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ETHIOPIA	Water and Land Resources Institute (WLRI)
FINLAND	Finnish Environment Institute (SIKE)
ITALY	Agenzia Italiana per la Cooperazione allo Sviluppo – Sede Cairo (AICS-Cairo)
ITALY	Centro Internazionale di Alti Studi Agronomici Mediterranei di Bari (CIHEAM-Bari)
ITALY	Italian Research Council (CNR-IPSP)
KENYA	Kenya Agricultural & Livestock Research Organization (KALRO)
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THE NETHERLANDS	International Soil Reference Center (ISRIC)
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Abstract (for dissemination)	From 9th to 20th September 2024, the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM Bari), as technical and scientific lead partner of WATDEV project, organized and conducted the 2nd Module of the Course "Water, Soil, and Crop Management in a Climate-Smart Agriculture" on its Campus in Bari, Italy. The training module offers a comprehensive approach to cutting-edge technologies and their agriculture and water management applications. The second module was divided into two phases: virtual training from September 9th to 13th, and in-person sessions at the Mediterranean Innovation Hub at CIHEAM Bari, Italy, from September 16th to 20th. Twenty participants from Egypt, Ethiopia, Kenya, and Sudan attended the course, which combined theoretical lessons with hands-on experience in advanced agricultural practices. The first part of the course (September 9-13) was held online, in conjunction with CIHEAM Bari's Advanced Specialized Course on "Precision Agriculture for the Mediterranean Region". This week's Program dealt with innovative solutions such as remote sensing, satellite imagery, and drone technology, revolutionizing farming practices and water management. During the in-person segment (September 16-20), participants were attended frontal lectures and hands-on field visits. Highlights included learning about precision agriculture, automation, robotics, digital water management, and plant phenotyping. Visits to the Valle Verde farm, Andriani Spa Factory, and ApuliaKundi farm showcased the integration of circular economy principles and cutting-edge agricultural practices. The training also prepared participants to become trainers in their home countries, ensuring that the knowledge they gained could be shared with local farmers, authorities, and stakeholders. This initiative supported sustainable agricultural and water management practices across their regions. According to the participants' training evaluation, the participants' expectations were fulfilled plenty. As the second module concluded, participants left with enhanced skills and knowledge, ready to apply what they had learned in their regions. By empowering future trainers, the WATDEV project continued to promote sustainable agricultural and water management practices, contributing to the resilience and growth of agriculture in these regions.
Keywords	Precision agriculture, innovation, circular economy, Training, Capacity building

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Acronyms and Abbreviations

AI	Artificial Intelligence
AICS	Italian Agency for Development Cooperation
AQP	Acquedotto Pugliese, Italy
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa, Uganda
AU-EU	Africa-Europe
CIHEAM	Centre International de Hautes Etudes Agronomiques Méditerranéennes, Italy
CNR-	Consiglio Nazionale delle Ricerche, Italy
DG DEVCO	The Commission's Directorate-General for International Cooperation and Development
EARI	Ethiopian Institute of Agricultural Research, Ethiopia
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GIS	Geographic Information System
GPS	Global Positioning System
HRC	Hydraulics Research Center- Ministry of Water and Irrigation- Gezira, Sudan.
HU	Heliopolis University, Egypt
IRSA	Istituto di Ricerca sulle Acque, Italy
ISRIC	International Soil Reference Center, The Netherland
IWUA	Irrigation Water Users Association
KALRO	Kenya Agricultural & Livestock Research Organization, Kenya
KU	Khartoum University, Sudan
NRC	National Research Council, Sudan
PA	Precision Agriculture
R&I	Research and Innovation
SACCO	Savings Credit and Cooperative Organizations
STI	Science, Technology, and Innovation
SYKE	Finnish Environment Institute, Finland
URT	Thematics Research Unit
WATDEV	Climate Smart WATer Management and Sustainable DEVelopment for Food and Agriculture in North and East Africa
WLRC	Water and Land Resources Center, Ethiopia
WRC	Water Research Centre, Sudan

Executive Summary

The Climate Smart **WAT**er Management and Sustainable **DEV**elopment for Food and Agriculture in East Africa (WATDEV) aims to enhance the sustainability of agricultural water management and resilience of agro-ecosystems to climate change in Easter Africa and Egypt. AICS (Agenzia Italiana per la Cooperazione e lo Sviluppo) is the executive agency, CIHEAM-BARI is leading scientific institution working with ASARECA (Strengthening Agricultural Research in Eastern and Central Africa), KALRO (Kenya Agricultural and Livestock Research Organization), WLRC (Water, Land Resources Centre - Ethiopia), WRC (Water Research Centre, Sudan) and HU (Heliopolis University, Egypt). The project aims to develop an in-depth understanding of small to large-scale water and agricultural resource dynamics and management and people's resilience to climate through innovative research, modeling, and capacity-building approaches.

The overarching objective of the project is to enhance sustainability of agricultural water management and resilience of agro-ecosystems to climate change in East Africa and Egypt. The specific objectives include: (1) National Ministries and Research Institutions improve their knowledge and management of water in agriculture; and (2) Farmers and local actors, cooperatives and Water User Associations implement innovative/sustainable solutions and skills on water management.

The A2.2 Training and Capacity Building initiative aims to empower local stakeholders in effectively implementing Best Management Practices (BMPs) and Innovations within their respective regions and communities. Emphasis is placed on advocating for the adoption of targeted BMPs while nurturing sustainable development. The training program comprises three modules, each spanning a week.

The 2nd Module of the Course: "Innovative Technologies in Agriculture and water Management" took place from September 9th to 20th, 2024, hosted at the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) in Bari - Italy.

This comprehensive training aimed at providing participants with the latest knowledge in managing water, soil, and crops - critical components for implementing climate-smart agriculture in their regions.

The second module was divided into two phases: virtual training from September 9th to 13th, followed by in-person sessions at the Mediterranean Innovation Hub at CIHEAM Bari, Italy, from September 16th to 20th.

Twenty participants from Egypt, Ethiopia, Kenya, and Sudan attended the course, which combined theoretical lessons with hands-on experience in advanced agricultural practices. The training also prepared participants to become trainers in their home countries, ensuring that the knowledge they gained could be shared with local farmers, authorities, and stakeholders. This initiative supported sustainable agricultural and water management practices across their regions.

During the online training, jointly hold with the CIHEAM Bari Advanced Specialized Course: "Precision Agriculture for the Mediterranean Region", participants attended lectures covering a range of topics, such as:

- An introduction to Precision Agriculture (PA) and its practical applications
- The use of mechanization, robotics, and artificial intelligence (AI) in agriculture
- Socio-technical perspectives on PA, including its challenges and sustainability
- The role of technology producers and service providers in precision agriculture
- Tailored PA strategies for the Southern Mediterranean region
- Contributions of PA to sustainable water management
- CIHEAM Bari's innovations in pest surveillance and large-scale water management

These sessions provided a solid foundation for the hands-on training that followed in Italy.

