DEVELOPING FULLY AUTONOMOUS WIRELESS MONITORING SYSTEMS FOR SMALLHOLDER FARMERS COMMUNITIES

Congduc Pham and Guillaume Gaillard, University of Pau, France

AFRICOMM
17th EAI International Conference on Africa Internet infrastructure and Services
23-26 November 2025
Ile-Ife, Nigeria

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European Commission | Horizon 2020 European Union funding for Research & Innovation

WAZIUP
IoT – from idea to reality
WAZIHUB

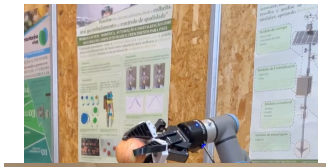
HUBiquitous
Paving for the next 10 years of innovation in IoT and AI

PRIMA
Intel-IrriS RESILINK
Advanced and disruptive IoT/AI technologies targeting the smallholder community for increased resilience

Intel-IrriS

Digital Innovation in Agriculture?

- THERE ARE LOT'S OF DIGITAL INNOVATION IN AGRICULTURE!



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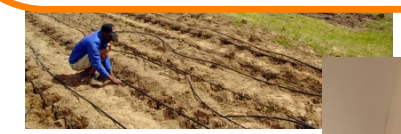
Digital innovation for all farmers?




Possible for large farms

Technologies

Too expensive
Too integrated
Highly specialized
Difficult to customize
Difficult to upgrade
Vendor lock-in SW&HW
Heavily rely on Clouds
& Internet servers



Out of reach smallholder

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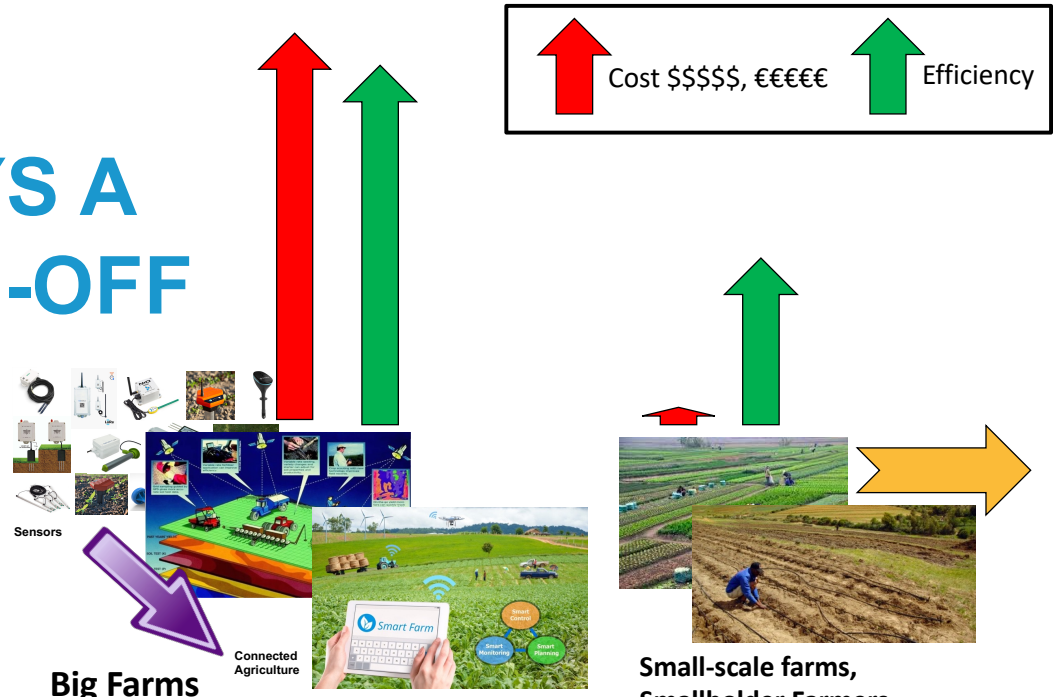
Optimizing irrigation in agriculture

- About 70% of water is used for agriculture activities
- Digital technologies can help reducing and optimizing usage of water

IT IS ALWAYS A TRADE-OFF



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What we did in the last 10 years

Smarter Agriculture for Small Farms

2015-2021

IoT – from idea to reality

Integration & Technologies	Scaling-up with DIHs

2021-2024

Paving for the next 10 years of innovation in IoT and AI

More scaling-up

More capacity-building

HUBiquitous

2021-2024

Less technology More applications

2025-2030

AgriFutur

Out-of-the box innovative sensing systems for agroecology

PRIMA

Intel-IrriS

IoT targeting the smallholder community

AgriFutur

Wireless Sensors Made Simple for agroecology & sustainable agriculture

WAZIHUB

WAZIUP

European Commission | Horizon 2020 European Union funding for Research & Innovation

WAZIUP

IoT – from idea to reality

WAZIHUB

HUBiquitous

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Intel-IrriS

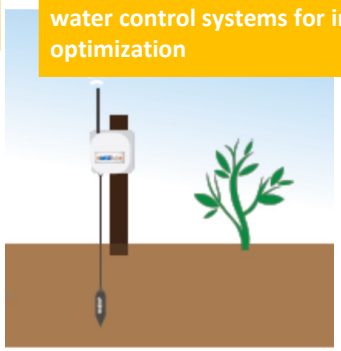
INTEL-IRRIS's main objectives

Low-cost

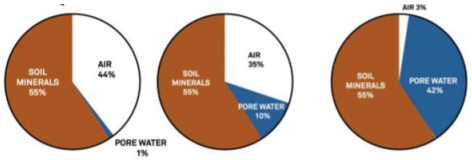
Advanced technologies

Autonomous Plug-&-Sense

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



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

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Intel-IrriS

Not only the cost barrier…

CO-DEVELOP SOLUTIONS!

High acceptability of technologies, even complex ones

Very low acceptability of technologies because too complex!

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INTEL-IRRIS's starter kit

FROM IDEA TO REALITY!

Small-scale farms,
Smallholder Farmers

NO INTERNET
FULL EDGE
MODE ☺

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Generic hardware platform

~ 30€

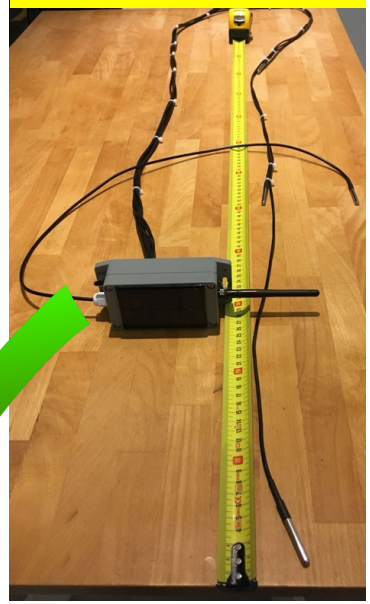
SEN0308
capacitive sensor

~ 60€

Watermark WM200
Water tension sensor

2 WATERMARK SENSORS

6 TEMPERATURE SENSORS



AIR TEMP/HUM

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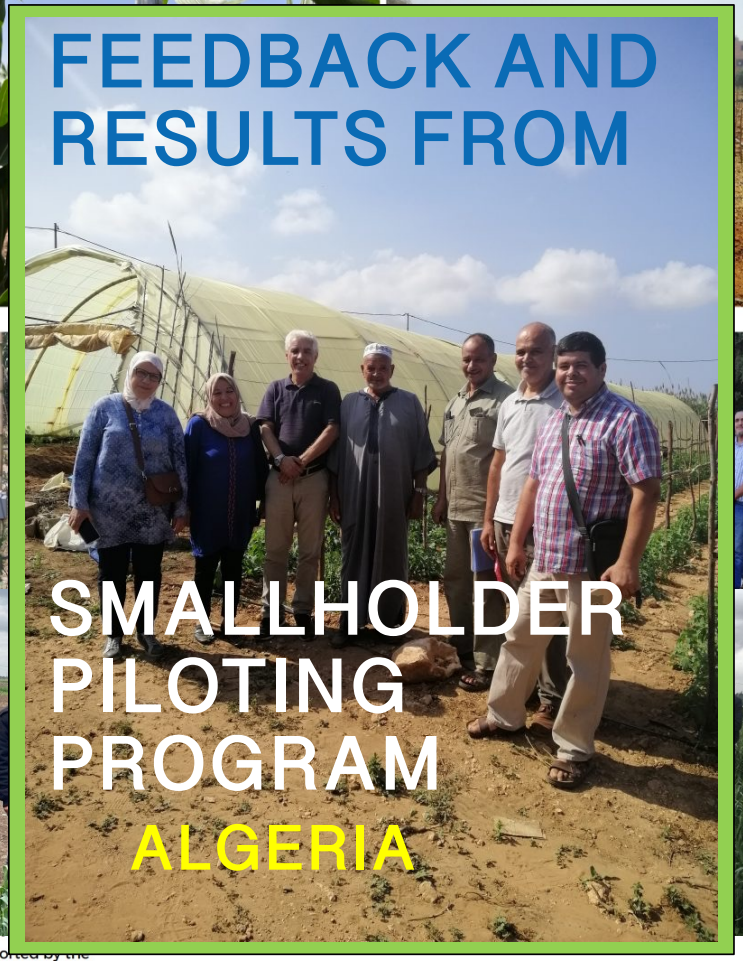
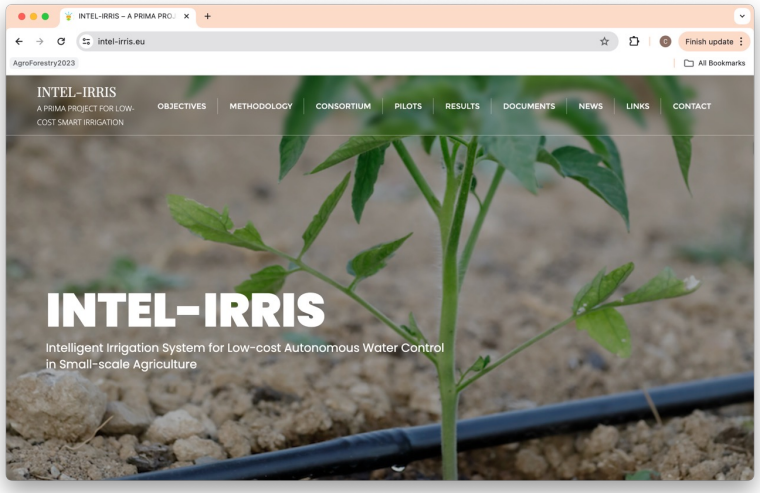
Intel-IrriS

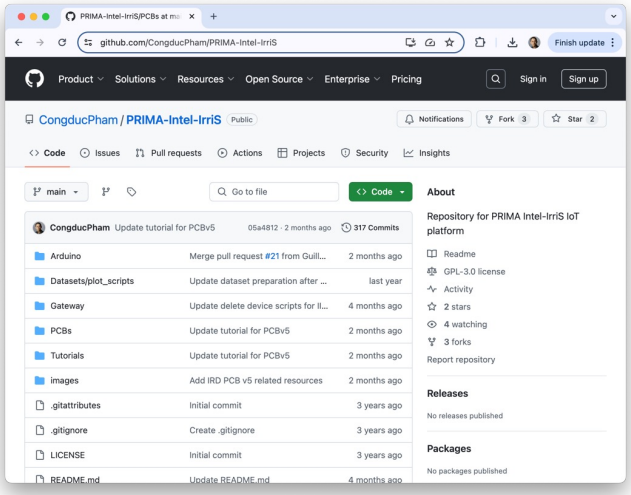
Smallholder Piloting Program



Programme supported by the European Union

PUBLICATIONS, TUTORIALS, VIDEOS, CODE, PCB FILES, …





Web site
https://intel-irris.eu

INTEL-IRRIS GITHUB

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INTEL-IRRIS

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

WHAT DID WE LEARNED?

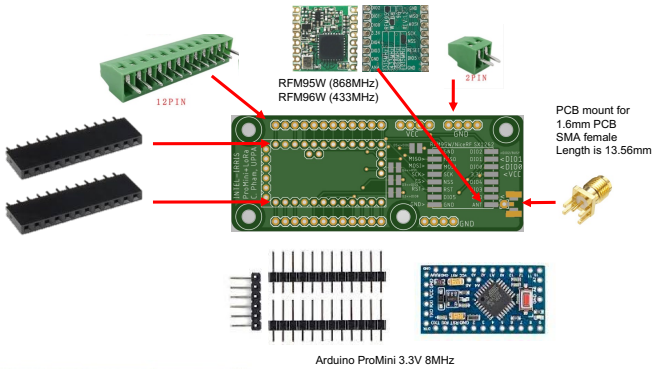
MODULAR & OPEN HARDWARE PLATFORM

CO-DEVELOP?

WENT THE HARD WAY!

A LOT OF TRIALS & ERRORS!

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



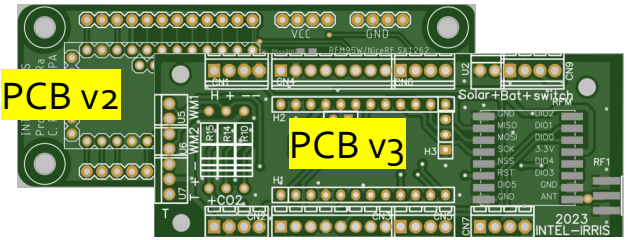
Wh

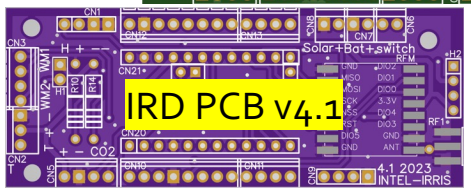
COST-EFFECTIVE, MODULAR & OPEN HARDWARE PLATFORM

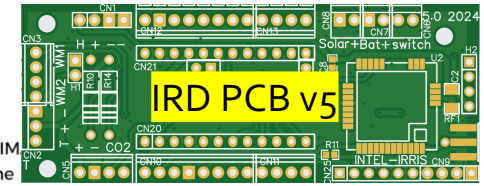
V1, V2, V3, V4, V5!

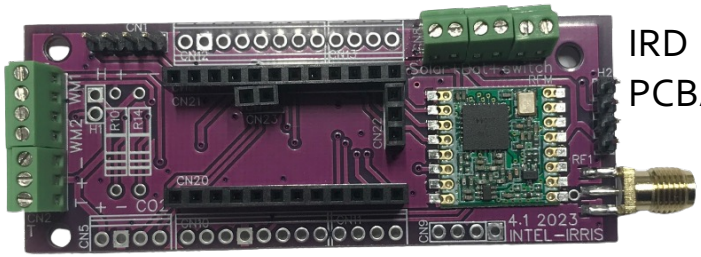
MANY FEEDBACK TO GET TO V5!

