CIHEAM
BARI

Digital Agriculture for Sustainable development

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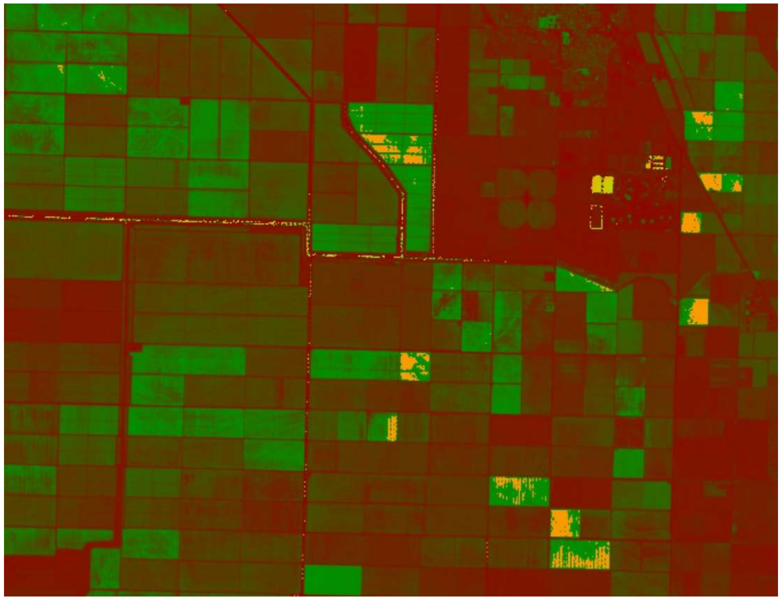
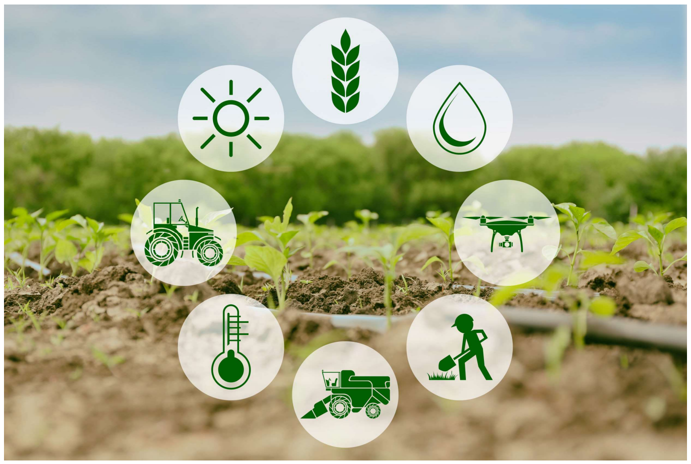
Digital Agriculture

It's the use of digital devices to gather, process and analyze spatial (object) or temporal (time) data. This data can then guide targeted actions to improve agricultural efficiency, productivity and sustainability.

Smart farm management system that uses information technology (IT) to ensure that crops and soil get what they need for their good health and productivity. (Hemathilake et al., 2022).

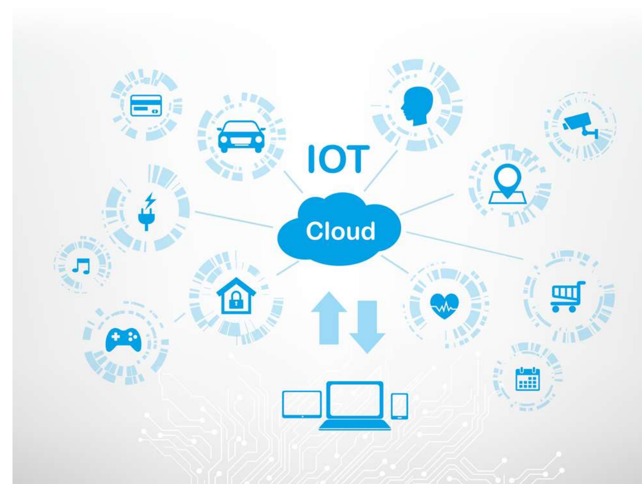


Digital Agriculture



Digital Agriculture

Ag tech



Internet of things (IoT)

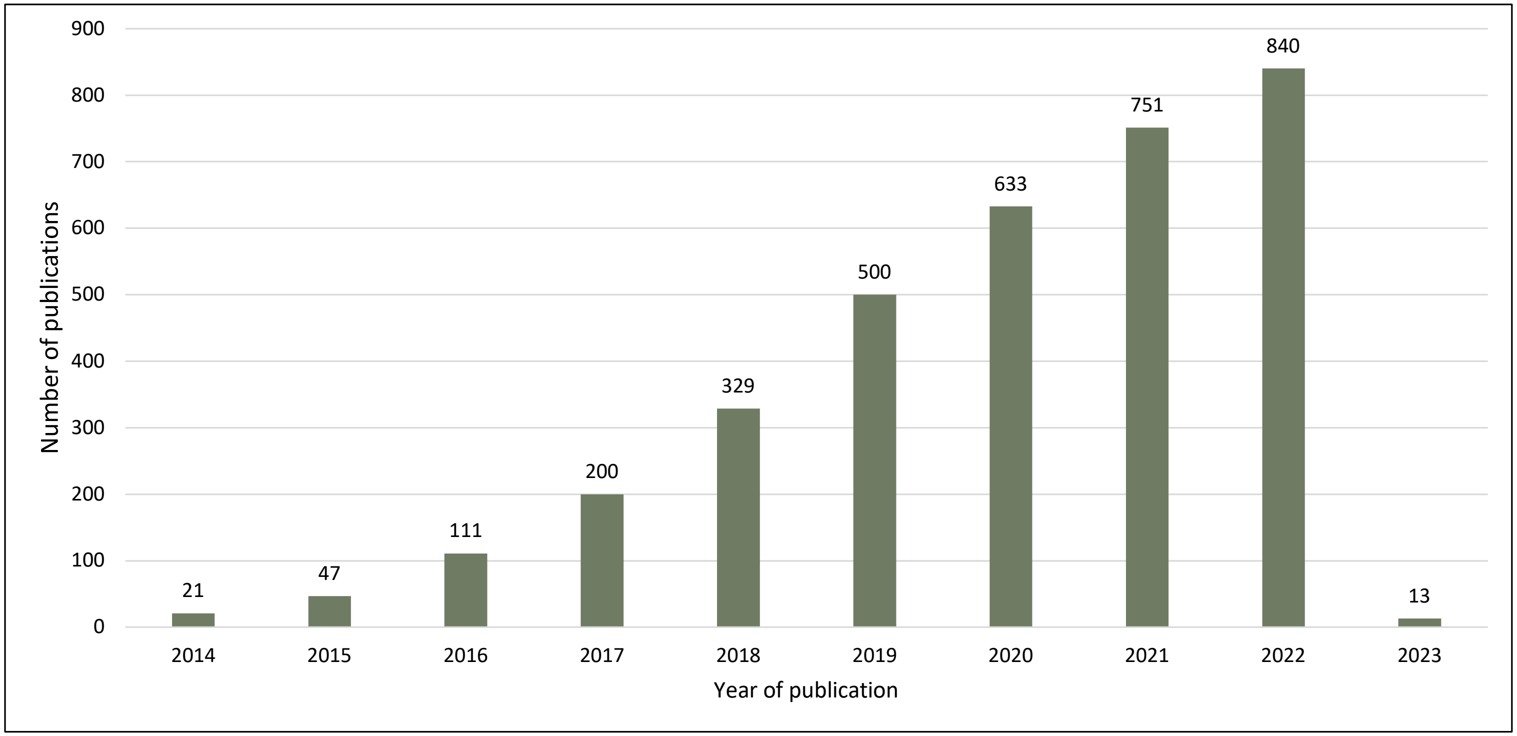
Why Digital Ag

Data reliability

Data Accessibility

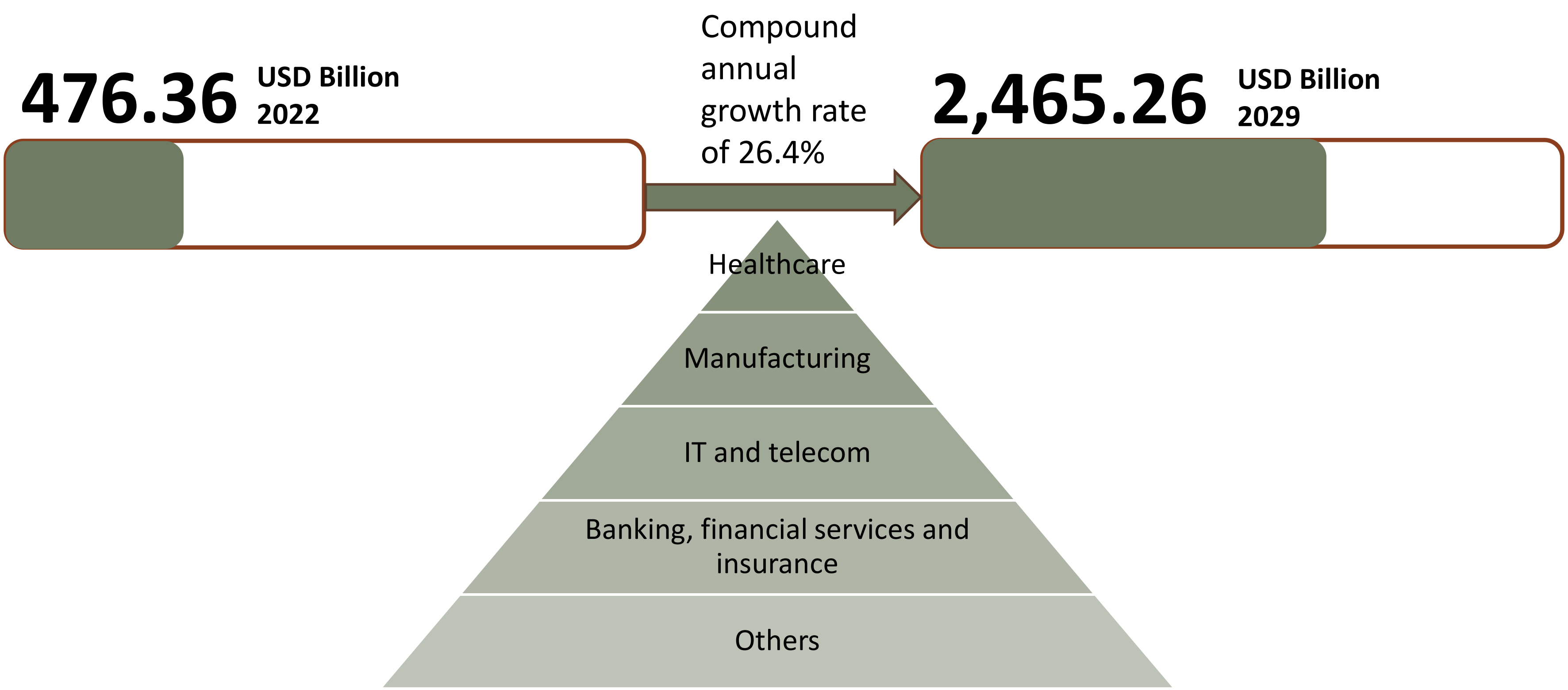
Data scattering

Number of publications related Digital Ag



Why Digital AG?