The in-person portion of the program focused on digital technologies in agriculture, smart farming, and solar-powered irrigation systems. Participants had the opportunity to apply what they learned during a field visit to CIHEAM Bari's experimental fields. They practiced using drones for agricultural monitoring, specifically the DJI MAVIK 3 ENTERPRISE drone, equipped with multispectral and RGB cameras. Participants conducted exercises on post-flight mapping and scanning.

On September 18th, the group visited the Acquedotto Pugliese (AQP) Headquarters in Bari.

Here, they attended presentations on key topics in water management, including:

- Water Distribution Systems (WDS) addressing leakages and rehabilitation
- Smart Water Management (SWM) solutions and their role in managing non-revenue water (NRW)
- A technical tour of AQP's laboratory and control room
- This visit provided practical insights into water management, a crucial element for the efficient and sustainable use of resources in agriculture.
- The following day, participants travelled to the "Metapontum Agrobios" URT-IPSP experimental farm to explore recent advancements in plant phenotyping. Topics covered included:
- Platforms for precision phenotyping, both indoors and in the field
- Saline agriculture and the selection of resilient plant species
- The use of AI in plant phenotyping and lean phenotyping technologies
- Reuse of treated wastewater for irrigation, including a demonstration of a portable prototype for treating municipal wastewater

These discussions highlighted the importance of using advanced scientific tools and sustainable practices to strengthen agricultural resilience against climate change.

The final day of training included visits to several innovative agricultural businesses in Gravina di Puglia. At Andriani SpA, participants learned about the company's work in healthy food production, particularly its pioneering gluten-free pasta factory. They also visited the ApuliaKundi farm to see how spirulina alga was produced using treated wastewater coming from the pasta's production cycle.

The course concluded with a visit to La Valle Verde farm, where participants observed no-till seed drilling technology integrated with 4.0 agriculture practices, demonstrating how innovation could boost both productivity and sustainability.

As the second module concluded, participants left with enhanced skills and knowledge, ready to apply what they had learned in their own regions. By empowering future trainers, the WATDEV project continued to promote sustainable agricultural and water management practices, contributing to the resilience and growth of agriculture in these regions.

1. Introduction

1.1 Preamble

The Climate Smart **WAT**er Management and Sustainable **DEV**elopment for Food and Agriculture in East Africa (WATDEV) aims to enhance the sustainability of agricultural water management and resilience of agroecosystems to climate change in Easter Africa and Egypt. Agenzia Italiana per la Cooperazione e lo Sviluppo (AICS) is the executing agency, while CIHEAM-BARI is the leading scientific institution, working closely with the Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Kenya Agricultural and Livestock Research Organization (KALRO), Water, Land Resources Centre – Ethiopia (WLRC), Water Research Centre (WRC), Sudan and Heliopolis University (HU), Egypt.

The project develops an in-depth understanding of small to large-scale water and agricultural resource dynamics and management and people's resilience to climate through innovative research, modelling, and capacity-building approaches.

The overarching objective of the project is to enhance the sustainability of agricultural water management and the resilience of agroecosystems to climate change in East Africa and Egypt.

The specific objectives include: (1) National Ministries and Research Institutions improve their knowledge and management of water in agriculture; and (2) Farmers and local actors, cooperatives and Water User Associations implement innovative/sustainable solutions and skills on water management.

1.2 Purpose, Context and Scope of this Deliverable

The **main objective** of the activity A2.2 Training and Capacity Building is to provide support to local actors in effectively implementing Best Management Practices (BMPs) and Innovations in their respective territories and communities. The focus will be on promoting the adoption of selected BMPs and fostering sustainable development.

1.3 Structure and Content of the Deliverable

Deliverable D2.2.1 Two (2) reports on performed training and capacity building sessions

The structure for the D2.2.1 report is as follows: (i) executive summary, (ii) introduction (purpose, context, scope of the deliverable, and structure, content of the deliverable), (iii) context (organization of the Training, target audience, and impacts), (iv) conclusion; (v) references; and (vi) annexes.

This second document (D2.2.1(b)) contributes to the final deliverable providing information on the program and feedback received from participants to the 2nd Module carried out on early-September 2024.

2. Course structure

The overall training course is structured into three (3) modules, each spanning one week. These modules have been carefully designed to address the identified training needs and are outlined as follows:

Module 1: Introduction to BMPs and Innovations

- Comprehensive introduction to the selected Best Management Practices (BMPs) and Innovations, focusing on their technical aspects and providing participants with the knowledge necessary for successful implementation.
- Training on assessing the sustainability of BMPs, covering environmental, economic, and social dimensions. Participants will gain insights into evaluating the long-term viability and impact of BMPs in these key areas.

Module 2: Innovative Technologies in Agriculture and Water Management

- Exploration of cutting-edge technologies in agriculture and water management, equipping participants with an understanding of the latest advancements and their practical applications.
- Introduction to digital agriculture and decision-support tools, enabling participants to leverage technology for data-driven decision-making in agricultural practices and efficient water management.

Module 3: Networking for cooperating, Project design and Funding Opportunities

- Guidance on navigating the landscape of project design and funding opportunities. Participants will learn how to design or contribute designing a competitive and effective project idea to submit to international and local institutions for funding.
- Strategies for creating synergies at both the local and regional levels, fostering collaboration and knowledge sharing among stakeholders for enhanced outcomes.
- Training on techniques for accurate reporting and effective communication of results to end-users and decision-makers.

By structuring the training course in this manner, participants will acquire a comprehensive understanding of BMPs, innovations, sustainable practices, advanced technologies, project funding avenues, and effective communication strategies.

The course will provide participants with the necessary skills and knowledge to make meaningful contributions to the adoption and successful implementation of BMPs and innovations in their respective contexts.

2.1 Summary of Training course contents

The training course is strategically designed with a regional focus, aiming to have a broad impact on the target countries. It adopts the Training for Trainers (ToT) concept, emphasizing the multiplier effect by equipping participants to disseminate knowledge and skills within their local communities. The content of the training course has been developed based on the training needs identified during the A1.3 Multi-Actors' Regional Meeting that took place in Nairobi, Kenya, on 8th March 2023.

The primary beneficiaries of this training course are people from Egypt, Ethiopia, Sudan, and Kenya, who will play key roles in water management in food and agriculture through implementing relevant Best Management Practices (BMPs) and innovations within their respective regions.

The course features a combination of lectures and interactive work, providing participants with practical experiences and valuable insights.

To ensure the delivery of high-quality instruction, experienced international tutors will facilitate the training sessions. Their expertise and diverse perspectives will enrich the learning experience and foster knowledge exchange among participants. At the end of the course, attendees will be awarded attendance certificates issued by CIHEAM-Bari, acknowledging their active participation and successful completion of the training program. These certificates can serve as valuable credentials, highlighting the participants' commitment to advancing BMP implementation and innovation in their professional capacities.

Organizer and Contributing Partners

CIHEAM-Bari (Lead Partner)

CNR

ASARECA

HU

WLRC

WRC

KALRO

2.2 Beneficiaries

The A2.2 Training and Capacity Building Course targets a range of beneficiaries involved in the implementation of Best Management Practices (BMPs).