- OPEN SOURCE PCB DESIGN, GERBER FILES AVAILABLE
- EASY WIRING OF PHYSICAL SENSORS
- LONG-RANGE WIRELESS TRANSMISSION (LORA)
- SOLAR CHARGING CAPABILITIES → INFINITE AUTONOMY

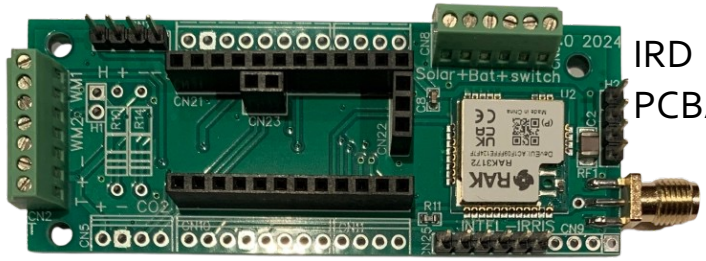








IRD PCBA v4.1



IRD PCBA v5

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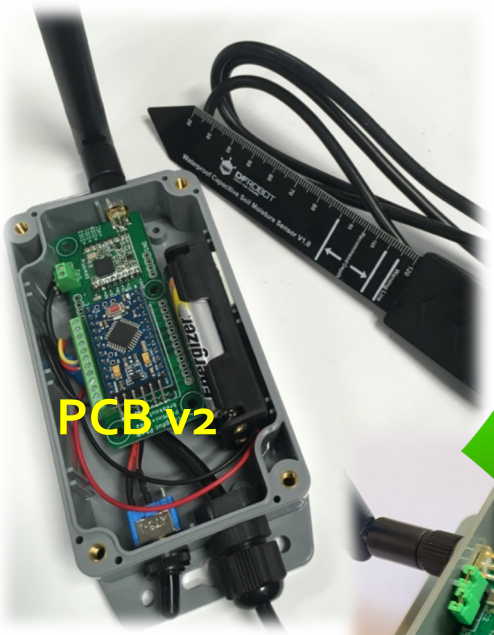
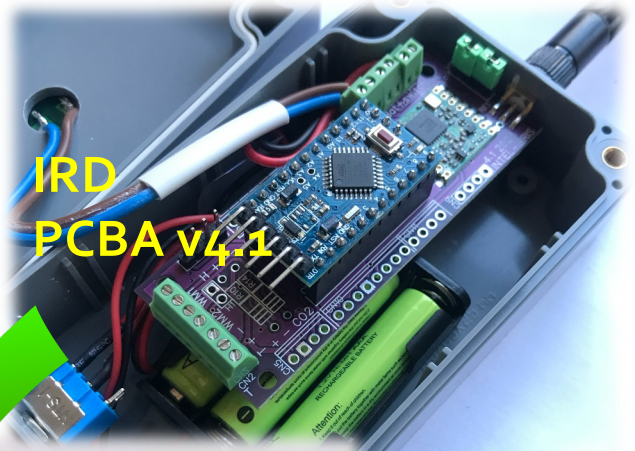
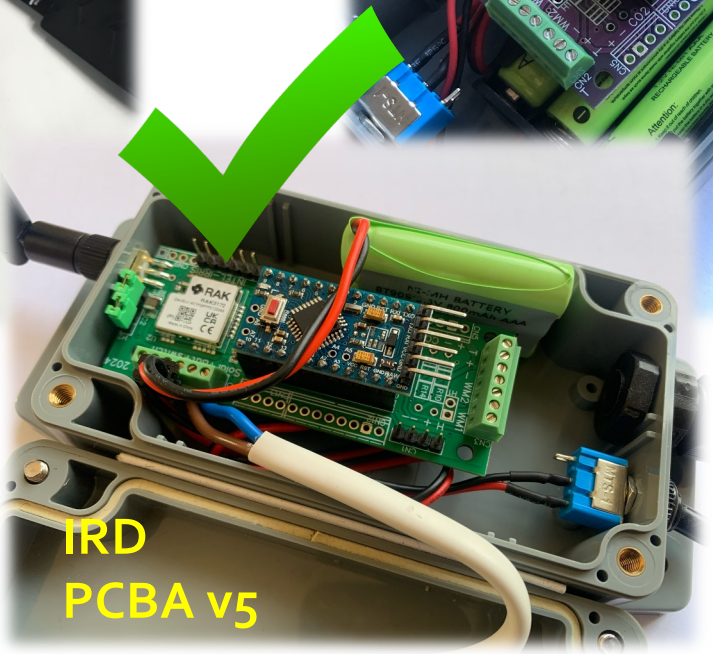
COST-EFFECTIVE, MODULAR & OPEN HARDWARE PLATFORM

EASY & ROBUST INTEGRATION

With 1 measure/hour → ~ 2 years of autonomy on alkaline batteries!







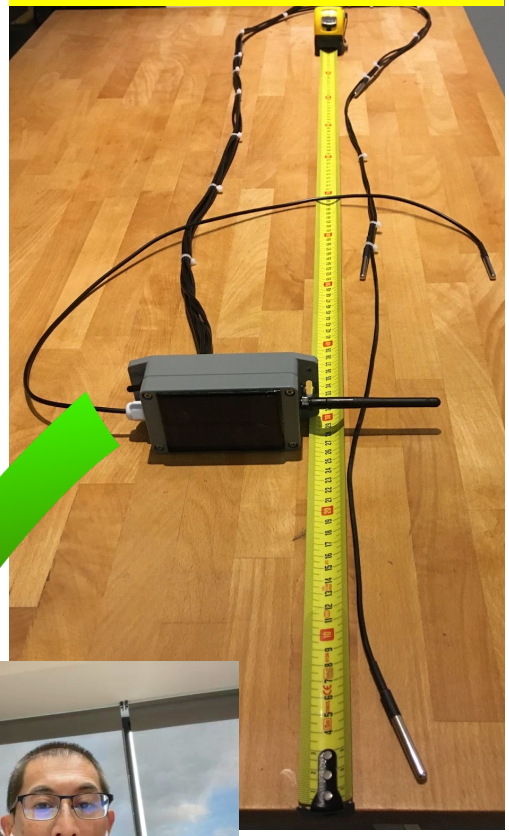
2500mA

HIGHLY ADAPTABLE FOR AD-HOC DESIGNS

SUITABLE FOR A LARGE VARIETY OF APPLICATIONS

2 WATERMARK SENSORS

6 TEMPERATURE SENSORS



AIR TEMP/HUM

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TARGETING THE SMALLHOLDER FARMER COMMUNITIES

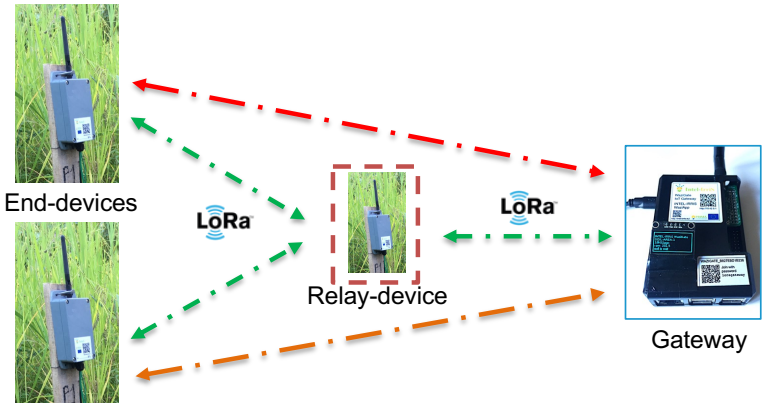
OUT-OF-THE-BOX, EASY DEPLOYMENT IN PILOTING FARMS

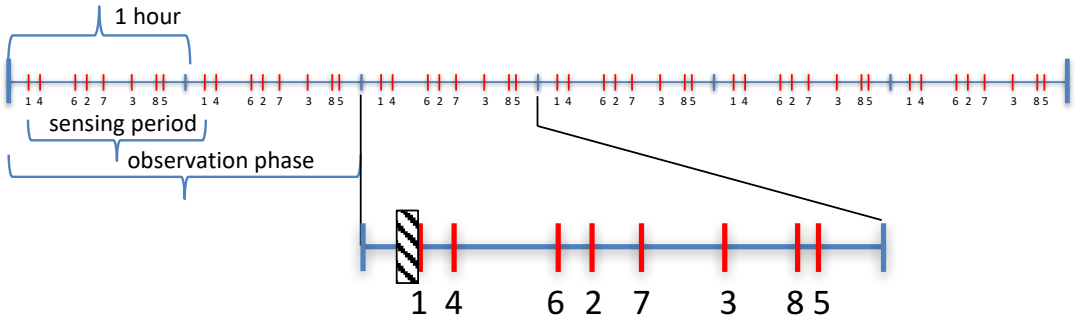
- SIMPLE CAPACITIVE SENSOR DEVICE IS EASILY INSTALLED BY SMALLHOLDERS THEMSELVES
- WATER TENSION SENSORS REQUIRE MORE PRE-PARATION AND NEED ASSISTANCE OF PARTNERS

TARGETING THE SMALLHOLDER FARMER COMMUNITIES

INCREASE COVERAGE, ADVANCED DATA RELAYING

- SOME FIELDS MAY BE FAR AWAY FROM THE GATEWAY
- SMART RELAY NODES CAN BE BUIDT FROM REGULAR DEVICES TO TRANSPARENTLY INCREASE COVERAGE

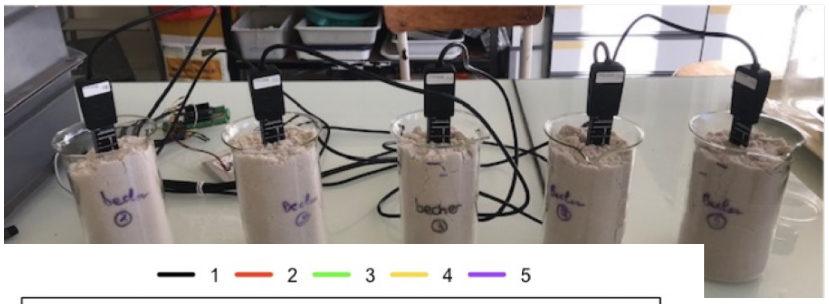


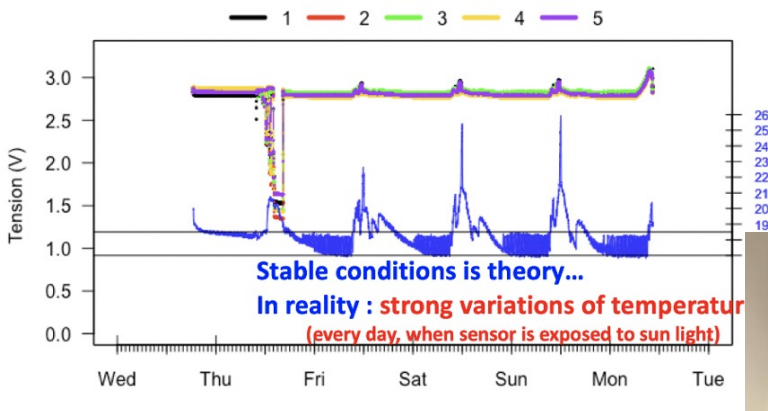


TARGETING THE SMALLHOLDER FARMER COMMUNITIES

LOW-COST SENSORS

- LOW-COST SENSORS WITH CALIBRATION TO INCREASE ACCURACY

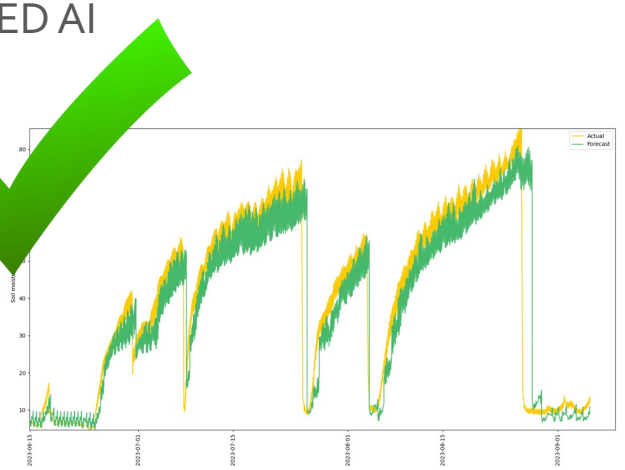




TARGETING THE SMALLHOLDER FARMER COMMUNITIES

FULLY AUTONOMOUS NO INTERNET

- FULLY AUTONOMOUS, NO NEED FOR INTERNET CONNECTIVITY, REMOTE SERVERS OR CLOUDS
- ALL SENSOR DATA ARE PROCESSED LOCALLY ON A VERSATILE IOT GATEWAY – FULL EDGE MODE
- PROOF-OF-CONCEPT OF EMBEDDED AI



sliding windows pre-treament & LSTM

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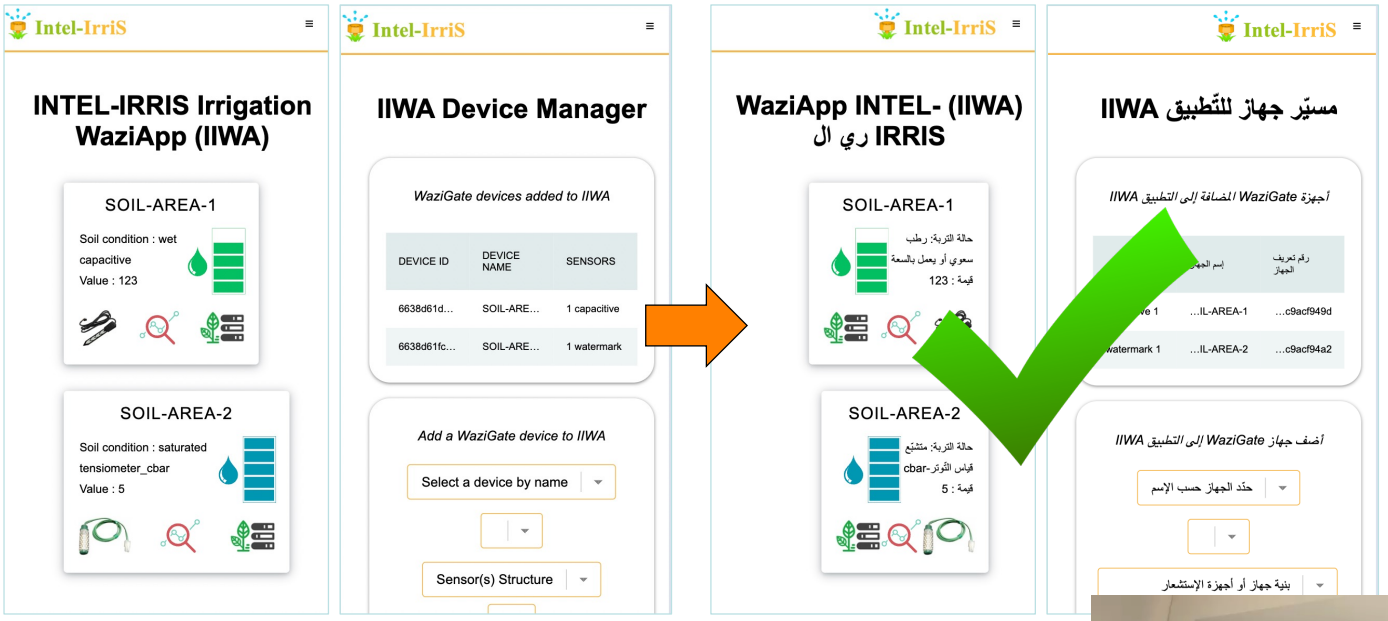
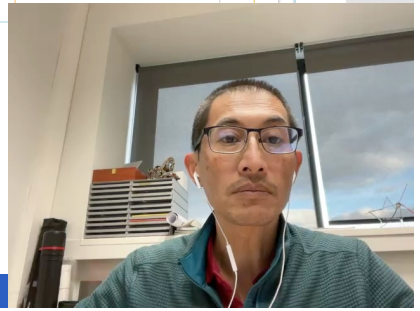
TARGETING THE SMALLHOLDER FARMER COMMUNITIES

USER INTERFACES

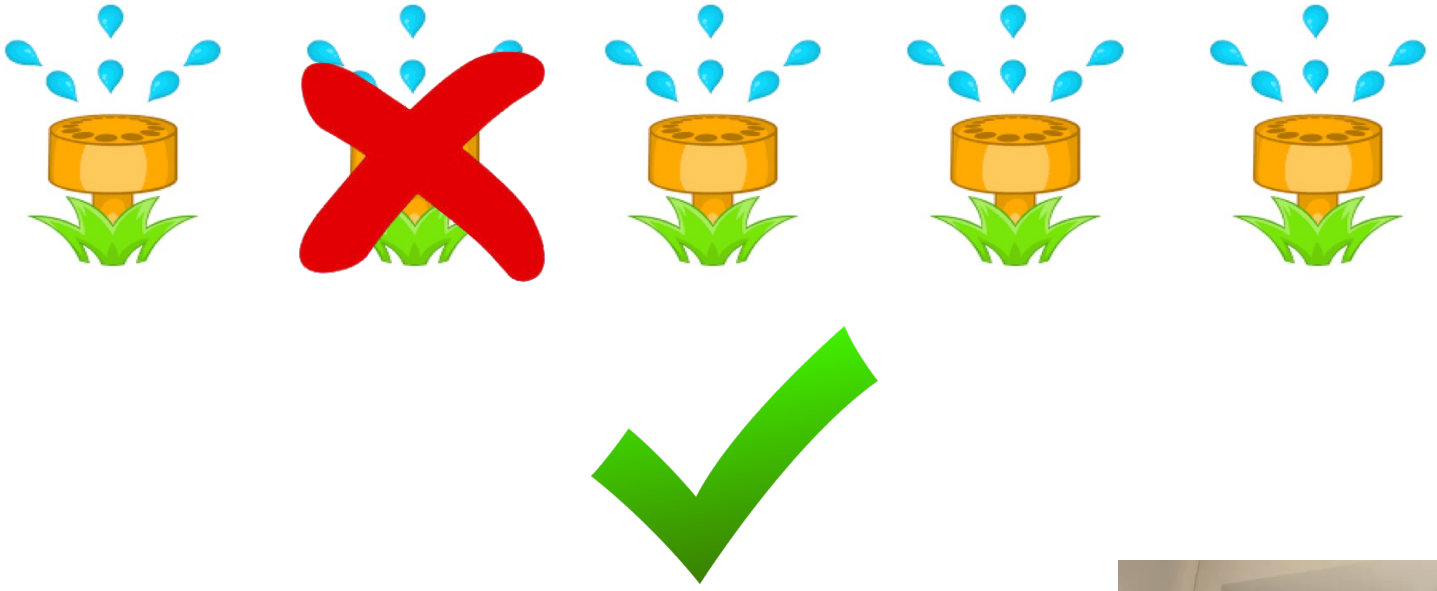
LOCAL LANGUAGE!





TARGETING THE SMALLHOLDER FARMER COMMUNITIES

CAN WE SAVE WATER?



AgriFutur

Wireless Sensors Made Simple
for agroecology & sustainable agriculture

Going beyond irrigation

AgriFutur

Wireless Sensors Made Simple
for agroecology & sustainable agriculture

Powered by technologies developed in Intel-IrriS

- Use the same approach of cost-efficiency and out-of-the-box deployment, expanding the sensor ecosystem
- Complementarity & Adaptability: high-end, low-end, innovative, …
- Target Agroecology, Nature-Based Solutions & Sustainable Agriculture
- Better Qualify & Quantify the impact of these new practices
- More data = more correlation in agroecological system

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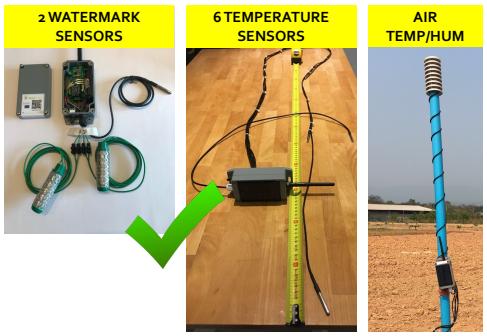
FRANCE 2030 PROGRAMME DE RECHERCHE AGROÉCOLOGIE ET NUMÉRIQUE

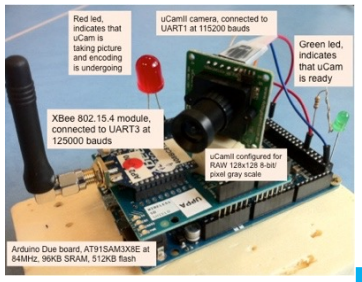
AgriFutur

Wireless Sensors Made Simple for agroecology & sustainable agriculture

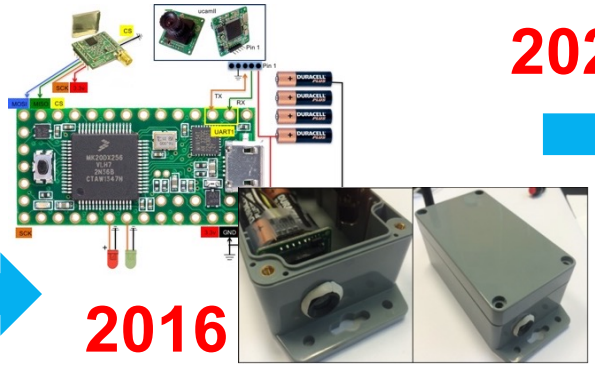
Advanced Sensing Systems



- Many applications need visual information → Image Sensing IoT

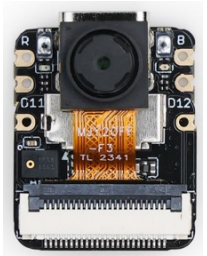


2012



2016

2024



ESP32S3 32-bit, dual-core, up to 240 MHz

XIAO ESP32S3

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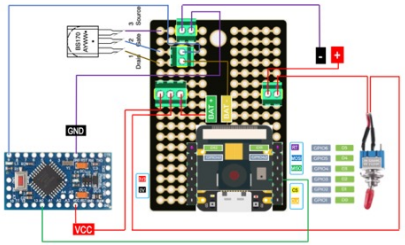
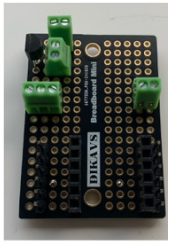
AgriFutur

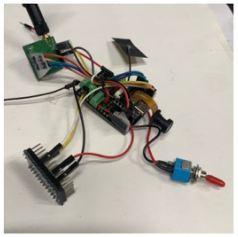
Wireless Sensors Made Simple for agroecology & sustainable agriculture

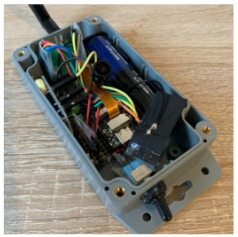
Proof-of-concept: LORACAM-AI

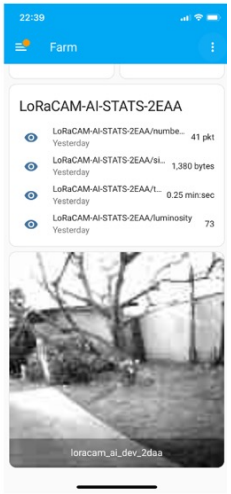
UPDATED VERSION IN 2025 FOR THE PEPR AGRIFUTUR PROJECT

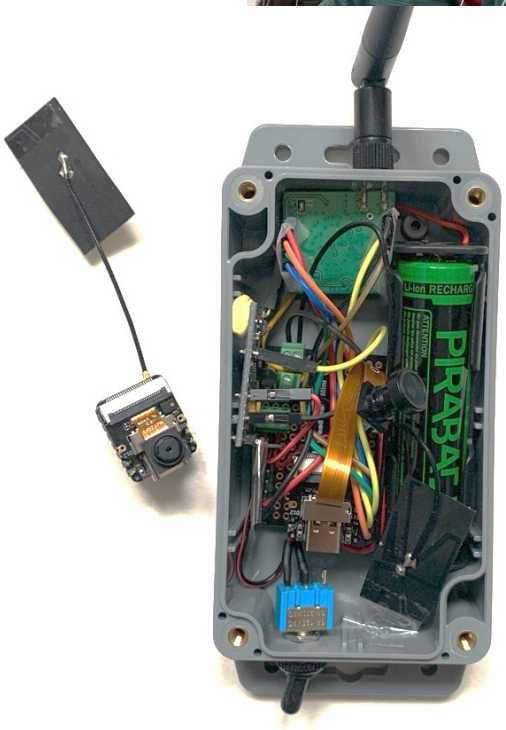












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