Digital Agriculture Market growth rate



Top 5 users of IoT in 2021, Internet of things Market research report, 2022, Fortune business insights

Limitation and challenges of Digital Ag based solutions

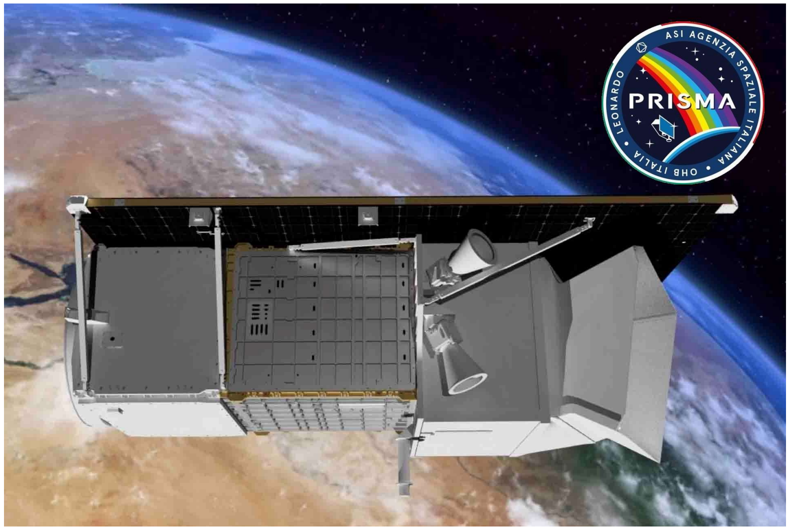
Case study: Earth Explores Africa

In the framework the European Space Agency (ESA) initiative EO AFRICA stands for African Framework for Research, Innovation, Communities an Applications and in cooperation with Planetek Italia and Planetek Hellas. Funded by ESA.

It aims to develop an open-source, innovative and integrated model to assess in near-real-time actual crop evapotranspiration (ETa) based on hyperspectral data (PRISMA and EOSTRESS) .

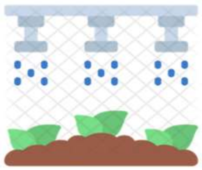
The validation will take place on large scale level (13,000 ha pivoted field).

The project also includes a capacity building component to ensure its sustainability.



Case study area

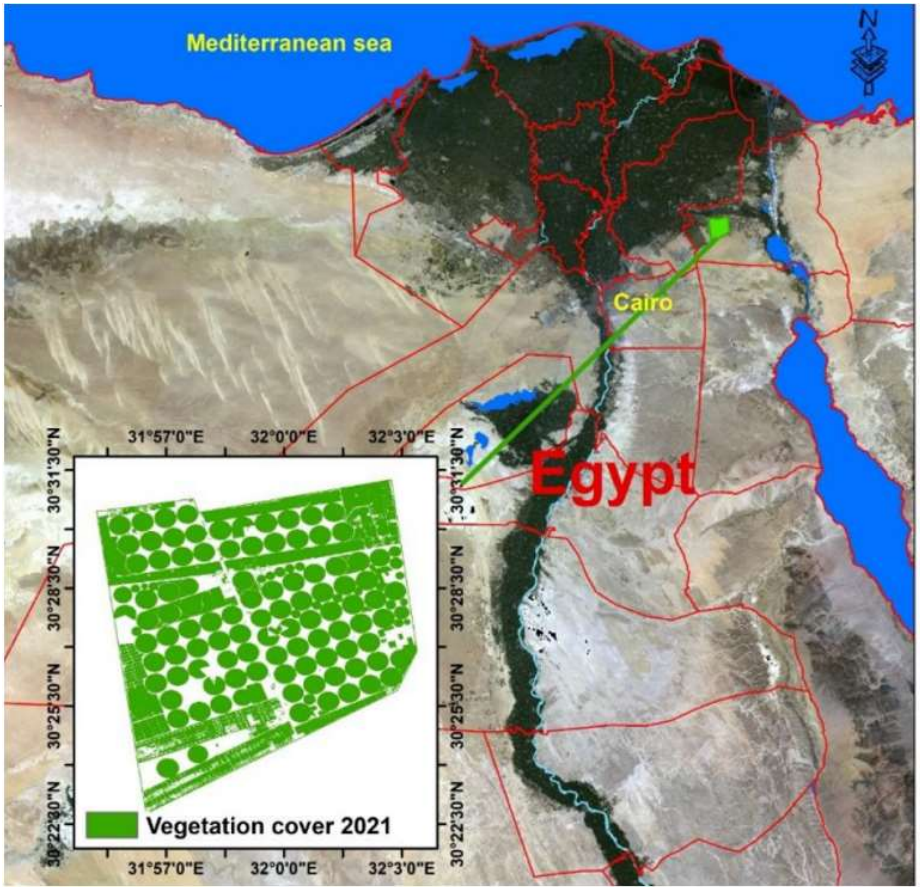
An area of **13.800 hectares**



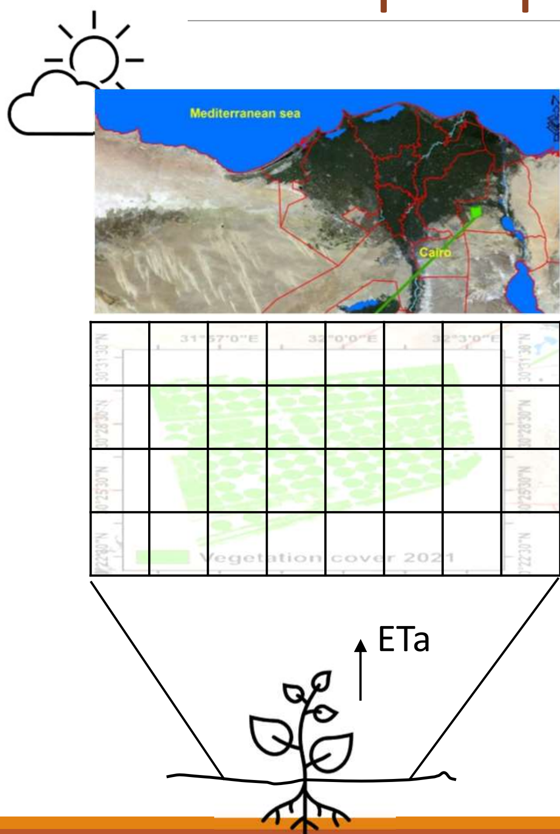
120 irrigation pivots

Annual water consumption of **140 million m³.**

Wheat, **peanuts** and **maize** 40% of the total area.

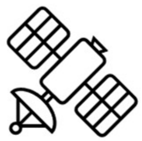


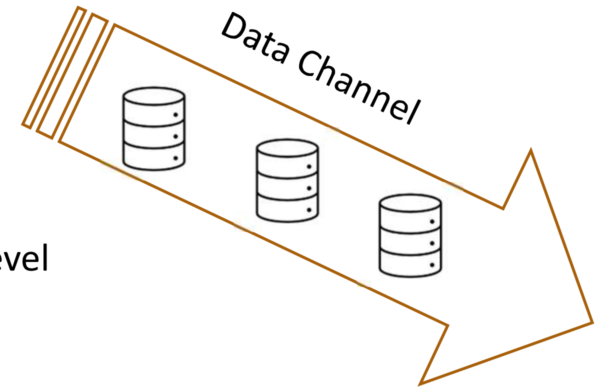
The proposed solution



Landscape level

On farm scale

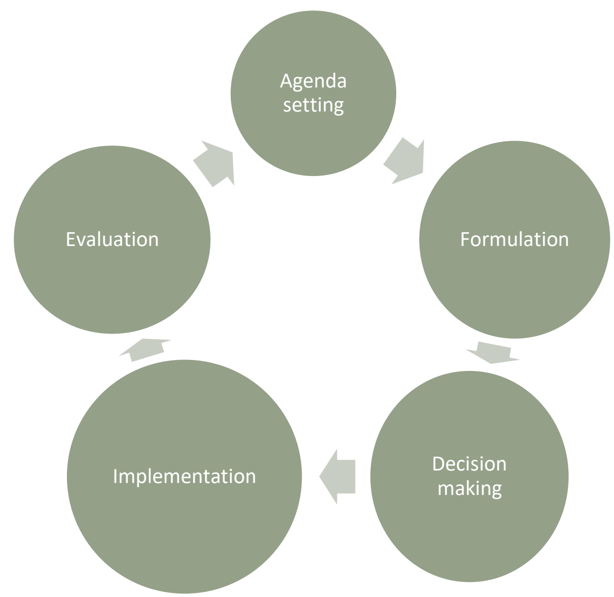




Thus,
the proposed solution had to be …

- Reliable
- Accessible
- Integrated

Policy cycle



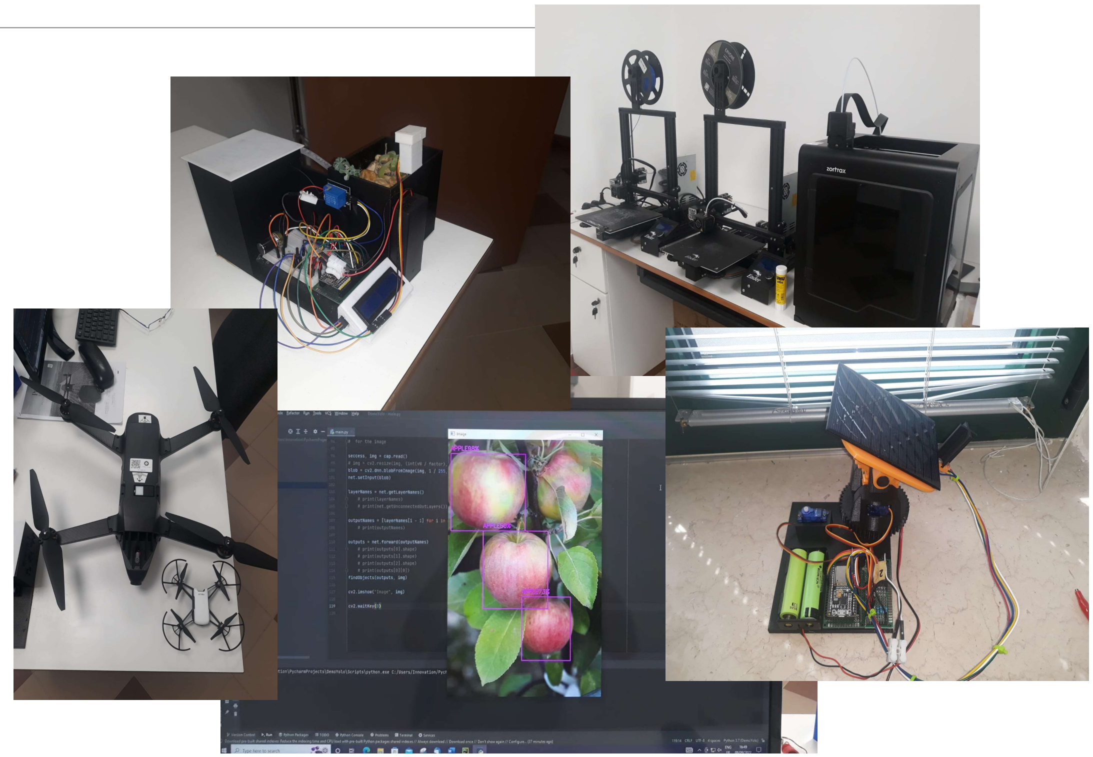
Overcoming challenges through digital agriculture Education

The Digital Agriculture lab was established in October 2021

To integrate digital tools, data driven approaches, prototyping skills, and proof of concepts into CIHEAM Bari’s educational and training programs in sustainable water and land management in agriculture.