Targeted selected beneficiaries are end-users, extensionists, junior researchers, public officers, and young innovators engaged in BMPs implementation and innovation projects. By involving this diverse group of beneficiaries, the training aims at building a strong network of expertise with knowledge and skills able to enhance sustainable development in their respective fields.

Five participants for each country were selected by local partners (HU, KALRO, WRC, WLRC).

2.3 Participants' selection

The selection to enrol for the training and capacity building course on "Water, soil and crop management in a Climate-smart agriculture" was opened on **1st August 2023**.

The timeline of the selection procedure is in the table here below.

Table 1 – Timetable for the selection procedure

Selection start	1st August 2023
Selection closure	1st September 2023
Consensus phase	10th September
Communication of the selected participants	up to 15th September 2023
Start of the Course	Mid-December 2023

Local Partners carried out the selection of participants to ensure the highest impact and enhance the capacity of local personnel to effectively disseminate the knowledge acquired during the training course. While the Local Partners primarily handled the selection process, CIHEAM-Bari played an advisory role, especially in establishing the minimum requirements for participants.

This collaborative approach helped identify individuals with the potential to maximize the benefits of the training and contribute significantly to BMP implementation and innovation in their communities.

2.4 Participants' profiles

The A2.2 Training and Capacity Building Course was open to individuals with diverse educational backgrounds and expertise. The course welcomed graduates in scientific disciplines such as agronomy, ecology, geology, civil engineering, and agricultural engineering. While participants with professional experience were preferred, the course recognized the value of inclusivity and encourages individuals at various stages of their careers to participate.

There was no age limit for participants, and special consideration was given to young people showing a strong commitment to making a positive impact in their fields. By prioritizing the involvement of young participants, the training aimed to empower and nurture the next generation of leaders in BMP implementation and innovation.

Proficiency in the English language is essential as the training is conducted entirely in English.

This requirement ensures effective communication and facilitates seamless knowledge sharing among participants from diverse backgrounds.

Overall, the participant profile was characterized by a blend of educational qualifications, professional experience (where applicable), and a shared enthusiasm for advancing sustainable practices in BMPs and innovations. The course values diversity and encourages participants to bring their unique perspectives, contributing to a dynamic learning environment that fosters collaboration and cross-disciplinary knowledge exchange.

Table 2 - Participant Profile Criteria

Criteria	Requirement
Professional Experience	Preferred, but not mandatory
Age limit	No age limit
Foreign language knowledge	Proficiency in English
University degree	Graduates in relevant scientific disciplines

2.5 The Modules' structure and Duration

The first two modules of the Course will take place in CIHEAM-Bari Campus "Cosimo Lacirignola" (Valenzano, Bari- Italy): https://www.iamb.it/education/student-life/.

Each module is thoughtfully divided into various components to provide a comprehensive learning experience:

- Theoretical Lessons:

Participants were engaged in in-depth theoretical sessions led by subject matter experts. These sessions covered the fundamental concepts, principles, and theoretical frameworks related to the course topics.

- Practical Exercises:

To reinforce the theoretical knowledge, participants actively participated in practical exercises. These exercises provide hands-on experience, allowing participants to apply their learnings in simulated scenarios or real-world situations.

- On-Field Technical Visits:

To provide a practical understanding of the course topics, participants have the opportunity to embark on on-field technical visits. These visits enabled them to observe and learn from real-life implementations of Best Management Practices (BMPs) and innovations.

The course structure ensures a balanced blend of theoretical knowledge, practical application, and real-world exposure. This approach aims to enhance participants' understanding and skills, enabling them to effectively implement BMPs and innovations in their respective contexts.

The overall duration of the course's modules is the following:

Table 3 - Dates and Duration of the modules

Module no.	Duration (hours/days)	Date	Venue
1	42 hours (6 days)	11-16 December 2023	CIHEAM-Bari Campus
2	20 hours (5 days) 35 hours (5 days)	9-13 September 2024 (online) 16-20 September 2024	CIHEAM-Bari Campus
3	20 hours (4 days)	November-December 2024	online

Language

The course is held in English.

3. Methodology

3.1. Abstract of the Module 2 "Innovative Technologies in Agriculture and Water Management"

In the 2nd Module of the training course, participants will delve into the exciting realm of innovative technologies in agriculture and water management. This module is designed to equip participants with a comprehensive understanding of the latest advancements and their practical applications in these fields.

The **first week of the course (from 9 to 13 September)** was held online, jointly with the CIHEAM Bari Advanced Specialized Course: "Precision Agriculture for the Mediterranean Region". This first part led to an exploration of cutting-edge technologies in agriculture and water management, including the use of modern technologies in water resources management. Participants will be introduced to a wide range of innovative solutions that have the potential to revolutionize farming practices and water resource management.

One of the key areas covered in this module is precision agriculture and smart farming. Participants learned about the use of sensing technologies for precise monitoring and management of crops and soils. They discovered how remote sensing techniques, such as satellite imagery and drones, can provide valuable data for optimizing agricultural practices.

The participants attended in presence the **second week of the course (from 16 to 20 September)**. This session presented a mix between lectures and on-field technical visits, covering key areas ranging from precision agriculture and smart farming. Participants learned about the use of sensing technologies for precise monitoring and management of crops and soils. They discovered how remote sensing techniques, such as satellite imagery and drones, can provide valuable data for optimizing agricultural practices.

Throughout Module 2, participants will have the opportunity to engage with expert lecturers who specialize in innovative technologies in agriculture and water management. The module is designed to enhance participants' knowledge and skills, enabling them to leverage technology-driven approaches for sustainable and efficient agricultural practices and water resource management.

During a visit to the Valle Verde farm, in Gravina di Puglia, the participants can also see the benefits of the integration of automation and robotics in agriculture, exploring how autonomous systems and robotics can enhance efficiency and productivity in farming operations.

During the technical visit to the Andriani Spa Factory and ApuliaKundi farm, participants have a showcase of a successful experience of circular economy linking together the production of gluten-free pasta in a fully automatized plant, the reuse of water in the grown of Spirulina algae and the use of this one in the production of healthy food.

An in-depth analysis will be devoted to the recent advances in plant phenotyping to improve tolerance against abiotic stresses. This item will be afforded in the frame of an ad-hoc workshop organized under the umbrella of CNR-IPSP, during a technical visit to their experimental farm in Metaponto (Italy).

Another crucial aspect of Module 2 is digital water management systems. With the support of Acquedotto Pugliese (AQP) expertise, participants will gain insights into the role of digital technologies in water resource management. They will learn about the use of Internet of Things (IoT) applications, smart sensors, and real-time monitoring systems for efficient water utilization and conservation. The module will also cover the use of remote sensing techniques for water resources assessment, enabling participants to understand how satellite-based observations and data analysis can support effective water management.

By the end of this module, participants will have a solid understanding of the latest advancements in agriculture and water management. They will be equipped with the knowledge to identify and adopt appropriate technologies for optimizing farming practices, improving resource utilization, and addressing water management challenges.

