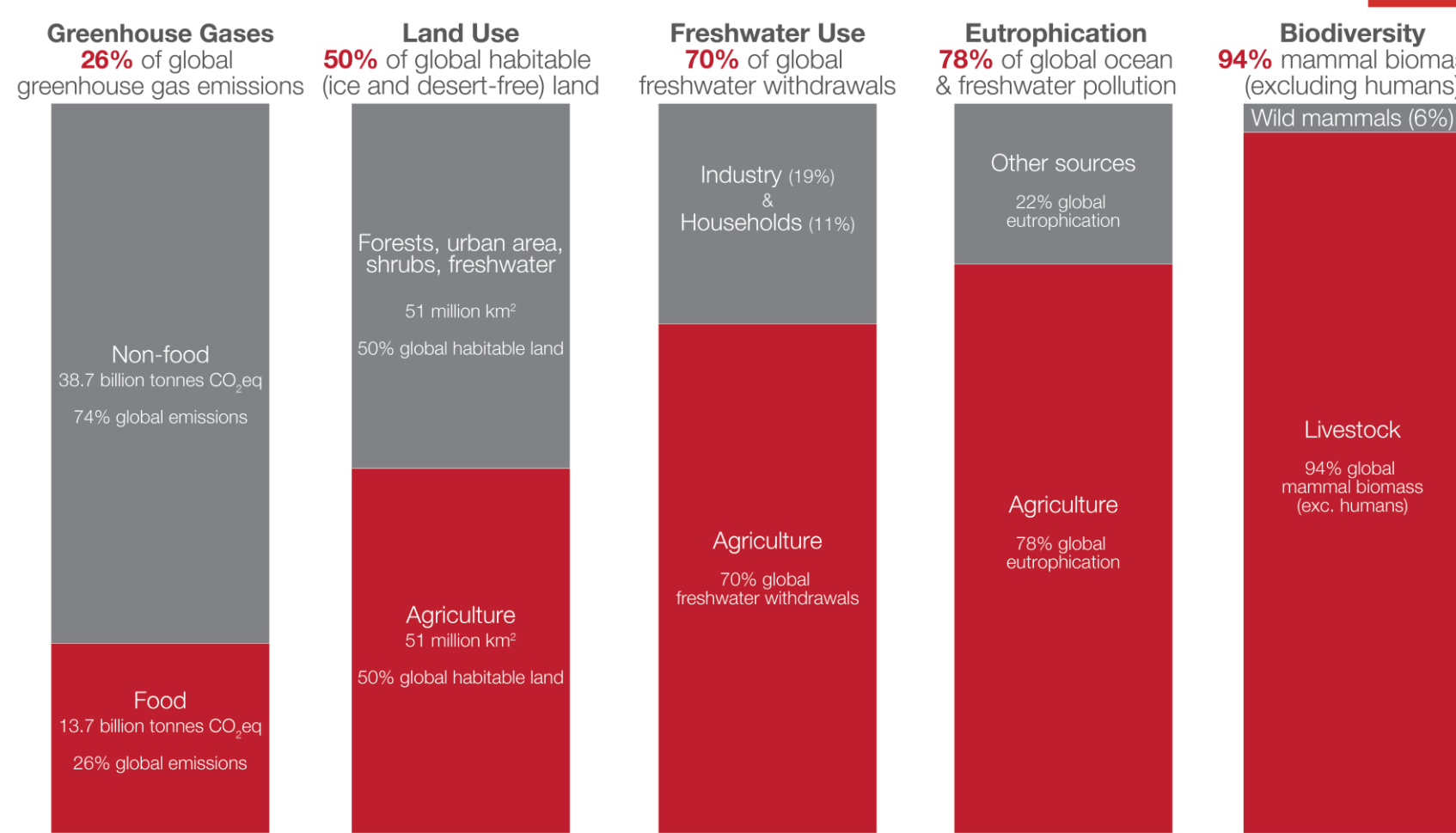


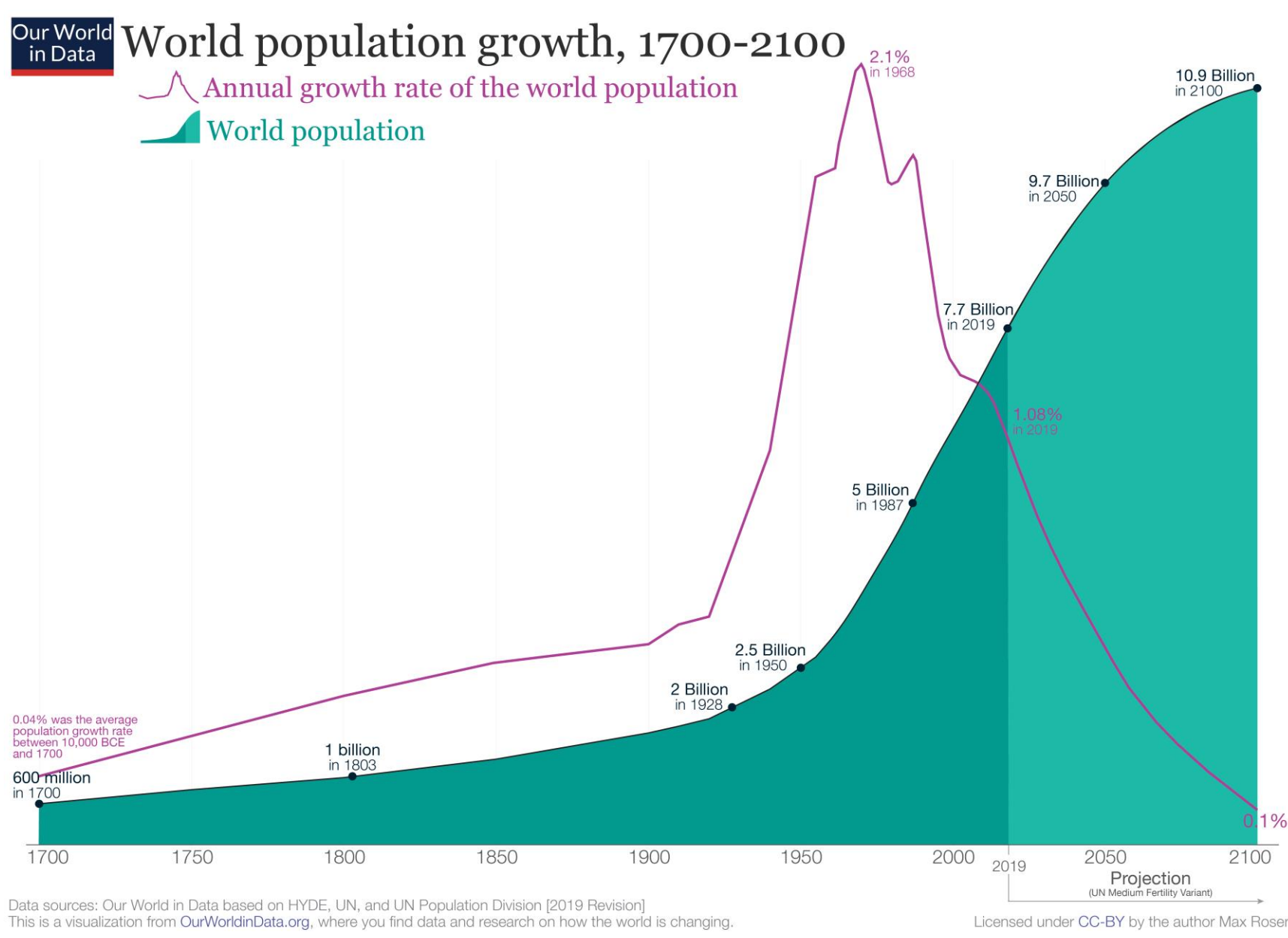
Research context and motivation

What are the environmental impacts of food and agriculture?



- Food Production is responsible for **30%** of global **greenhouse gases emission** and **70%** of **freshwater withdrawals**
- Recent studies state that world population will reach **10 billion** by the end of this century

- Food production needs to boost dramatically to feed an increasing population and its environmental footprint **MUST** decrease significantly
- **Smart Agriculture** will have a major role in the next decades to **increase food production** and, at the same time, **reduce its environmental impact**



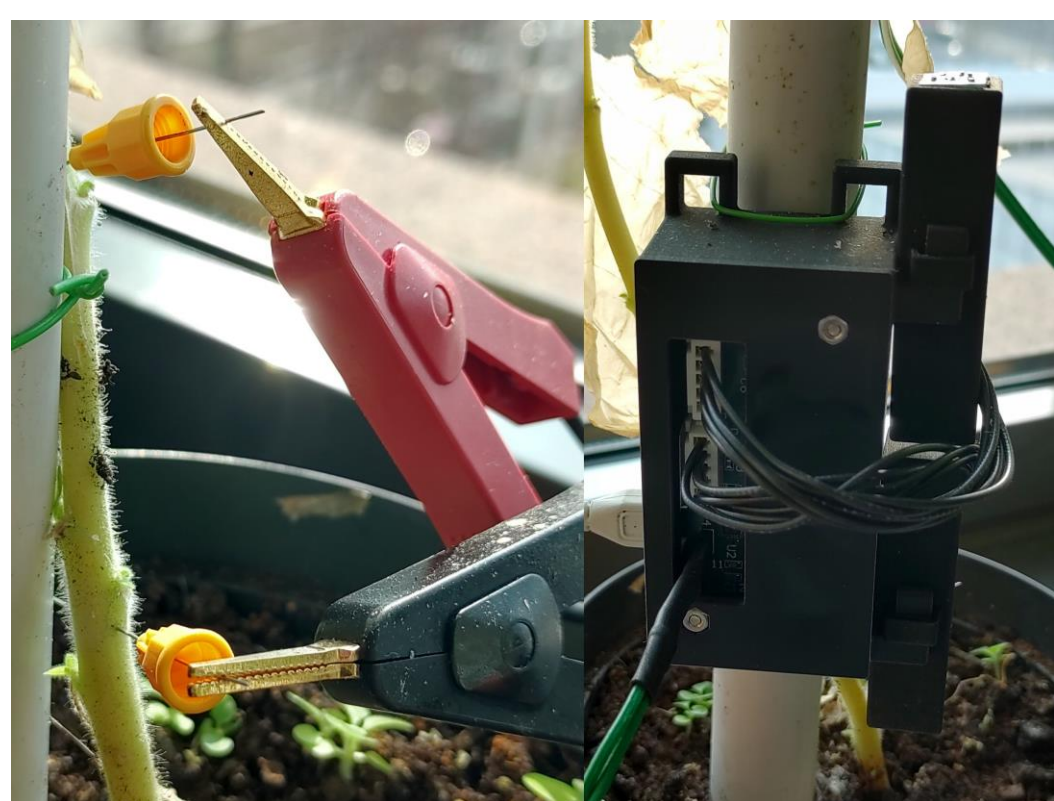
Addressed research questions/problems

- Until recently, smart agriculture focused on inspecting crops **environment** rather crops themselves
- Bulky, **expensive**, and **hard-to-use** instruments
- Unexperienced users



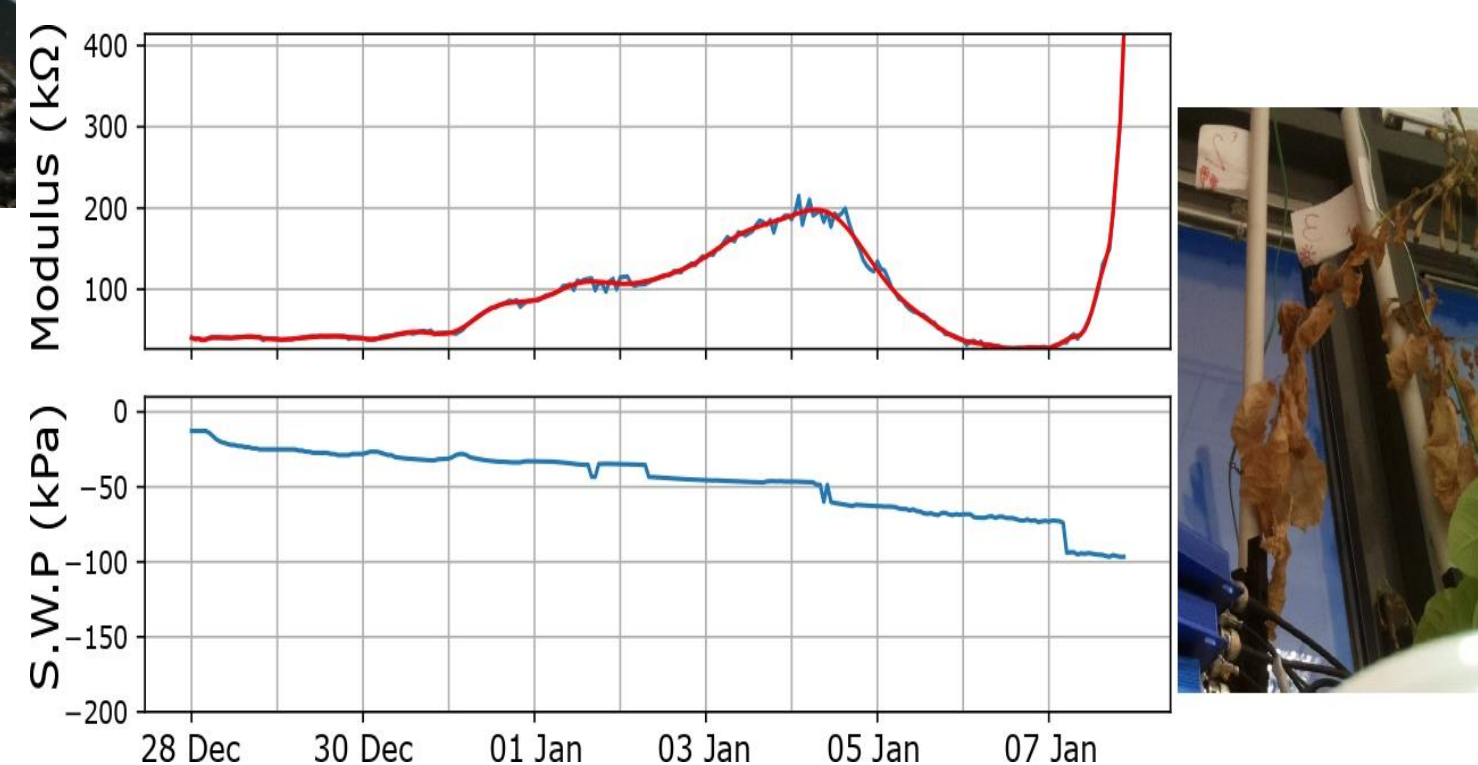
Picture taken from: «NetSens» website, url:https://www.netsens.it/en/products/agricultural-weather-stations-1

- Focus on the plant itself
- Plants seen as a 'patience'
- **Low-power, low-cost, autonomous**, light-weighted, and easy-to-use devices
- **Deploy and Forget**



Pictures taken from: «Ask the Plants Directly: Understanding Plant Needs using Electrical Impedance Measurements», Garlando, U. et al., 2022

- Although soil water potential level (S.W.P.) did not significantly change, the **plant dried...**
... And the **impedance noticed it**

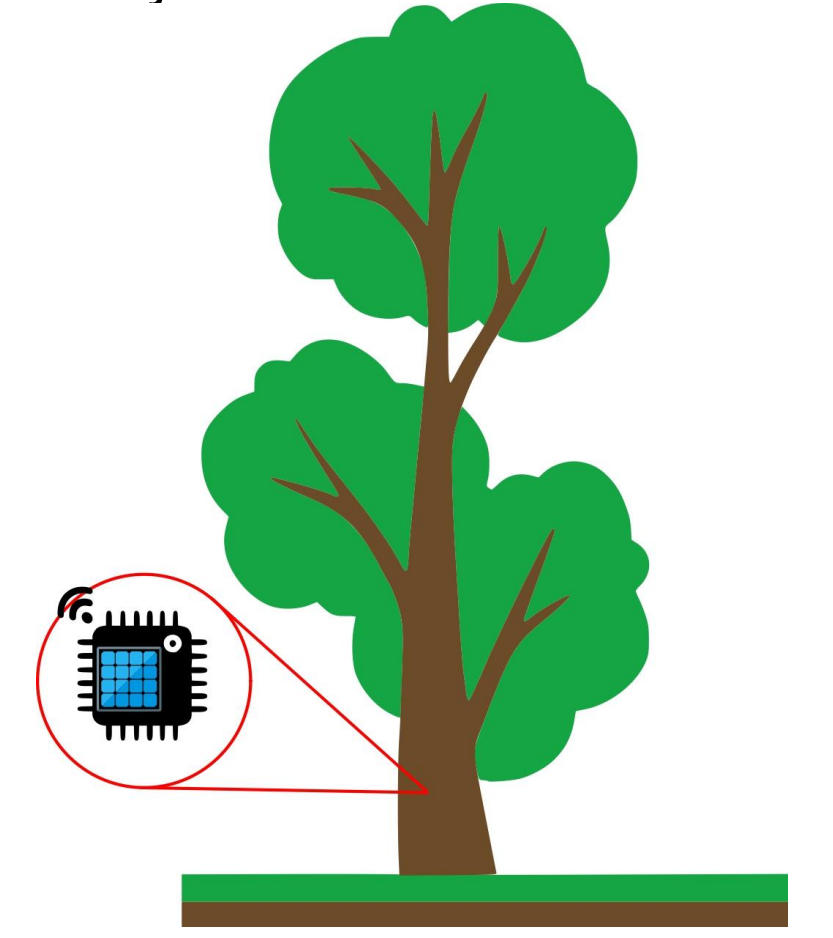


Submitted and published works

- Garlando, U., Bar-On, L., Motto Ros, P., Sanginario, A., Calvo, S., Martina, M., Avni, A., Shacham-Diamand, Y., and Demarchi, D., "Analysis of In-Vivo Plant Stem Impedance Variation with External Condition Daily Cycle", IEEE Internal Symposium on Circuits and Systems (ISCAS), Daegu, Korea, 2021, pp. 1-5
- Garlando, U., Calvo, S., and Barezzi, M., Sanginario, A., Motto Ros, P., and Demarchi, D. "Ask the Plants Directly: Understanding Plant Needs Using Electrical Impedance Measurements", Computers and Electronics in Agriculture, Vol. , no. 193, 2022, pp. 106707