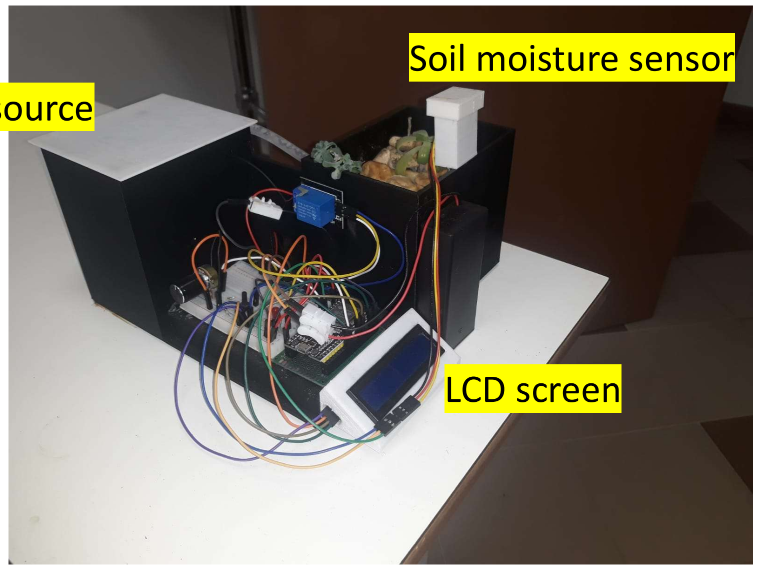
Building skills for the trainees with view to transform the innovative ideas into prototypes and proof of concepts.

Provides the means to develop, test, field validate, and mainstream the solutions, into research activities and scientific publications.

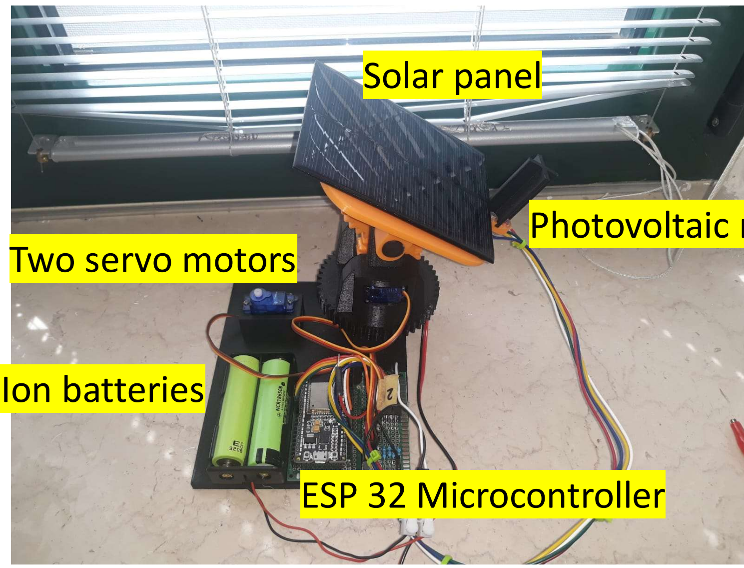


Digital agriculture lab activities

IoT sensing (moisture, weather parameters, solar trackers, ….etc)



Smart Farm simulation



Solar Tracker

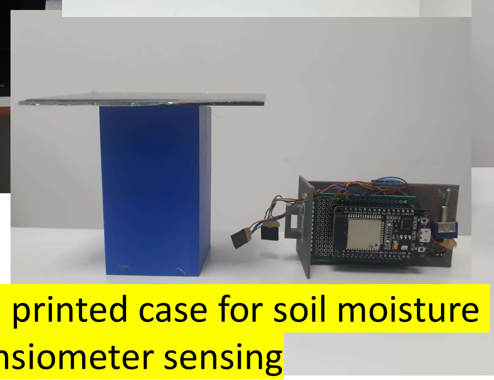
Digital agriculture lab activities

3D printers

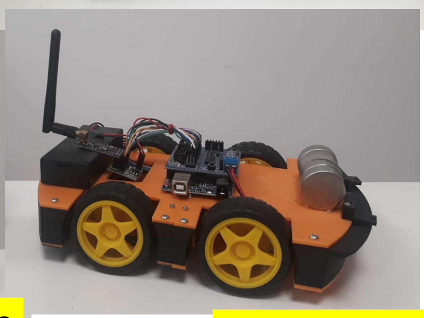
Weather station
3D printed case

3D printed robot
for monitoring with RGB camera

Prototyping and proof of concepts



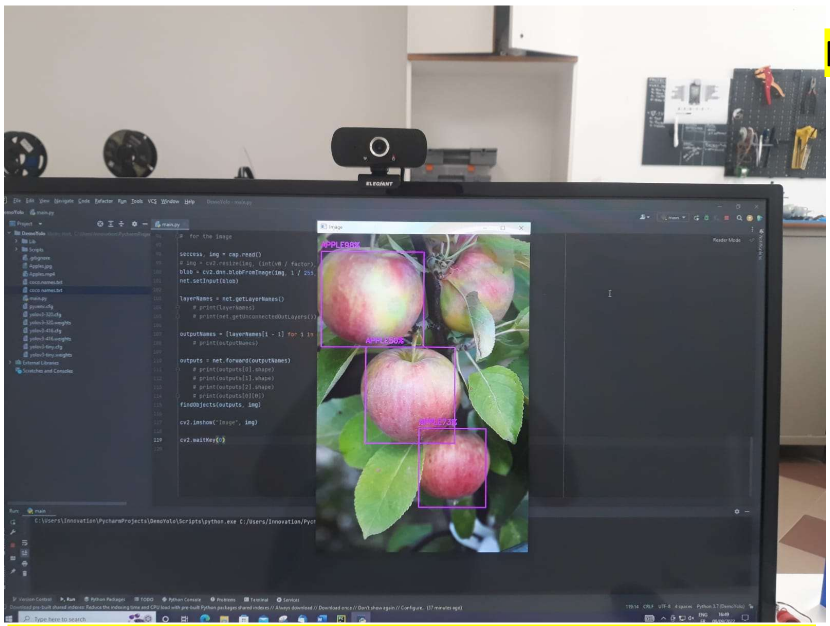
3D printed case for soil moisture
tensiometer sensing



Easy to assemble wheeled robot platform for
prototyping

Digital agriculture lab activities

UAVs, Programmable drones and computer vision



Using computer vision to evaluate apples maturity

Parrot drone with Sequoia multi spectral camera

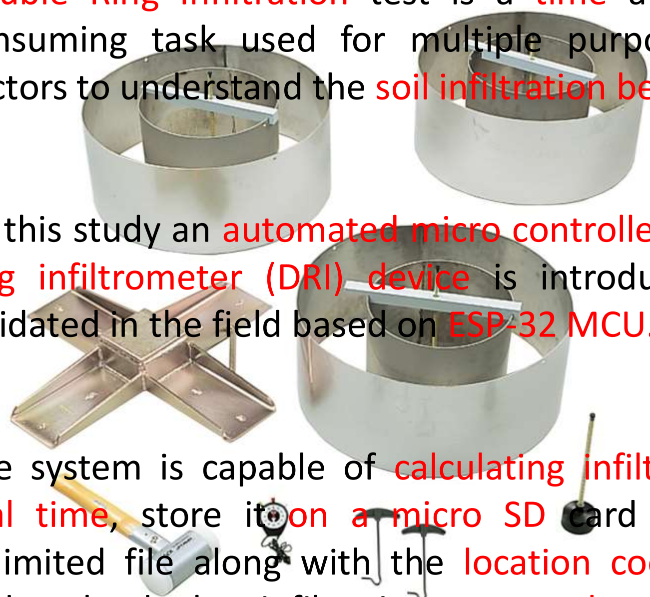
Tello programable drone

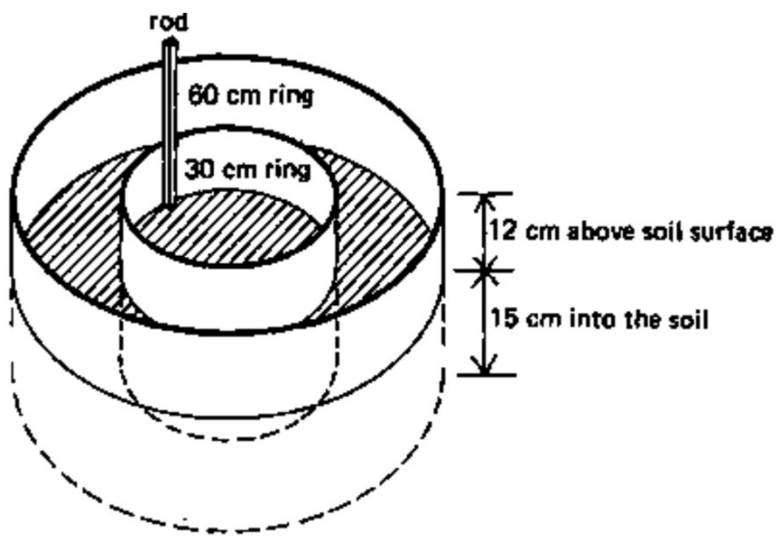
Examples of the lab Prototypes: DRI

- Double Ring Infiltration test is a time and effort consuming task used for multiple purposes and sectors to understand the soil infiltration behavior.

- In this study an automated micro controlled double ring infiltrometer (DRI) device is introduced and validated in the field based on ESP-32 MCU.

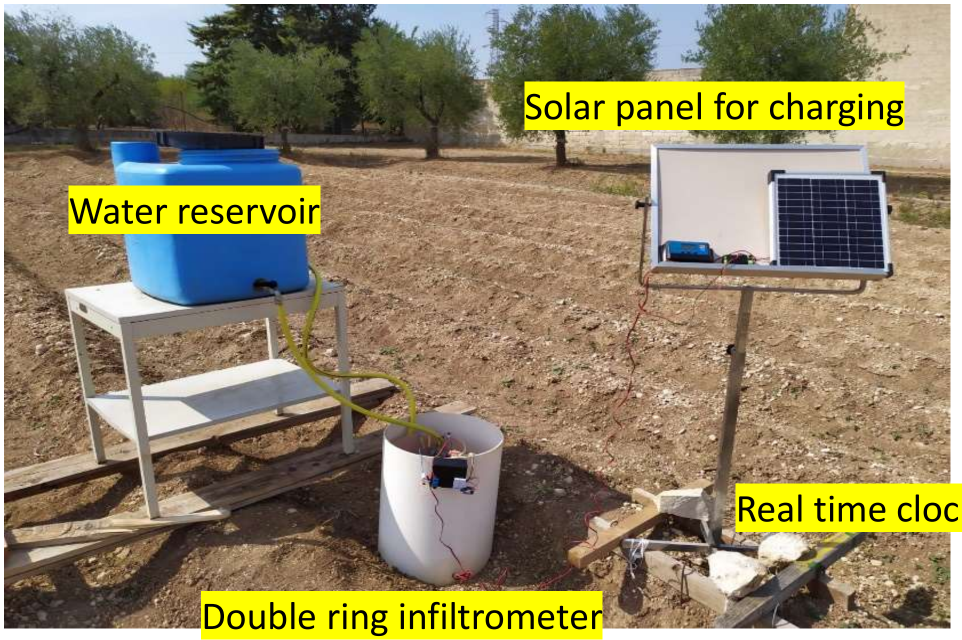
- The system is capable of calculating infiltration in real time, store it on a micro SD card as a txt delimited file along with the location coordinates and upload the infiltration on a cloud service platform.