The focus will be on understanding the principles and underlying concepts behind these technologies, as well as their benefits and applications in real-world scenarios.

Table 4 - Module 2 contents

Module 2	**Innovative Technologies in Agriculture and Water Management**
Title	*Contents*
Introduction to Precision Agriculture (Online part, joined with the CIHEAM Bari's Advanced Specialized Course in Precision Agriculture)	• Opening • Presentation of the advanced specialized course • General concepts of Precision Agriculture (PA) • Practical knowledge for an effective PA application • Mechanisation, robotics & Artificial Intelligence (AI) • Drivers and challenges of PA: a socio-technical perspective • The role of technology producers & service providers • The Southern Mediterranean context: the need of a tailored PA • Contribution of PA to sustainable water management • CIHEAM Bari innovations for precision pest surveillance & water management at landscape level
Innovative Technologies in Agriculture and Water Management	**Sensing Technologies and renewable energy integration** • Remote sensing techniques (satellite imagery, drones) • Sensor technologies for soil and crop monitoring • Data collection, analysis, and interpretation • Powering precision agriculture technologies with renewable energy. • Solar energy applications in agriculture • Irrigation systems, and farm operations
	Water resources management and monitoring • Integrated Water Resources Management approach • Hydraulic modelling • Flood Risk Management with Transboundary Conflict
Digital agriculture and decision-supporting tools	**Digital solutions for Water Management** • Overview of water management challenges • Role of digital technologies in water management • Integration of sensors and data in water monitoring
	Remote Sensing and IoT Applications • Remote sensing techniques for water and soil monitoring • Satellite-based observations of precipitation and evapotranspiration • Mapping and analysis of water availability, quality, and soil conditions • Smart sensors and network systems • Real-time monitoring and control of water resources
	Water Data Analysis and Decision Support • Data-driven approaches for water management

Module 2	**Innovative Technologies in Agriculture and Water Management**
Title	*Contents*
	• Water data analytics and modeling • Decision-support systems for efficient water allocation and conservation
Technical visit	• Digital Technologies for Agriculture & Smart farming: Installation of the base pack and monitoring practices and training with XFARM platform. • No-till seed drill with 4.0 technology La Valle Verde farm, Gravina di Puglia - Bari

3.2. Participants list

Table 5 – 2nd Module participants list

Name	Surname	Country	Affiliation	Contacts
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Mohammad Osman Ali	BABIKER	Sudan	Gezira Scheme Authority	mohammadosmannagro@gmail.com
Mohammed Babiker Ibrahim	BARSI	Sudan	WATDEV PhD student	mohammed.barsi@wur.nl
Ali Mohamed M.	ELHAJ	Sudan	The Hydraulics Research Center (HRC-SUDAN)	ali_hrc@hotmail.com
Ahmed Alsiddig A.	ELSHAIKH	Sudan	University of Khartoum, WRC	ahmedhayaty@live.com
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Eslam Ahmed G.	MOHAMED	Sudan	Agricultural Research Corporation	eslamahmed485@gmail.com

3.3. Programme of the Course

Monday 09th September	
08.30 - 09.00	Online connection
09.00 - 09.30	**Welcome of participants by:** **Maurizio Raeli** –Director of CIHEAM Bari
09.30 – 10.00	**Presentation of the Course Programme** **Anna Maria D'Onghia** (CIHEAM Bari, Italy)
10.00 – 10.30	**Presentation of the participants**
10.30 - 13.00	**General concepts of Precision Agriculture (PA)** **Lecturer: Fabrizio Mazzetto** (University of Bolzano, Italy)
Tuesday 10th September	
08.30 - 09.00	Online connection
09.00 – 13.00	**Practical knowledge for an effective PA application** **Lecturer: Fabrizio Mazzetto** (University of Bolzano, Italy)
Wednesday 11th September	
08.30 - 09.00	Online connection
09.00 – 13.00	**Mechanisation, robotics & Artificial Intelligence (AI)** **Lecturer: Lorenzo Marconi** (University of Bologna, Italy)
Thursday 12th September	
08.30 - 09.00	Online connection
09.00 – 13.00	**Drivers and challenges of PA: a socio-technical perspective** **Lecturer: Maurizio Prosperi** (University of Foggia, Italy)
	Precision agriculture and sustainability: economic and environmental evaluations **Lecturer: Deborah Bentivoglio** (University of Marche, Italy)
	The role of technology producers & service providers **Lecturer: Alessio Bolognesi** (Federazione Nazionale Costruttori Macchine per l'Agricoltura, Italy)
Friday 13th September	
08.30 - 09.00	Online connection
09.00 – 13.00	**The Southern Mediterranean context: the need of a tailored PA** **Lecturer: Mouin Hamzé** (CIHEAM Bari, Italy)
	Contribution of PA to sustainable water management **Lecturer: Nicola Lamaddalena** (CIHEAM Bari, Italy)
	CIHEAM Bari innovations for precision pest surveillance & water management at landscape level **Lecturers: Anna Maria D'Onghia, Roula Khadra** (CIHEAM Bari, Italy)

***Note**: this week will be held jointly with the Advanced Specialized Course: "Precision Agriculture for the Mediterranean Region" in the Mediterranean Innovation Hub (see map A3)*

Monday 16th September	
08.30 – 09.00	Registration of participants
09.00 – 11.00	**Digital Technologies for Agriculture & Smart farming** **Lecturer: Maurizio Triggiani** (Polytechnic of Bari, Italy)
11.00 - 11.15	Coffee break
11.15 – 13.30	**Digital Technologies for Agriculture & Smart farming** **Lecturer: Maurizio Triggiani** (Polytechnic of Bari, Italy)
13.30 - 14.30	Lunch at CIHEAM-Bari canteen
15.00 - 16.00	**Digital Technologies for Agriculture & Smart farming** **Lecturer: Maurizio Triggiani** (Polytechnic of Bari, Italy)
16.00 - 16.15	Coffee break
16.15 - 17.00	**Digital Technologies for Agriculture & Smart farming** **Lecturer: Maurizio Triggiani** (Polytechnic of Bari, Italy)
17.00-18.00	**Presentation of the 2nd module programme** Delivery of the Pocket money **Gaetano Ladisa, Silvia Lecci** (WATDEV Team, CIHEAM Bari, Italy)
20.00 – 23.30	End of the day

***Note**: The lecture scheduled on Monday 16's will be held jointly with the Advanced Specialized Course: "Precision Agriculture for the Mediterranean Region" in the Mediterranean Innovation Hub (see map A3)*

Tuesday 17th September	
08.30 – 09.00	Registration of participants
09.00 – 11.00	**Field visit** (CIHEAM Bari experimental fields) Presentation to the use of drone, definition of a flight plan, post-flight mapping and scanning **Lecturer: Carlo Ranieri** (CIHEAM Bari, Italy)
11.00 - 11.15	Coffee break
11.15 – 13.00	**Field visit** (CIHEAM Bari experimental fields) Presentation to the use of drone, definition of a flight plan, post-flight mapping and scanning *The practical exercise will be carried out using the drone DJI MAVIK 3 ENTERPRISE equipped with multi-spectral and RGB camera.* **Lecturer: Carlo Ranieri** (CIHEAM Bari, Italy)
13.00 - 14.30	Lunch at CIHEAM Bari canteen
15.00 - 16.00	**Introduction to the Solar Powered Irrigation Systems: Design, Consideration, and Sustainability.** **Lecturer: Fouial Abdelouahid** (CIHEAM Bari, Italy)
16.00 - 16.15	Coffee break
16.15 - 17.30	**Introduction to the Solar Powered Irrigation Systems: Design, Consideration, and Sustainability.** **Lecturer: Fouial Abdelouahid** (CIHEAM Bari, Italy)
20.00 – 23.30	End of the day

Wednesday 18th September	
08.30 – 09.00	Transfer to Acquedotto Pugliese Headquarter, Bari
09.00 – 09.30	Welcome Coffee
09.30 – 09.45	Welcome Address - Chair AQP Managing Director, CIHEAM General Secretary
09.45 – 10.00	**Water Management in AQP** **Lecturer: Gianfredi Mazzolani** (AQP)
10.00 – 11.00	Visit to the AQP historical building
11.15 – 12.00	**WDS - Leakages and Rehabilitation** **Lecturers: Serena Spagnuolo and Giusy Messa** (AQP)
12.00 – 12.30	**SWM - Smart Water Management. Presentation of the decision support tool for network management** **Lecturer: Paolo Lanza** (AQP)
12.30 – 13.00	**Deep dive on SWM. Use cases for WMS in NRW management and network operations** **Lecturer: Luigia Troiano** (AQP)
13.00 – 13.30	Transfer to CIHEAM Bari Campus
13.30 - 15.00	Lunch at CIHEAM Bari canteen
15.00 – 15.30	Transfer to Bari AQP Site, viale Orlando
15.30 - 16.30	**Technical Visit of AQP Laboratory** **Lecturer: Pier Paolo Abis** (AQP)
16.30 – 17.00	**Technical Visit of the Acquedotto Pugliese's Control Room** **Lecturers: Marco Mottola, Stefania Augenti and Simona Corrado** (AQP)
17.00 – 17.30	**Discussion**
17.30 – 18.00	Transfer to Bari Old Town
18.00 – 20.00	Touristic tour of the Old Town (visit to S. Nicola Basilica, the Cathedral, etc.)
20.00	Social dinner in Bari Old Town
23.00 – 23.30	Transfer to CIHEAM Bari Campus

Thursday 19th December	
WORKSHOP **RECENT ADVANCES IN PLANT PHENOTYPING FOR ABIOTIC STRESSES** URT-IPSP experimental farm, Conference room "Metapontum Agrobios"	
07.30 – 09.00	Travel to Metaponto URT-IPSP experimental farm, Matera
09.00 - 09.30	Welcome coffee and registration
09.30 – 10.00	Opening and quick introduction **Lecturers: F. Cellini** (ALSIA-Agrobios) and **M. Centritto** (CNR-IPSP)
10.00 – 11.00	**Technical Visit to phenotyping platforms (indoor & in the field)**
11.00 – 11.30	Coffee break
11.30 – 11.50	**Field platforms for precision agriculture and high-throughput plant phenotyping** **Lecturers: M. Centritto**, **V. Montesano**, **A. Conte** and **D. Danzi** (CNR-IPSP)
11.50 – 12.10	**Selection of plant species with cultivation potential for saline agriculture** **Lecturer: G. Atzori** (CNR-IPSP)
12.10 – 12.30	**Volatilomics and metabolomics: tools for plant phenotyping** **Lecturers: V. Lazazzara** and **F. Menicucci** (CNR-IPSP)
12.30 – 12.50	**Lean phenotyping technologies** **Lecturers: G. Marino** and **M. Haworth** (CNR-IPSP)
12.50 – 13.00	**Discussion**
13.00 – 14.30	Lunch at URT-IPSP experimental farm's canteen
14.30 – 14.50	**Controlled environment phenotyping in Metaponto: from lab to field** **Lecturers: A. Petrozza** and **S. Summerer** (ALSIA-Agrobios)
14.50 – 15.10	**From precision agriculture to precision phenotyping** **Lecturers: A. Montaghi** (CNR-IRET), **A. Fabbri** and **S. Mozzoni** (CNR-IPSP)
15.10 – 15.30	**Applications of AI in plant phenotyping and precision agriculture** **Lecturer: V. Renò** (CNR-STIIMA)
15.30 – 16.00	Coffee break
16.00 – 16.20	**Reuse of treated wastewater for irrigation** **Lecturers: D. Caniani** and **S. Masi** (UNIBAS)
16.20 – 16.40	**A new transportable prototype for the treatment of municipal wastewater for irrigation** **Lecturer: C. Di Iaconi** (CNR-IRSA)
16.40 – 17.00	**General discussion and closing remarks**
17.00 – 18.30	Touristic visit to Metaponto's "Tavole Palatine" Greek Temple
18.30 – 20.00	Transfer to CIHEAM Bari Campus
20.00 – 23.30	End of the day

Friday 20th September	
08.00 – 08.30	Registration of participants
08.30 – 09.30	Transfer to Andriani SpA (Gravina di Puglia)
09.30 – 10.30	**Technical Visit to Andriani SpA (Gravina di Puglia)** Presentation of Group's activities in healthy food, visit to the pasta production plant **Lecturer: M. Caravella** (Andriani SpA, Italy)
10.30-10.45	Transfer to ApuliaKundi farm (Gravina di Puglia)
10.45 – 12.00	**Technical Visit to ApuliaKundi farm (Gravina di Puglia)** Spirulina algae production plant, irrigated with treated wastewater **Lecturer: D. Chiapperini** (ApuliaKundi, Italy)
12.00 – 12.15	Coffee break
12.15 – 12.30	Transfer to La Valle Verde farm (Gravina di Puglia)
12.30 – 13.00	**Technical Visit to La Valle Verde farm (Gravina di Puglia)** No-till seed drill with 4.0 technology **Lecturer: P. Giglio** (La Valle Verde farm, Italy)
13.00 - 14.30	Lunch at Valle Verde farm
14.30 – 15.00	Transfer to Gravina di Puglia old town
15.00-16.30	Touristic tour on Gravina di Puglia old town
17.00 - 18.00	Transfer to CIHEAM Bari Campus
20.00 – 23.30	End of the day

Saturday 21st September
Transfer to the Airport Departure of participants

Sunday 22nd September
Transfer to the Airport Departure of participants

3.4. Lecturers' short bios

	**Anna Maria D'Onghia** (CIHEAM Bari) She is an internationally recognized expert in the field of plant health on: surveillance, monitoring, diagnosis, characterization, epidemiology, and control of quarantine and regulated pests; production and use of healthy plant material; and food safety (detection and control of post-harvest diseases, toxin producer fungi, and mycotoxins in fruits and vegetables). For the past 15 years, she has promoted "Precision Crop Protection" by contributing to the development of various digital tools and systems (e.g., forecasting models, Applications, spatial DSS) and methods for onsite pathogen detection (e.g., DTBIA, real-time LAMP). She supervised numerous MSc theses (about 40) and PhD theses (about 20) in collaboration with Italian and foreign universities, as well as tutored/lectured in several international short courses (e.g., EU Commission-BTSF training on 'Leveraging Remote Sensing for plant health' Protection Officers' in 2024). She promoted and participated in numerous national and international projects as: coordinator (e.g., PH-PROMODE PNRR; Multitrace PON-MISE) and WP leader (e.g., Xf-Actors EU-H2020; EUPHRESCO III H2020-WIDERA 2023). She covers several international roles, e.g.: Member of the Governing Board and Network Management Group of the EUPHRESCO network (European phytosanitary research coordination); Secretary of the MPU (Mediterrannean Phytopathological Union); member of the IPPC Steering Committee (International Year of Plant Health 2020); Member of PhD Councils (e.g., University of Tuscia, Italy). In 2018, she was awarded by Euphresco "Scientist of the Month" for coordinating the international project "Remote sensing application in plant health (PHeRS)". She is co-editor and reviewer of the scientific journal Phytopathologia Mediterranea and reviewer in Plant Pathology and Journal of Phytopathology. She is co-editor of 6 books, co-author of 1 chapter, co-author of over 250 publications in scientific journals and co-inventor of the Patented endotherapy method for the chemical control of Rhynchophorus ferrugineus.
	**Fabrizio Mazzetto** (UniBZ) Prof. Fabrizio Mazzetto, MSc in Agricultural Sciences (1983) and PhD in Agricultural Engineering (1990), both at University of Milan (Italy). Now Full Professor of Farm Machinery and Mechanization at the Free University of Bolzano. His main research topics are related to: a) development of new prototypes for mountain contexts; b) ICT application to supply information management tasks of farm and forestry processes; c) development of precision agriculture and forestry techniques, d) rural energy applications. Past FAO-UNDP energy consultant and coordinator of several national/international research projects. Now ordinary member of the "Accademia dei Georgofili" of Florence and Past President of the 7th Section of the Italian Society of Agricultural Engineering, for ICT applications in agriculture. He is responsible of the new Agroforestry Innovation Lab at the NOI-Techpark of Bolzano dealing also with new approaches in the certification issues of farm machinery. At present, he is actively involved as task responsible in the PNRR-Agritech (National Centers – Spoke 4) research program. Since 2022 he has been also Director of the Mountain Innovation Ecosystems Competence Centre at UNIBZ, set up to implement the Spoke 1 research measures of the iNEST consortium (Interconnected North-East Innovation Ecosystem) funded by PNRR-MUR NextGenerationEU program.

Lorenzo Marconi (UniBO)

Lorenzo Marconi graduated in 1995 in Electrical Engineering from the University of Bologna. Since 1995 he has been with the Department of Electronics, Computer Science and Systems at the University of Bologna, where he obtained his Ph.D. degree in March 1998. From 1999 he has been an Assistant Professor in the same Department where is now Full Professor since January 2016.

He has held visiting positions at and collaborations with various academic/research international institutions. He is co-author of more than 250 technical publications about linear and nonlinear feedback design published on international journals, books and conference proceedings. He is also co-author of three international monographs.

In 2005, he has been awarded jointly by Elsevier and the International Federation of Automatic Control (IFAC) for the best paper published in the period 2002-2005 on "Automatica". He is also the recipient of the 2014 IEEE Control Systems Magazine Outstanding Paper Award for the best paper published on the magazine in the period 2012-2013, He is the recipient of the 2018 O. Hugo Schuck Best Paper Award assigned by the American Automatic Control Council for the best paper presented at the 2017 American Control Conference. He is Fellow of IEEE for "contributions to feedback design of nonlinear systems and unmanned aerial vehicles"

He chaired the IFAC Technical Committee on "Nonlinear Control Systems" from 2011 to 2017 and he is member of the IEEE Technical committee on "Nonlinear Systems''.

Dr. Marconi has been the chair of the International Program Committee of the 8th IFAC Workshop on nonlinear control systems (NOLCOS) held at the University of Bologna in September 2010. He is the Principal Investigator of the EU projects AiRobots (2010-2013), SHERPA (2013-2017), AirBorne (2018-2021). He is the co-founder of the startup FieldRobotics dealing with robotics for agriculture.

He served as associate and senior editors of the main international journals in the field of control, such as Automatica, IEEE Transaction on Automatic Control, and IEEE Control Systems Technology.

His current research interests include nonlinear control, output regulation and stabilisation of nonlinear systems, control of autonomous aerial vehicles, robotics for agriculture, robust control.

Maurizio Prosperi (UniFG)

Maurizio Prosperi is an associated professor of Agricultural Economics at the University of Foggia (Italy), where he has been employed since 2005. His teaching subjects include microeconomics, farm business and accounting, rural appraisal, and logistics in agri-food supply chains. His research activity covers topics of interest for agriculture and rural development in Mediterranean regions, such as water management and policy, development of circular economy and biorefinery schemes, social innovation.

He graduated in Agricultural Sciences from the University of Bologna (Italy) in 1994 and spent 6 years in advanced education at Kyoto University (Japan), where he obtained his MSc degree in 1999 and his PhD in Agricultural Economics in 2005. Prof. Prosperi has always been attracted by cutting-edge knowledge and science. In 1995 he performed a pioneer study on the LCA of beef production in Italy. During his postgraduate program at Kyoto University, he explored the application of Artificial Neural Networks for the ex-post analysis of the Common Agricultural Policy. In the last decade, he has been involved in trans-disciplinary research in social innovation related to the development of marginalized rural areas.

Throughout his scientific career, he has co-authored about 130 publications, including 28 published in international peer-reviewed journals. He is member of several national and international scientific societies for the advancement of Agricultural Economics. Finally, he promotes the creation of innovative start-ups, where he aims to apply scientific knowledge to generate new qualified jobs for young scholars and enhance the well-being of rural communities.

	**Deborah Bentivoglio** (UnivPM) Deborah Bentivoglio is a researcher (AGRI-01/A - Agricultural and Food Economics, and Rural Appraisal) at the Polytechnic University of Marche (UNIVPM) – Department of Agricultural, Food and Environmental Sciences (D3A), where she teaches Food Policy and Agricultural Policy and Rural Development. She graduated with honors in Agricultural Science and Technology from D3A and received her Ph.D. in Agricultural and Resource Economics from the same university. From 2015 to 2019, she was a research fellow at D3A. In 2017, she obtained the national academic qualification of associate professor in 07/A1. During her research activities, she spent two periods as a visiting scholar at Universidade de São Paulo (Brazil) and at Wageningen University & Research (WUR) in the Netherlands. She was the responsible person for Cluster Agrifood Marche (ClAM) from 2013 to 2018. She is a member of the Italian Society for Agricultural Economics (SIDEA). Prof. Dr. Bentivoglio is actively involved in an Erasmus+ funded project (https://www.project-boost.eu/), a project of national interest (PRIN https://www.we-best-prin.it/), and various regional projects. She also supervises bachelor's, MSc, and Ph.D. students. Her main fields of research are agricultural and resource economics, biofuels, agri-food innovation, precision agriculture, agricultural and food policy, econometric modelling, circular economy, blockchain, and consumer behaviour. Her research activities are documented by national and international publications. Bibliometric indicators: Scopus h-index 14, citations 495.
	**Alessio Bolognesi** (FederUnacoma) Technical Officer for Digital Agriculture in FederUnacoma, Alessio Bolognesi was graduated in Electronic Engineering and immediately started to work as an ISOBUS system engineer. He worked 8 years for a small company and moved to CNH for 3 more years, where he was responsible for ISOBUS systems on small and large tractors. In his career he had to deal with many aspects of the application of precision agriculture technologies to agricultural machineries, including functional safety impacts. He is working in FederUnacoma for 10 years, still taking care of all those topics as well as new ones like Artificial Intelligence, sensing, robotics and cybersecurity for our industry. He is also appointed as an expert to international working groups in ISO, CEMA and AEF.
	**Mouïn Hamzé** (CIHEAM Bari) Mouïn Hamzé holds a “Doctorat d’Etat” in Science from France and is an Emeritus Professor and Former Dean of the Faculty of Agricultural Sciences at the Lebanese University. He previously served as the Secretary General of the National Council for Scientific Research in Lebanon (CNRS-L). Currently, he assumes the role of Chairperson of the Management Board at the Euro-Mediterranean University (EMUNI) in Slovenia and serves as a Scientific Advisor at the Mediterranean Agronomic Institute of CIHEAM-Bari. Prof. Hamzé is recognized as a regional advisor and expert on science policy, research, development, and innovation. He actively chairs and coordinates numerous international and Mediterranean organizations and programs devoted to advancing higher education, research, agriculture, environment, and scientific and technological collaboration. Prof. Hamzé has published more than 100 papers and technical reports on relevant topics, including natural resource management, food security, sustainable agricultural technology, research policy, ethics and management. Additionally, he is an accomplished author and has published and edited more than 15 books, including his recent publication, "Empowering Knowledge and Innovation: Challenges for the Arab Countries (in Arabic and English, 402 pages, Arab Thought Foundation 2020)."

	**Nicola Lamaddalena** (CIHEAM Bari) Holding a MSc in Hydraulic Engineer at Polytechnic of Bari and a PhD. in Irrigation Engineering at the Technical University of Lisbon, Nicola Lamaddalena has been working for more than 30 years on agricultural engineering and water resources management, with a focus of design, performance analysis and management of large-scale distribution systems, new delivery technologies with associate modelling development under water scarcity conditions, governance models of Water Users Associations. He served as University Professor at the Polytechnic of Bari (Italy) and provided consulting services to public and private sectors. Scientific and technical activities have been conjugated with the management of many water-related development projects in Southern Europe, North Africa and Near East, also in cooperation with International Research Centres and Universities. Author of over 100 publications in scientific journals and books, reviewer for several scientific journals, he is the author, among others, of the FAO Irrigation and Drainage paper n. 59. Past-Vice-President of the International Section Board on Land and Water - CIGR (International Commission of Agricultural and Biosystems Engineering). Chairman of the Task Team for the preparation of the Policy workshop on "Water for Food Security and Nutrition" (FAO-CFS) and Special Rapporteur at Policy workshop on "Water for Food Security and Nutrition" - FAO-CFS 42. Board member of the Ital-ICID and the Global Water Partnership – Mediterranean session. He joined CIHEAM Bari Institute in 1986 where he was the Head of the Land & Water Dept. from 2005 to 2019, Deputy Director from 2019 to 2023. He is currently International Senior Water Advisor.
	**Roula Khadra** (CIHEAM Bari) Science Coordinator and International Officer at CIHEAM-Bari, with a career spanning over two decades in the field of water management and agricultural innovation. With a rich academic background and extensive professional experience, Dr. Khadra has played a pivotal role in advancing research, technology development, and governance in the critical areas of water quality, water-energy nexus, and sustainable irrigation. She holds a Bachelor in Rural Engineering, a Master of Science in Land and Water Resources Management, and a Ph.D. in Mediterranean Agriculture. As a Fulbright Post-Doctoral Fellow at UC Davis, she had the opportunity to engage with cutting-edge research and collaborate with some of the brightest minds in her field. This experience significantly enriched her understanding of innovative agricultural technologies and sustainable practices. Throughout her career, she has authored numerous scientific papers, reports, and books, contributing significantly to the academic discourse surrounding water management and agricultural sustainability. One of Dr. Khadra's defining attributes is her commitment to fostering accountable, transparent, inclusive, and responsive governance in the realm of water resource management. She has played a key role in strategic planning, design, and implementation of national participatory irrigation management and transfer programs in the Mediterranean region. Dr. Khadra has also been at the forefront of technology development and transfer, particularly in the integra on of modern irrigation systems and schemes. Her expertise encompasses conceptualizing, modelling, and innovating irrigation, and water distribution. In recognition of her influence in the field, and distinction in promo ng responsible governance she has taken on leadership roles in various international organizations and boards. Notably, she is an elected Governor of the Arab Water Council Board of Delegates. Within CIHEAM-Bari, Dr. Khadra has made significant contributions as a lecturer and coordinator. Her dedication to educating the next genera on of water management professionals is evident through her coordination of the Master program in "Sustainable water and land management in agriculture", and the initiation of the "Digital Agriculture" Lab. She continues to make significant contributions to engaging youth in science and establishing stable partnerships for Research and Innova on.

	Furthermore, Dr. Khadra has been an active participant and/or leader in numerous international projects and made substantial contributions to the organization of international conferences and forums, the World Water Forums, Arab Water Forums, and COP among others. Her collaborative efforts have strengthened partnerships and platforms for exchange and cooperation at a regional scale.
	**Maurizio Triggiani** (PoliBA) Maurizio Triggiani, computer engineer, obtained his degree and Ph.D. at the Polytechnic University of Bari, where his studies focused on artificial intelligence algorithms applied to the interoperability of spectroscopic analyses, food fingerprinting, and precision agriculture. His thesis was titled "Integration of machine learning techniques in chemometrics practices." As an IT consultant, he applies his expertise to numerous projects across various fields, from data analysis to process control. Currently, he is a research fellow for ICQRF (Central Inspectorate for Quality Protection and Fraud Repression of Agri-food Products) at the Department of DICATEc (Department of Civil, Environmental, Land, Building Engineering, and Chemistry) of the Polytechnic University of Bari. Here, he continues his work in food fingerprinting, non-documentary traceability techniques for food quality certifications, and precision agriculture. With over a decade of experience as a full-stack software developer, he is an expert in databases and passionate about emerging technologies such as IoT and 3D printing. Beyond his professional commitments, he has a keen interest in video games, which fuels his creative and innovative spirit. His career is marked by a consistent dedication to research and the development of cutting-edge technological solutions.
	**Carlo Ranieri** (CIHEAM Bari) Soil-plant-atmosphere monitoring specialist and laboratory/open field technician at the CIHEAM-Bari Institute. He participated in training courses in Italy, Tunisia, Egypt, Kosovo and Albania. He provided Technical Support Research activities focused on the climate change impact/adaptation/mitigation in agriculture, water/irrigation management, eco-physiology, risk/alert assessment, and use of innovative technologies (remote sensing, DSS, IoT). Mr. Ranieri provided Technical and Eco-Physiology Laboratory Support in numerous master thesis of the CIHEAM-Bari students and PhD. He participated as a Technical Support and Weather Stations Specialist, in several EU-funded projects (WATNITMED, AQUASTRESS, WASAMED, SEDEMA, HYDROTECH, SUWARESA, IOF2020, ACLIMAS, IRRI-TECH). He participated in several cooperation projects in the Mediterranean region as Technician. He has 38 years of experience in the field of scientific instruments related to eco-physiology, agro-meteorology and weather stations, and soil moisture monitoring.
	**Fouial Abdelouahid** (CIHEAM Bari) Dr. Abdelouahid Fouial holds a PhD in Civil Engineering and a Master's degree in Water Management. He has extensive experience working on projects related to water management and solar energy in agriculture, particularly in the Mediterranean and sub-Saharan Africa regions. Currently, he is involved in a project as the lead expert and trainer, focusing on training 500 future trainers from sub-Saharan African countries in solar-powered irrigation systems. Additionally, he is actively engaged in developing new curricula on solar irrigation for 15 educational institutions across five sub-Saharan African countries. Dr. Fouial also teaches master's level courses on water management and renewable energy in agriculture.

	**Serena Spagnulo** (AQP) Since January 2000 she has been working in Acquedotto Pugliese: she manages projects of rehabilitation of hydraulic distribution networks, and she is currently Leader of the Rehabilitation Network Task Force. She has a wide experience in technical matters as well as in the administrative field for full development of rehabilitation plans, starting from design to complete construction and management: her rehabilitation network plans are the largest investments in Italy to reduce water losses in distribution networks.
	**Paolo Lanza** (AQP) CIO with strong experience in the infrastructure sector, rail and road, as well as in HS rail transportation, he has been Chief Innovation & IT Officer in Acquedotto Pugliese since 2022. With a degree in Electronic Engineering, his work experiences have led him to be a deep understanding of business processes, and he has always believed in promoting in the IT Department the language and view of business. An innovator in favour of process digitization, never forgetting architectural, technological, IT security and corporate compliance issues.
	**Luigia Troiano** (AQP) Luigia Troiano has been working at Acquedotto Pugliese since 2000 as head of the IT Systems Complex Unit in the Innovation and IT Department. She has in-depth knowledge of information systems engineering for the different phases of the software life cycle, from feasibility study to implementation, through functional analysis. She has operational project management skills from initiation, to planning, drafting, execution, control, testing, and closure of the project. She has highly specialized knowledge in the GIS field (collection and monitoring of territorial data, IT architectures, and information systems), the transversal approach to processes has allowed the design of the integration in the GIS of data from the various company information systems (SAP, ISU, ACS, AQPLAV, etc.). Expert in designing GIS-oriented WEB platforms, and customers (desktop and mobile).
	**Pier Paolo Abis** (AQP) PIER PAOLO ABIS earned an MS degree in Chemistry in 1991 and started soon to work in Italian High School as a teacher in Chemistry and industrial Chemistry. Between 1995 and 1999 he was employed in Texas Instruments Italy as a chemical Engineer and then, Responsible of the QC Chemical laboratory. He joined AQP in September 1999 where he is currently Leader of one of the biggest water quality and quality assurance organization in Italy consisting of 10 laboratories, some of them fully complying with ISO17025:2018, and about 120 resources. He has a strong technique experience coupled with a leader approach aimed to design and implement a more dynamic organization. Moreover, he is leader of the new organizational unit "Water Safety Plan" created to implement progressively a risk management approach for water quality to the entire drinking water network managed by AQP.

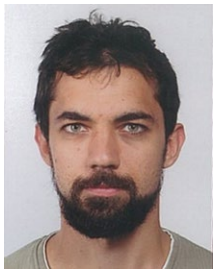
	**Stefania Augenti** (AQP) Master's degree in Forestry and Environmental Sciences, a second-level Master's in Circular Economy currently being completed. Stefania Augenti has gained significant experience in multinational companies, specializing in human resource management and strategic planning. In Acquedotto Pugliese since 2015, in the last four years she managed the emergency service, specifically the Technical Call Center, where successfully achieved the KPI objectives set by ARERA, improving operations through advanced data analysis and process optimization. Now, in her current role within Control Room, she is engaged in the Service & Reporting area, where she continue to drive improvements and ensure operational excellence.
	**Simona Corrado** (AQP) Master's degree with honours in Management Engineering at University Polytechnic of Bari. Enthusiastic, goal-oriented, highly motivated team player and naturally curious. Internationally experience gained in previous experiences in international business companies with relevant focus on manufacturing processes, continuous improvement, strategic planning activities and problem solving. She has been working in the Control Room of Acquedotto Pugliese since 2023. Her main tasks regarding monitoring sensors installed on field, fault analysis, creation of automatic alerts managed through a correlation matrix, optimizing and reducing water losses through Noise Loggers devices and development of hydraulic models.
	**Mauro Centritto** (CNR-IPSP) Mauro Centritto obtained his PhD at the Faculty of Science and Engineering, University of Edinburgh, under Prof. Paul Jarvis. He is currently Research Director in the Institute for Sustainable Plant Protection-National Research Council of Italy (CNR). Dr. Centritto is co-directing the ENI-CNR Joint Research Center "Water - Hypatia of Alexandria". He is the former director of the Institute for Plant Protection-CNR, the Trees and Timber Institute-CNR and of the Institute for sustainable Plant Protection-CNR. Dr. Centritto is Adjunct Professor at the PMAS Arid Agriculture University Rawalpindi-Department of Environmental Sciences (Rawalpindi, Pakistan). He has an international experience on biosphere-atmosphere interactions and over 35 years' experience on collaborative eco-physiological research on climate change impact on plant growth and physiology in relation to dry environments. He is currently Panel Member of the UNCCD-CSO representing Western Europe and member of the Steering Committee of DesertNet International (Scientific network for international research on desertification). Dr. Centritto seats in the Doctorate Board Ph.D. Program in Agricultural Science of the University of Sassari and served in the "Tang Prize Selection Committee", prize category Sustainable Development. He serves in the editorial board for different plant scientific journals. Dr. Centritto has coordinated several national and international projects.

	**Francesco Cellini** (ALSIA-Agrobios) Dr. Francesco Cellini has a scientific background in biochemistry and plant biotechnology, with 30 years of active research. Currently he is Director of Metapontum Agrobios Research Centre, part of the Basilicata Agency of Development and Innovations in Agriculture (ALSIA, www.alsia.it), a public regional research institution located in Basilicata, