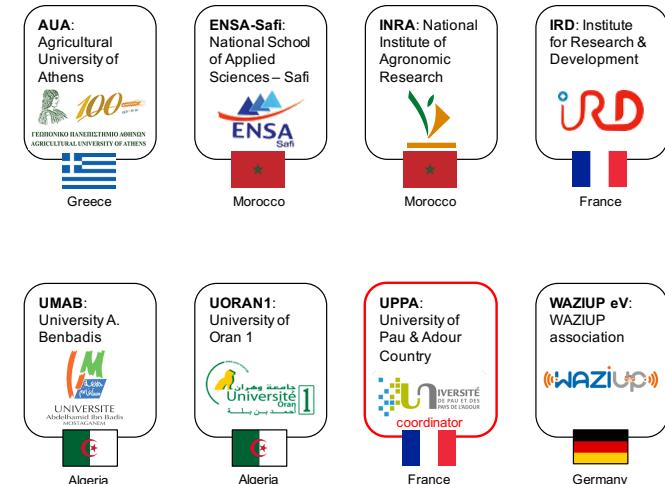
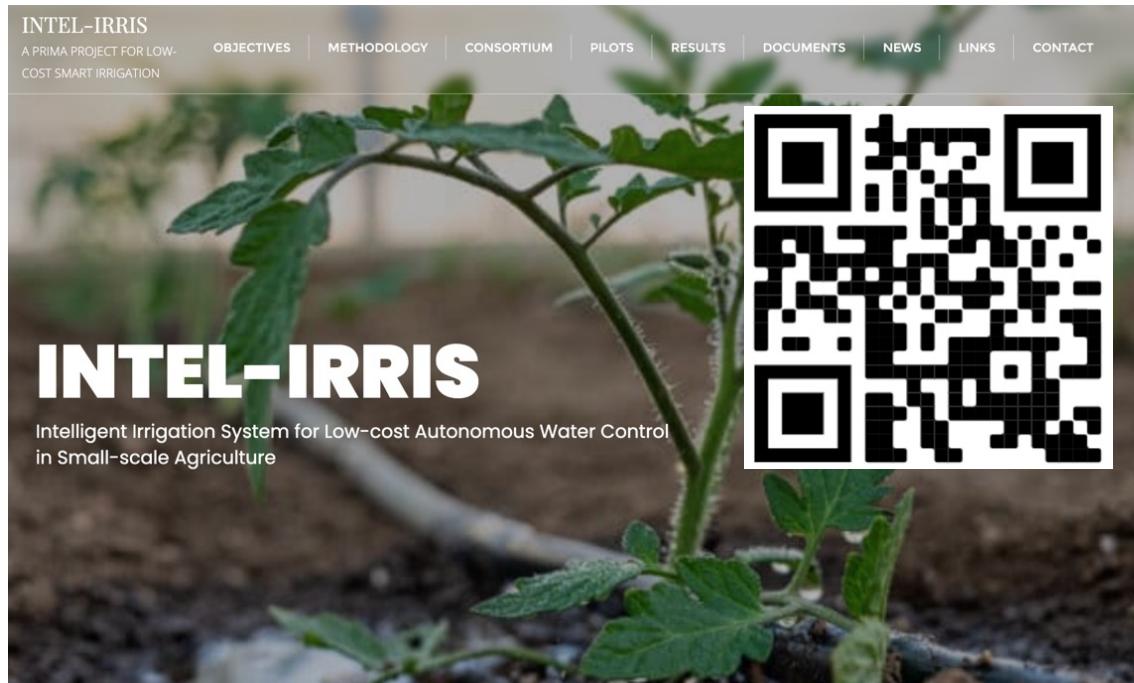


Towards full interoperable agri software & systems



# More information

- Web site: <https://intel-irris.eu>



- Twitter: [https://twitter.com/Intel\\_IrriS](https://twitter.com/Intel_IrriS)



Intel\_Irris  
@Intel\_IrriS

# Intelligent Irrigation System for Low-cost Autonomous Water Control in Small-scale Agriculture