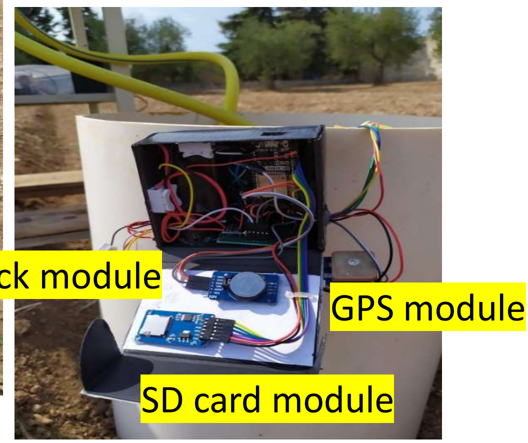


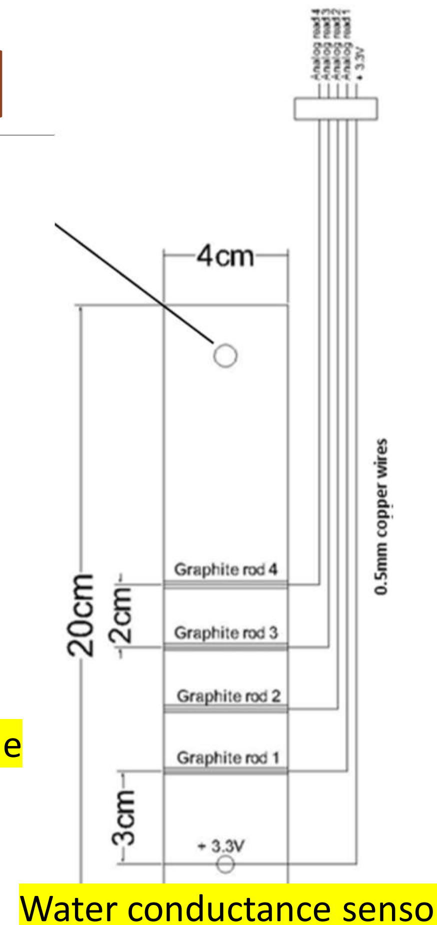


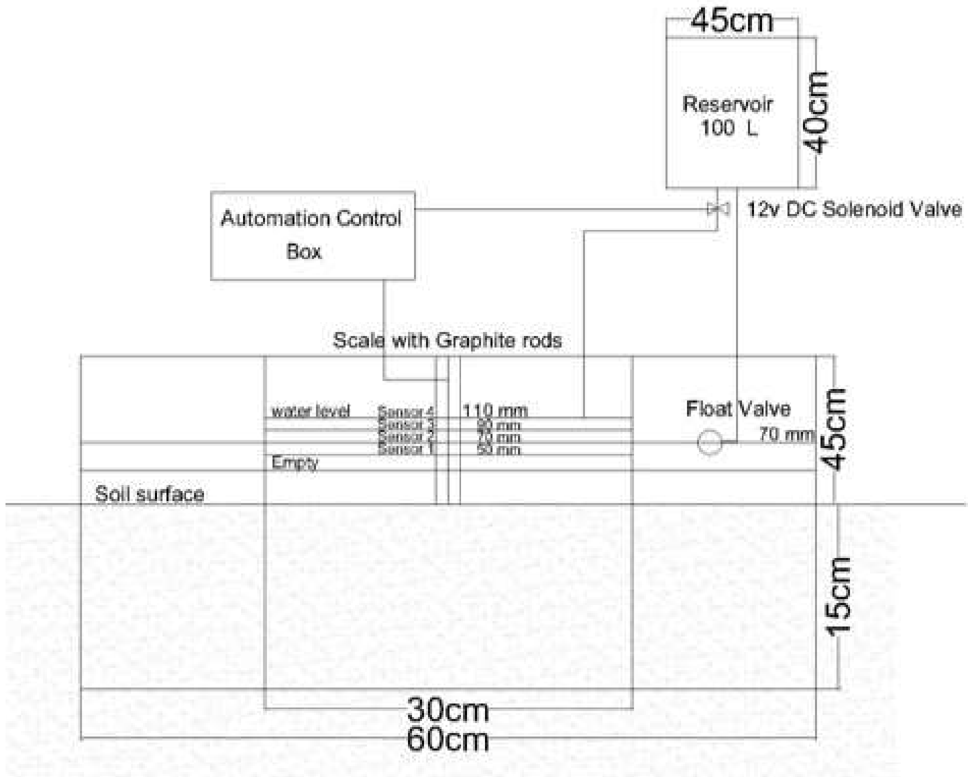
Examples of the lab Prototypes: DRI

Automation of infiltration measurement and the study

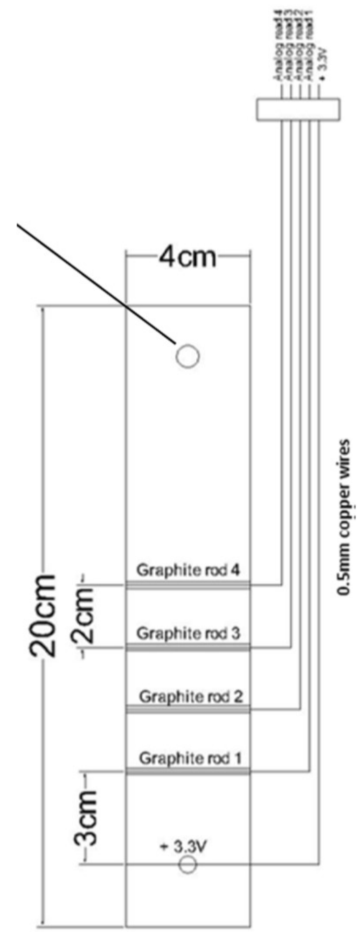




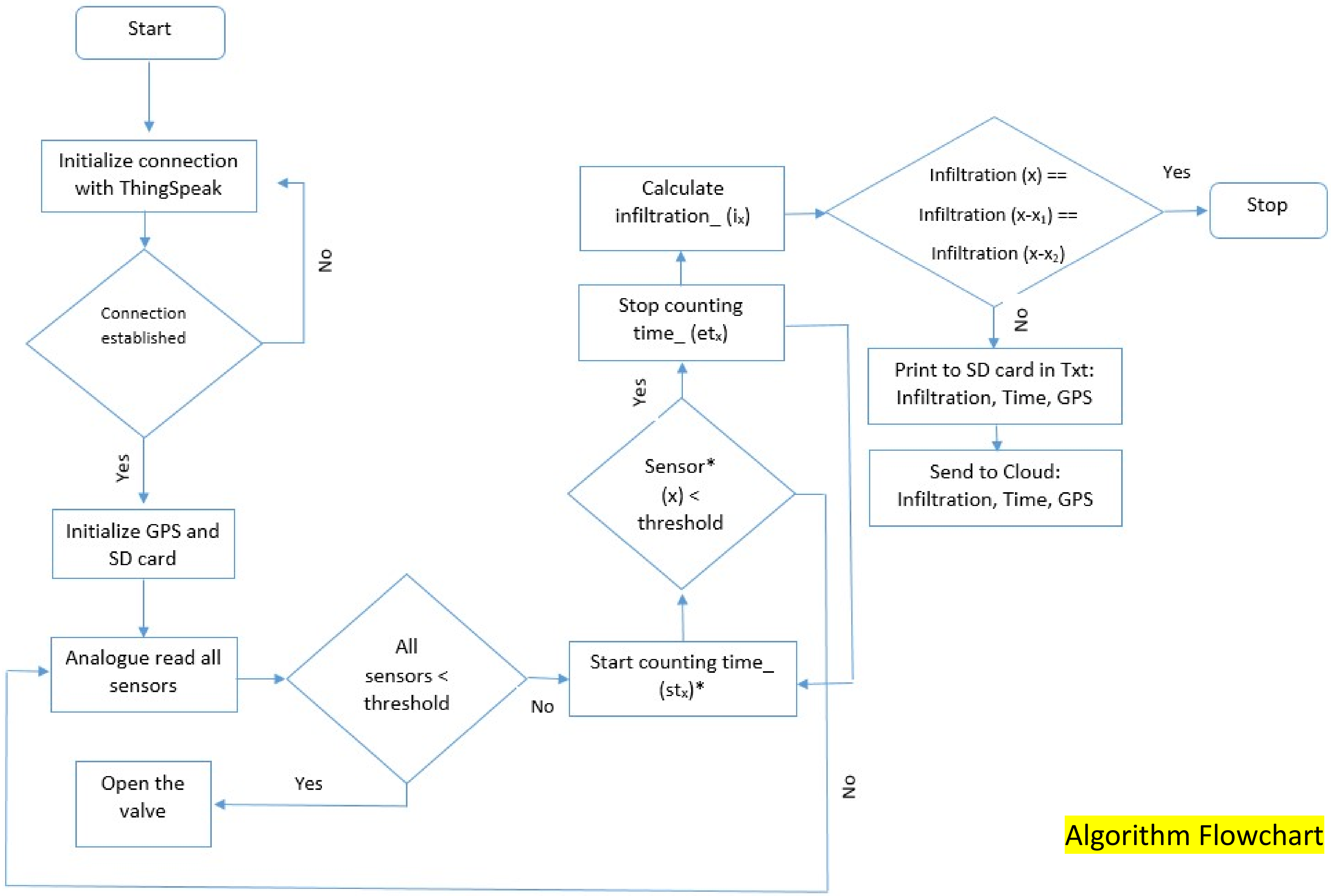




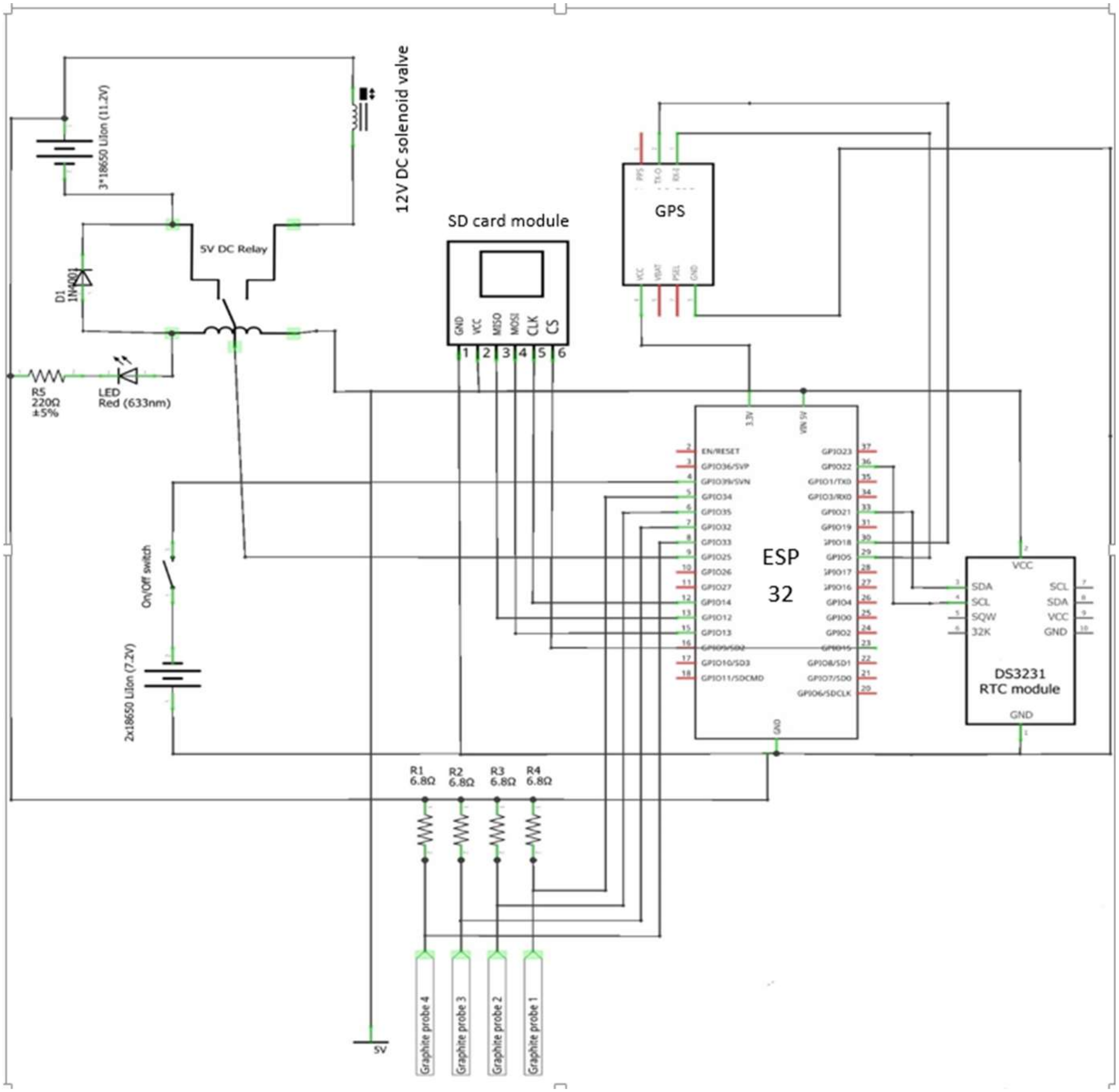
Automated DRI



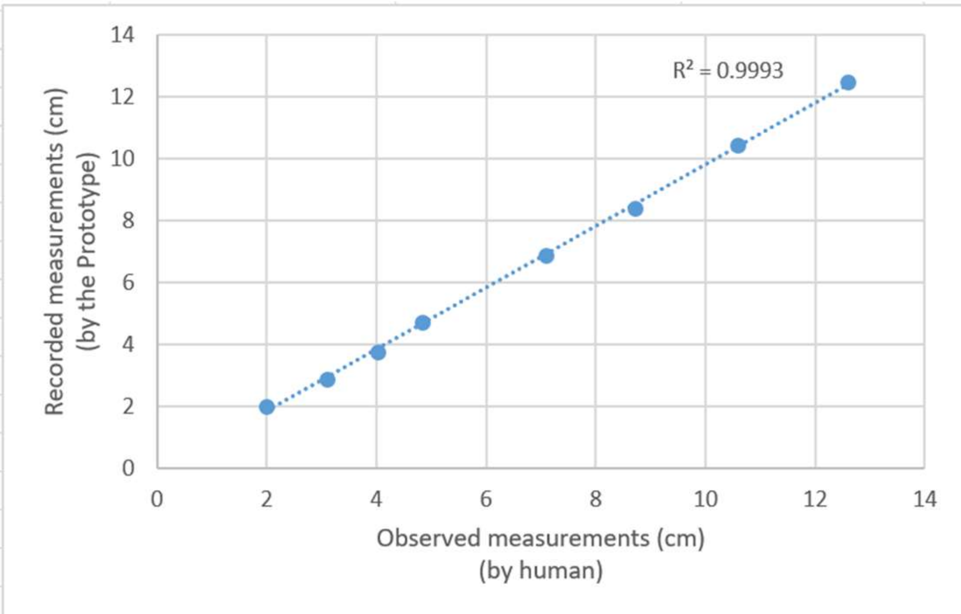
Water conductance sensor



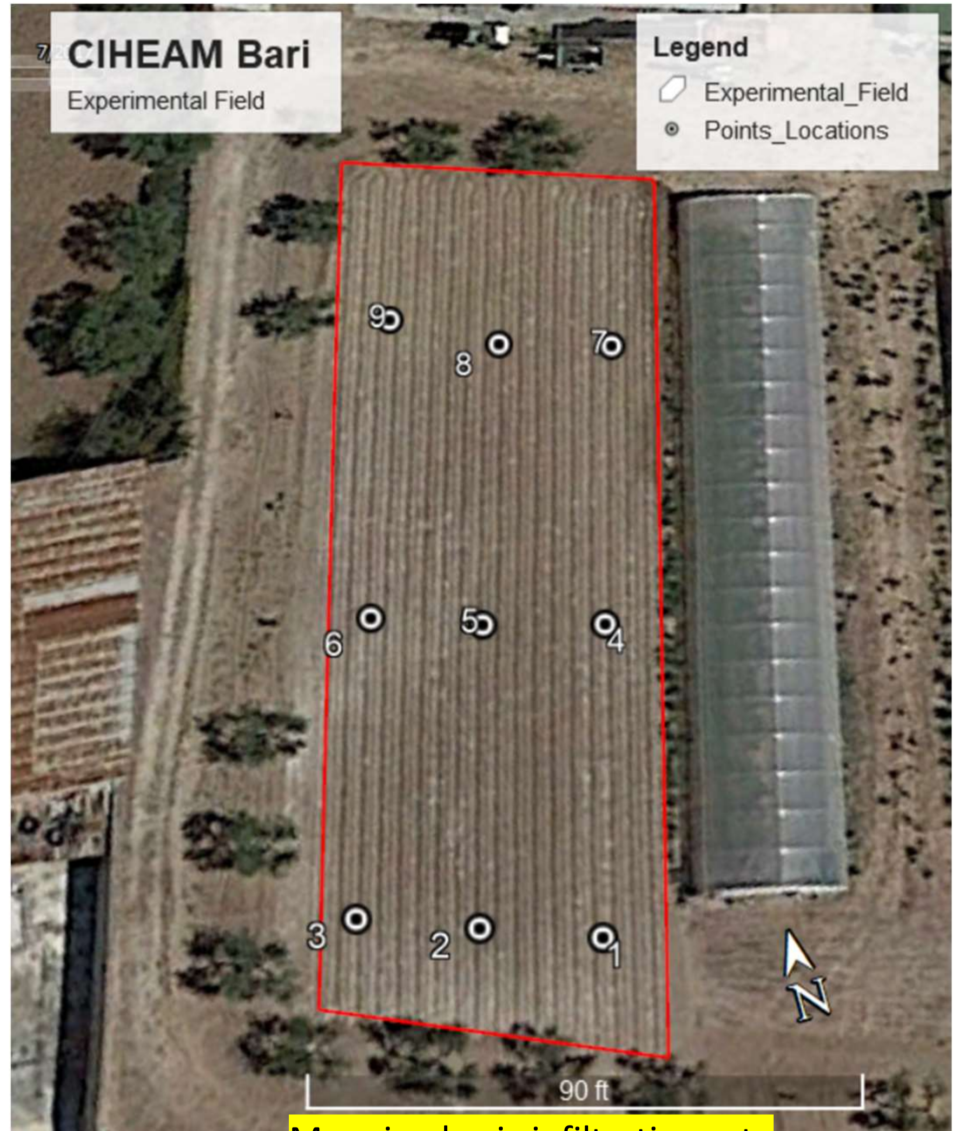
Algorithm Flowchart



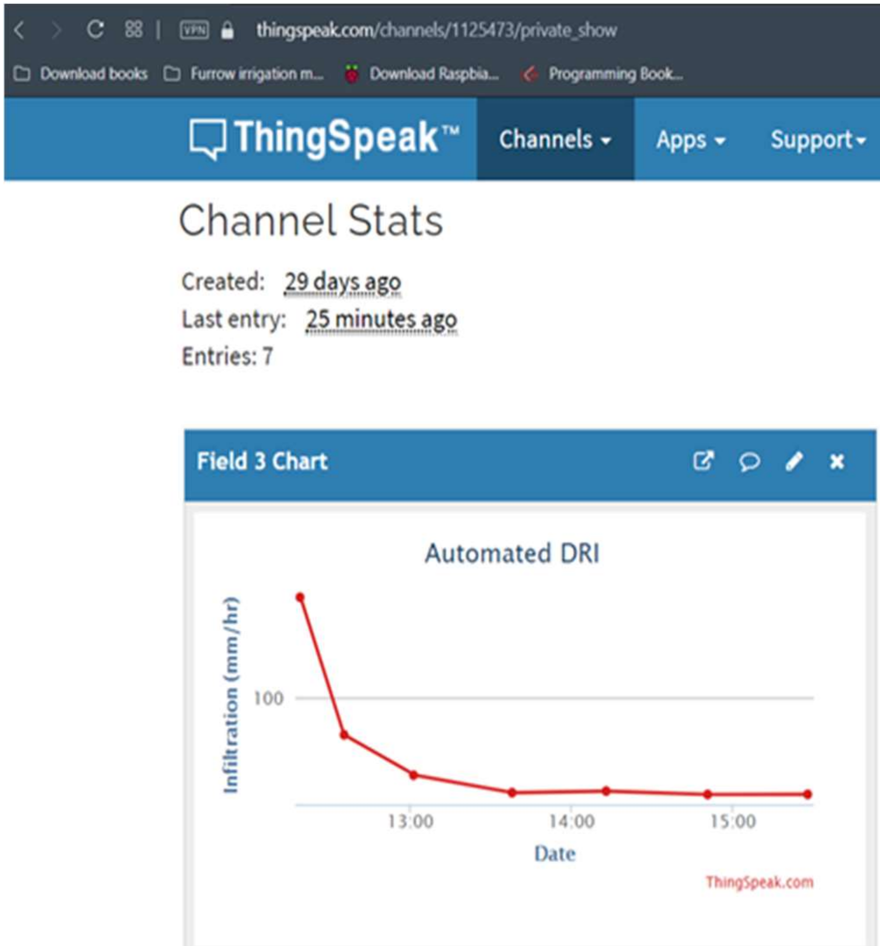
Connections scheme

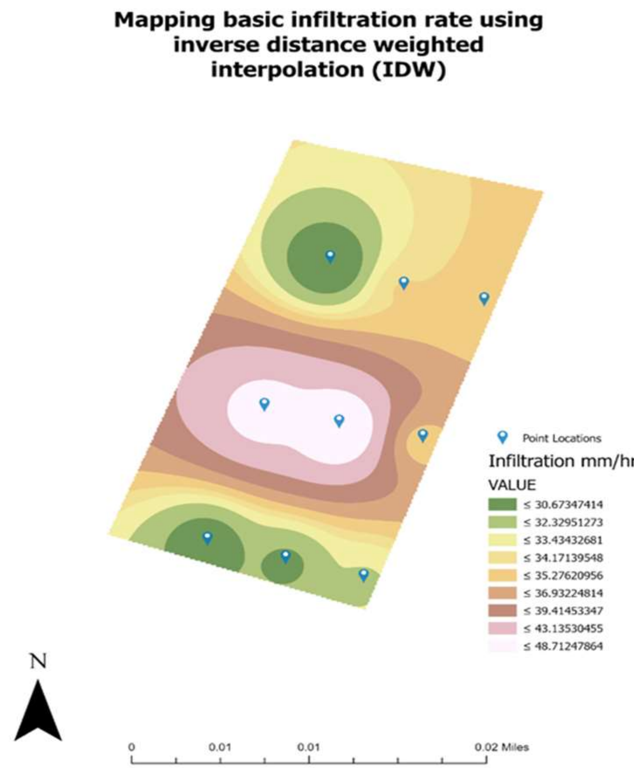


Validation results



Mapping basic infiltration rate


thingspeak.com/channels/1125473/private_show
Download books
Furrow irrigation m...
Download Raspbia...
Programming Book...
ThingSpeak™
Channels
Apps
Support
Commercial Use
How to Buy
AA
Channel Stats
Created: 29 days ago
Last entry: 25 minutes ago
Entries: 7
Field 3 Chart
Automated DRI
Infiltration (mm/hr)
100
13:00
14:00
15:00
Date
ThingSpeak.com


Mapping basic infiltration rate using inverse distance weighted interpolation (IDW)
Point Locations
Infiltration mm/hr
VALUE
≤ 30.67347414
≤ 32.32951273
≤ 33.43432681
≤ 34.17139548
≤ 35.27620956
≤ 36.93224814
≤ 39.41453347
≤ 43.13530455
≤ 48.71247864
N
0
0.01
0.01
0.02 Miles

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Original papers

Internet of Things (IoT) for double ring infiltrometer automation

Ahmed A. Abdelmoneim [a,c], Andre Daccache [b], Roula Khadra [c,*], Mayank Bhanot [b], Giovanna Dragonetti [c]

[a] Department of Agricultural and Environmental Science, University of Bari, Piazza Umberto 1, Bari, Italy
[b] Department of Biological and Agricultural Engineering, University of California Davis, One Shields Avenue, Davis, CA, USA
[c] Mediterranean Agronomic Institute of Bari, Via Ceglie 9, 70010 Valenzano, BA, Italy

ARTICLE INFO

Keywords:
Soil variability
Precision agriculture
Irrigation
Infiltration
Microcontroller
Hydraulic conductivity

ABSTRACT

Double ring infiltrometer is a simple device used to measure water infiltration rate in the soil, one of the most important hydro physical characteristics and an essential parameter for various applications including: surface irrigation and drainage projects, infiltration or water purification basins, seepage losses at canals, soil leaching at waste storage sites. However, the high spatial variability of a soil makes a single point measurement rarely representative of an entire field. Nonetheless, Double Ring Infiltration tests are tedious, time consuming and require continuous attention, hence limiting the number of tests that may be performed simultaneously on a given site.