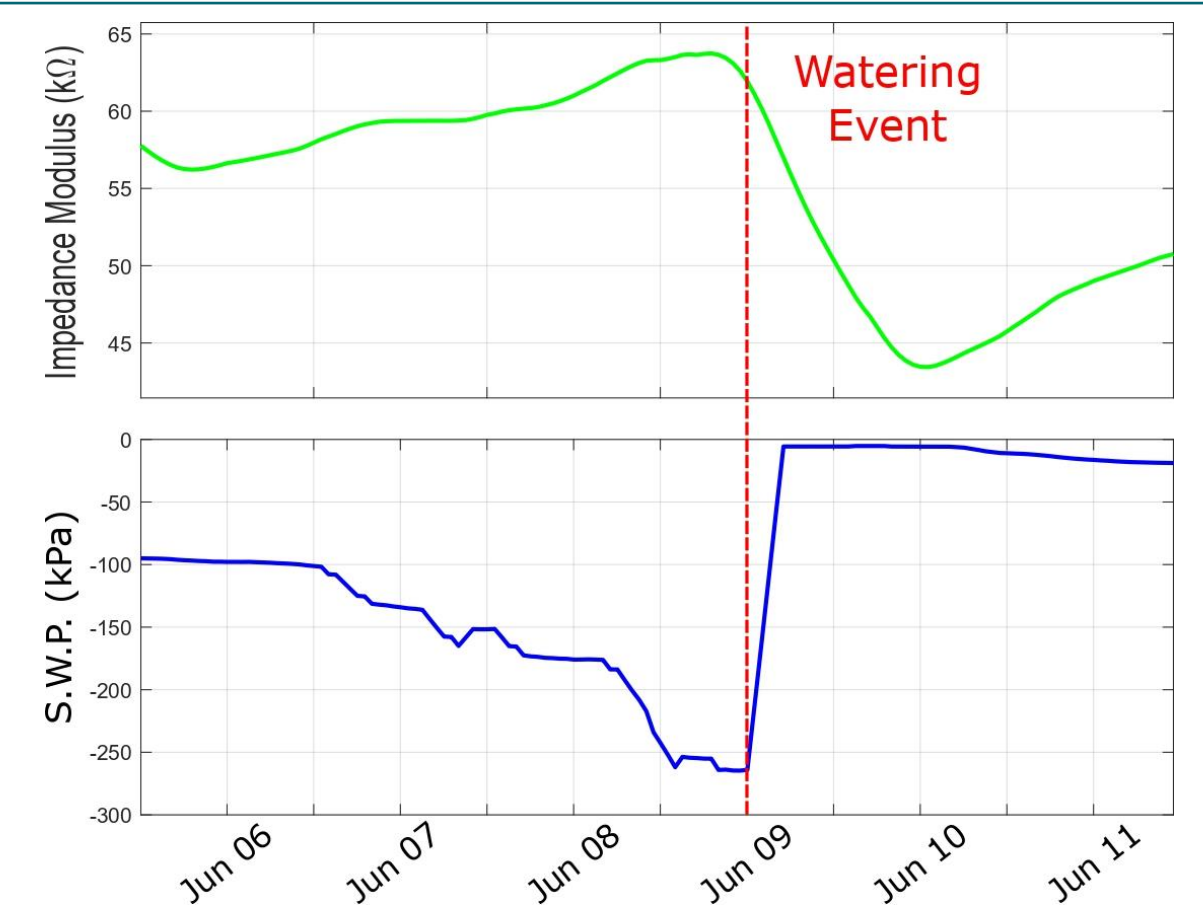
Novel contributions

- **In-Vivo** and **real-time** stem electrical impedance analysis over time used to assess plants health status.
- Development of a **device**:
 - **Cheap**
 - **Small**
 - **Energetically Autonomous**
 - **Relying on Renewable Resources**
 - Able to implement the approach of 'Deploy and Forget'



Adopted methodologies

- **24/7** electrical impedance analysis sampled once per hour
- The first step is to understand how the **impedance varies** with respect to **external stimuli** to estimate correlation
- Correlation assessed with **Pearson's test**

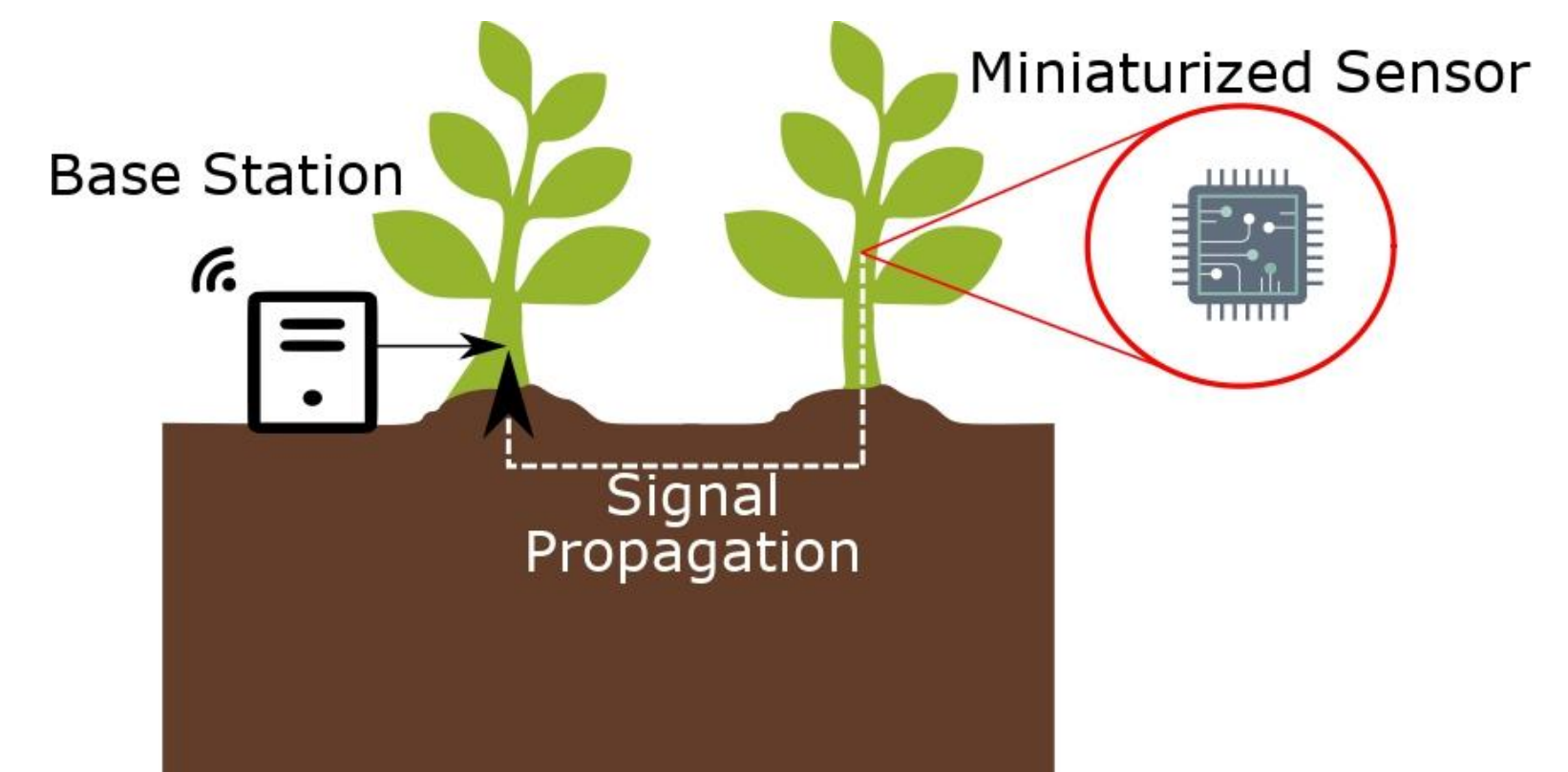


Correlation Coefficients	Impedance Modulus	Soil Moisture
Impedance Modulus	1	-0,91
Soil Moisture	-0,91	1

- Spectroscopy performed in a **200 Hz – 1 MHz** range
- High-passing filter behavior
- **10 kHz** chosen to perform statistical tests

Future work

- Design of a **custom PCB** to read plant stem impedance
- Exploit **soil and plant conductivity** to carry the signal towards the base station
- **Internet of Plants**: crops as nodes in a WSN



List of attended classes

- 02LWHRV – Communication (08-01-2022, 1)
- 01SHMRV – Entrepreneurial Finance (10-01-2022, 1)
- 01UIZRV – Microwave Sensing and Imaging for Innovative Application in Health and Food Industry (01-01-2022, 4)
- 01UNYRV – Personal Branding (16-12-2021, 1)
- 02SFURV – Advanced MATLAB Programming (21-04-2022, 6)
- 08IXTRV – Project Management (06-01-2022, 1)
- 01RISRV – Public Speaking (08-01-2022, 1)
- 01SYBRV – Research Integrity (23-12-2021, 1)
- 01SWQRV – Responsible Research and Innovation, The Impact on Social Challenges (09-01-2022, 1)
- 01QRTRV – Satellite Navigation Signal Exploitation For Atmospheric and Environmental Monitoring (30-06-2022, 3)
- 01DNHRV – System Level Low Power Technique for IoT (15-07-2022, 4)
- 01QEZRv – Sviluppo e Gestione di Sistemi di Acquisizione Dati (05-09-2022, 5)
- 02RHORV – The New Internet Society: Entering the Black-Box of Digital Innovations (07-01-2022, 1)
- 01UNXRV – Thinking Out of the Box (16-12-2021, 1)
- 01SWPRV – Time Management (16-12-2021, 1)