In the present research, an automated Internet of Things (IoT) double ring infiltrometer (DRI) is developed and validated in a loamy field. It consists of a DRI equipped with an ESP-32 microcontroller chip, a GPS module, a solenoid valve, a DIY conductance water level sensor, and a SD card module powered by a 12 V 11000mAh Li-ion battery charged by a 10 W solar panel. The double ring infiltrometer is designed to calculate the infiltration rate in real time, to store the data with the time stamp and geographical coordinates on an SD card or, to use a cloud service platform to upload the data over the internet. The aim is to facilitate soil infiltration mapping for precision agriculture and to build a soil infiltration inventory that could be used to continuously improve existing soil database.

The system was assembled and tested at nine different locations on a loamy soil experimental field. For validation, conventional (manually operated) tests were conducted at the same time. The system proved to be reliable (R^2 = 0.99), cost effective (115$) and a hassle-free solution, ideal for multiple soil infiltration measurements.

https://www.sciencedirect.com/science/article/pii/S0168169921003410

Examples of the lab Prototypes: Tensiometers

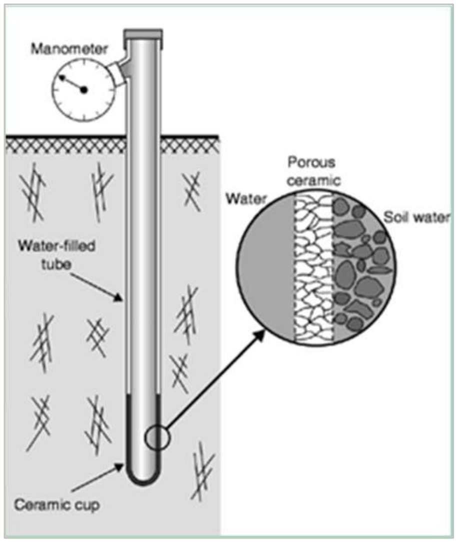
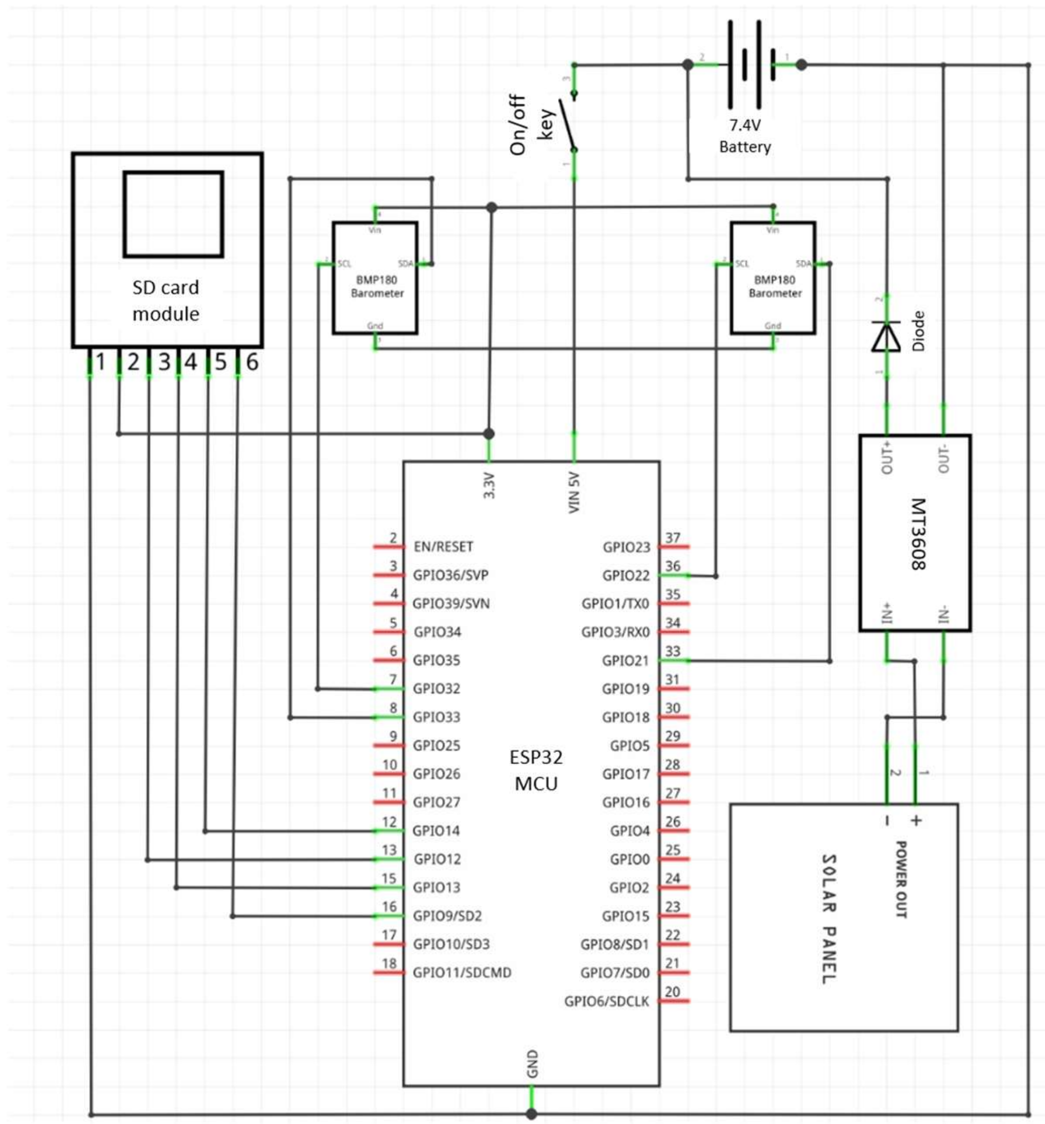


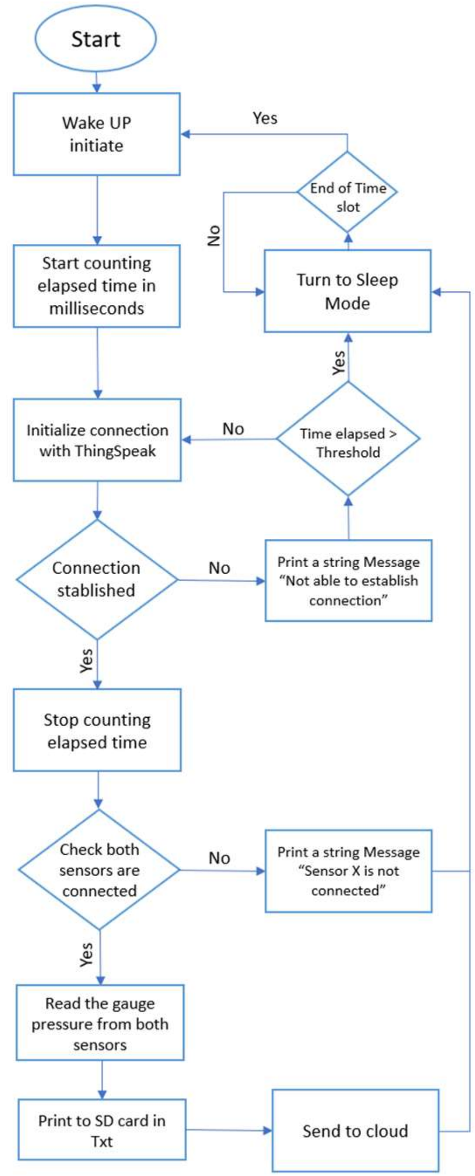
Figure 2: Diagram of a tensiometer (Encyclopaedia of Agrophysics,2014)

Traditional tensiometers drawbacks	Advantages tensiometers based on IoT
Needs physical presence and labor	Can have remote access to the field
Possibility of wrong readings	Less erroneous readings
Discontinuous manual readings and time consuming	Allows continuous monitoring of soil matric potential in real time
Only small amount of data can be sensed	Collects and stores a very big amount of data with higher resolution

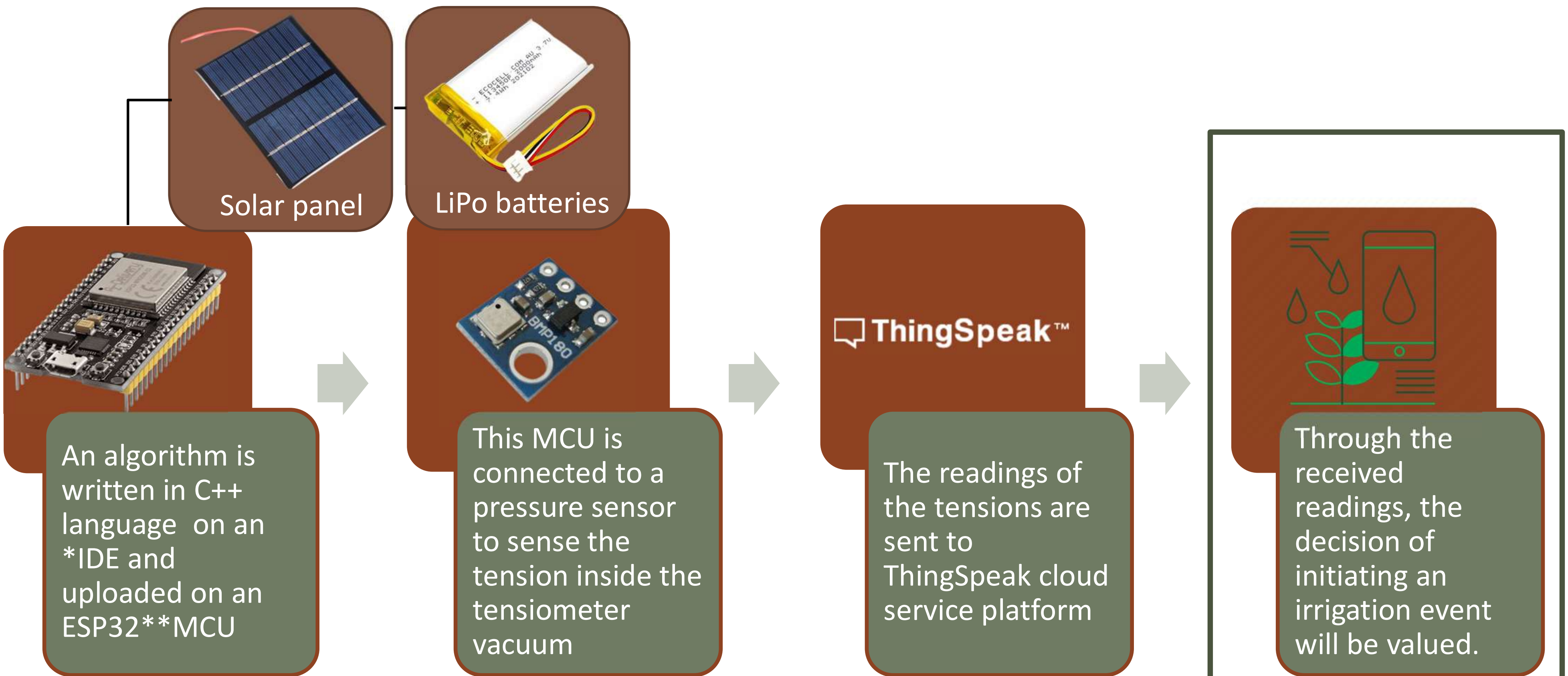
The tensiometer is an instrument composed by a porous cup, a vacuum gauge and a water filled tube



Connections scheme

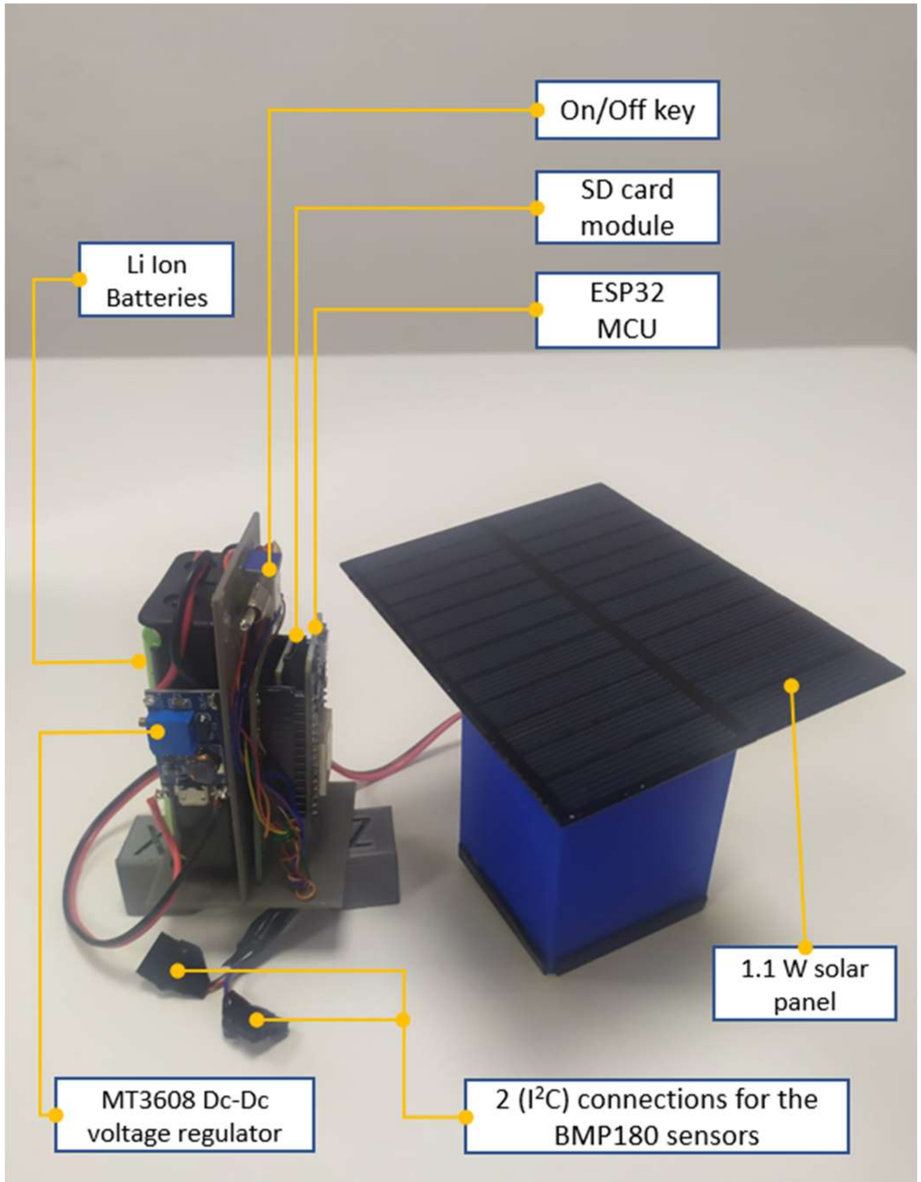


Algorithm Flowchart

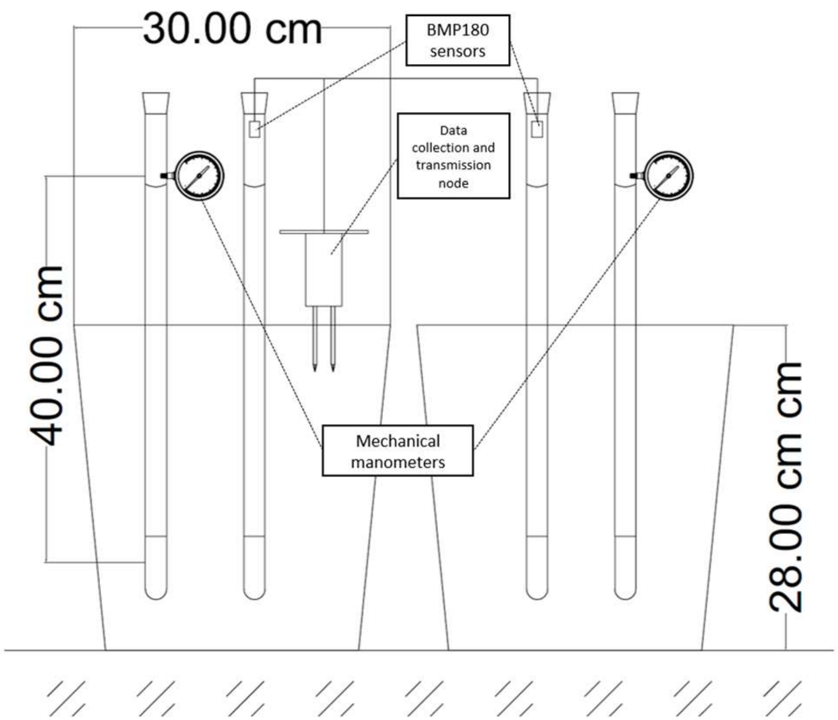


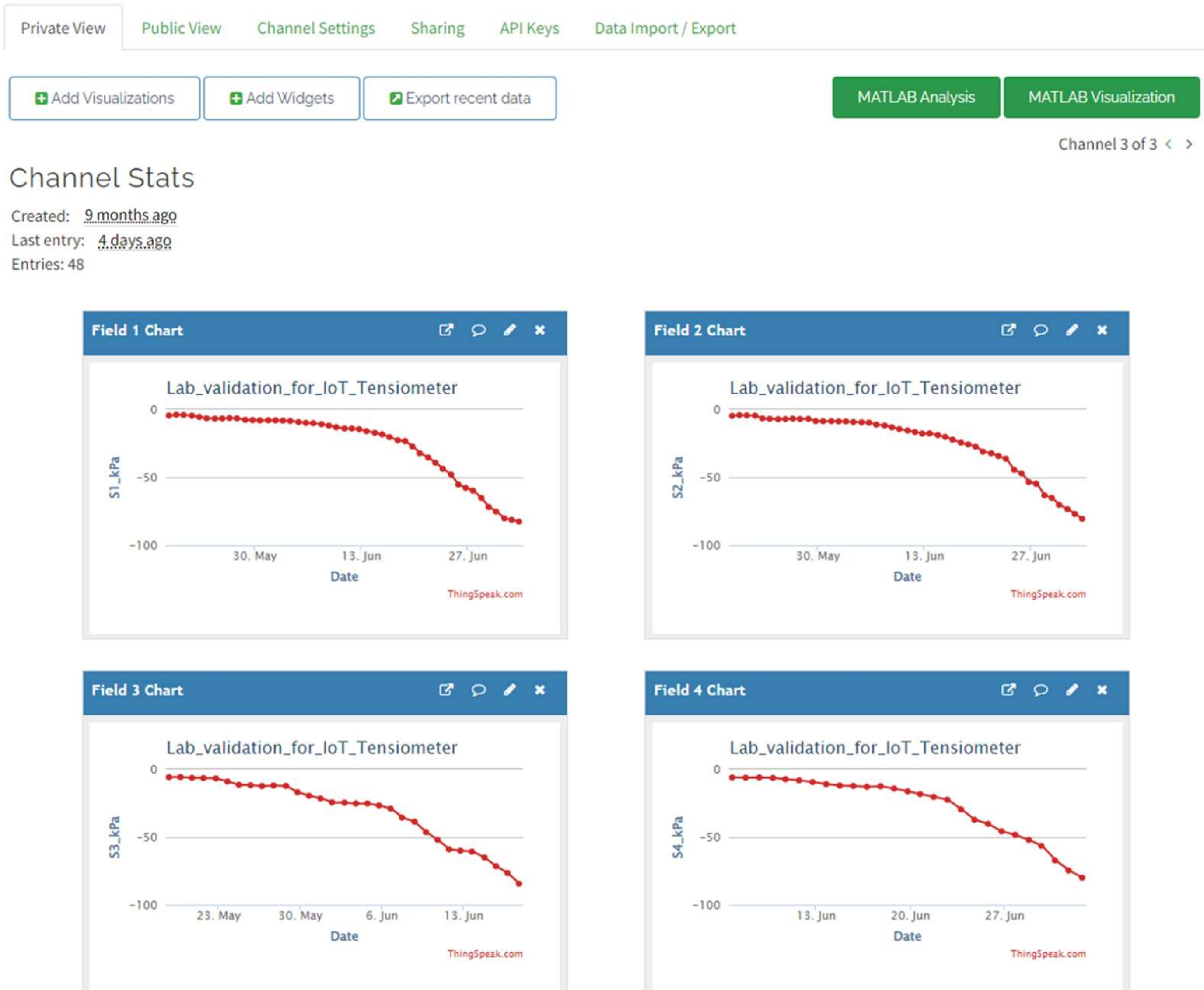
*IDE: Integrated development environment

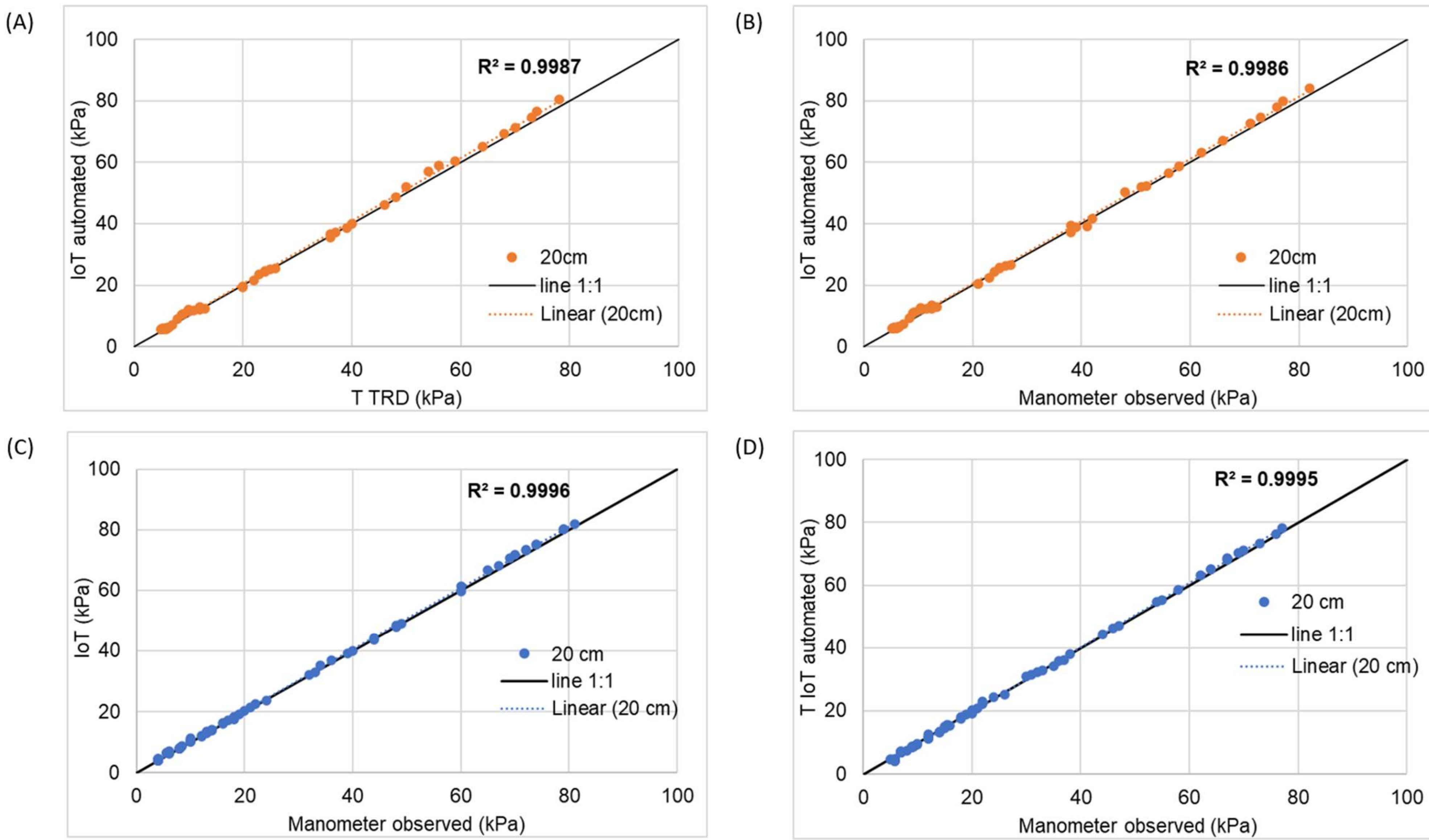
**MCU: Micro-controller unit


On/Off key
SD card module
ESP32 MCU
Li Ion Batteries
1.1 W solar panel
MT3608 Dc-Dc voltage regulator
2 (I2C) connections for the BMP180 sensors

Validation setup




Private View
Public View
Channel Settings
Sharing
API Keys
Data Import / Export
Add Visualizations
Add Widgets
Export recent data
MATLAB Analysis
MATLAB Visualization
Channel 3 of 3
Channel Stats
Created: 9 months ago
Last entry: 4 days ago
Entries: 48
Field 1 Chart
Lab_validation_for_IoT_Tensiometer
S1_kPa
0
-50
-100
30. May
13. Jun
27. Jun
Date
ThingSpeak.com
Field 2 Chart
Lab_validation_for_IoT_Tensiometer
S2_kPa
0
-50
-100
30. May
13. Jun
27. Jun
Date
ThingSpeak.com
Field 3 Chart
Lab_validation_for_IoT_Tensiometer
S3_kPa
0
-50
-100
23. May
30. May
6. Jun
13. Jun
Date
ThingSpeak.com
Field 4 Chart
Lab_validation_for_IoT_Tensiometer
S4_kPa
0
-50
-100
13. Jun
20. Jun
27. Jun
Date
ThingSpeak.com


(A)
R² = 0.9987
IoT automated (kPa)
T TRD (kPa)
20cm
line 1:1
Linear (20cm)
(B)
R² = 0.9986
IoT automated (kPa)
Manometer observed (kPa)
20cm
line 1:1
Linear (20cm)
(C)
R² = 0.9996
IoT (kPa)
Manometer observed (kPa)
20 cm
line 1:1
Linear (20 cm)
(D)
R² = 0.9995
T IoT automated (kPa)
Manometer observed (kPa)
20 cm
line 1:1
Linear (20 cm)

micromachines

MDPI

Article

Internet of Things (IoT) for Soil Moisture Tensiometer Automation

Ahmed Ali Abdelmoneim, Roula Khadra *, Bilal Derardja and Giovanna Dragonetti

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* Correspondence: khadra@iamb.it

Abstract: Monitoring of water retention behavior in soils is an essential process to schedule irrigation. To this end, soil moisture tensiometers usually equipped with mechanical manometers provide an easy and cost-effective monitoring of tension in unsaturated soils. Yet, periodic manual monitoring of many devices is a tedious task hindering the full exploitation of soil moisture tensiometers. This research develops and lab validates a low cost IoT soil moisture tensiometer. The IoT-prototype is capable of measuring tension up to −80 Kpa with R^2 = 0.99 as compared to the same tensiometer equipped with a mechanical manometer. It uses an ESP32 MCU, BMP180 barometric sensor and an SD card module to upload the measured points to a cloud service platform and establishes an online soil water potential curve. Moreover, it stores the reading on a micro-SD card as txt file. Being relatively cheap (76 USD) the prototype allows for more extensive measurements and, thus, for several potential applications such as soil water matric potential mapping, precision irrigation, and smart irrigation scheduling. In terms of energy, the prototype is totally autonomous, using a 2400 mAh Li-ion battery and a solar panel for charging, knowing that it uses deep sleep feature and sends three data points to the cloud each 6 h.

Keywords: precision agriculture; microcontroller; IoT irrigation; ESP32; sensors; BMP180

1. Introduction

Water scarcity, exacerbated by climate change, is becoming a fast-spreading threat impacting livelihood, food security, economic development, and social stability. Globally, irrigated agriculture represents 70% of freshwater consumption [1,2], acting as both a major cause and a casualty of water scarcity. Thus, efforts towards enhancing on-farm irrigation management are crucial to face such challenges for the finite resource.

One of the main obstacles that hinders such efforts is the lack of cost effective and reliable data monitoring systems. Putting into consideration the spatially variable nature of agricultural systems, the availability of low-cost energy autonomous data collection means is crucial; spatial features mapping being an essential step towards more precise planning (scheduling), monitoring, and evaluation of irrigation events [3]. In fact, a combination of monitoring and modelling techniques is needed to both understand spatial variability impacts and assess the accuracy of the models [4]. In this study, a low cost IoT soil moisture tensiometer is introduced and lab validated to enable soil water potential mapping, visualizing, and archiving in real time on a cloud service platform.

Citation: Abdelmoneim, A.A; Khadra, R.; Derardja, B.; Dragonetti, G. Internet of Things (IoT) for Soil Moisture Tensiometer Automation. *Micromachines* **2023**, *14*, 263. https://doi.org/10.3390/mi14020263

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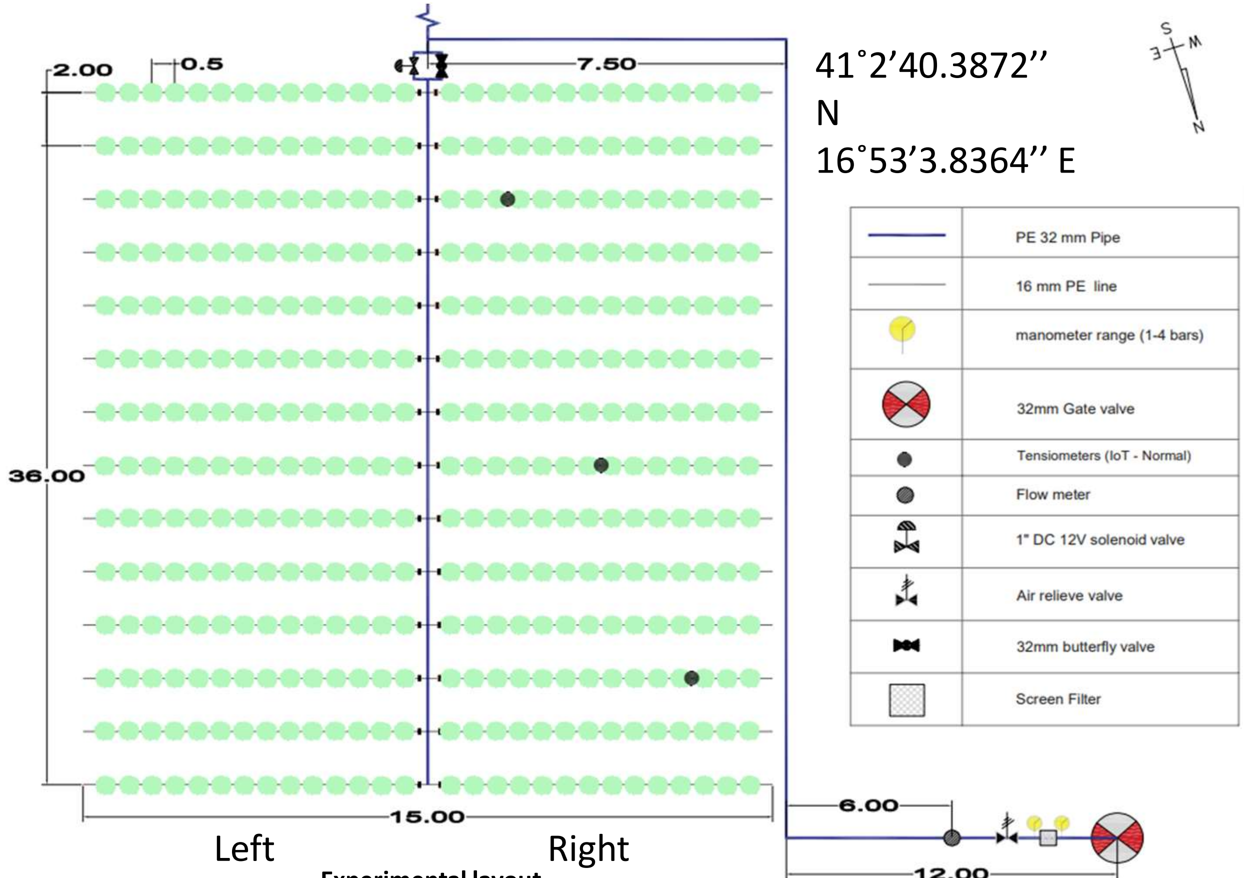
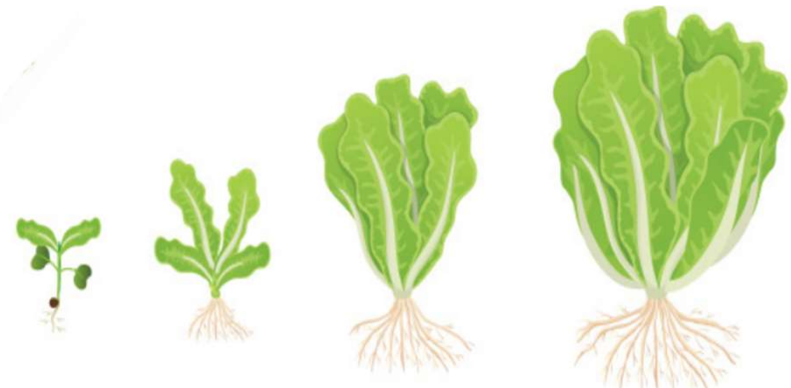
https://www.researchgate.net/publication/367316961_Internet_of_Things_IoT_for_Soil_Moisture_Tensiometer_Automation

Field Setup:



Experimental layout

41˚2’40.3872’’ N
16˚53’3.8364’’ E



Real image of the study field at CIHEAM Bari, Puglia region, Italy

Overcoming challenges through digital agriculture Education

Digital agriculture educational activities

- Hands on internet of things (IoT) sensing for data driven decision support systems through microcontrollers programming
- Using Unmanned Aerial Vehicles (UAVs) for spatial variability mapping and precision agriculture.
- Combining remote sensing with machine learning techniques for enhanced on farm management.
- AI and Computer vision for agricultural applications.
- Hands on 3D printing for prototyping.
- Introduction to robotics

Thanks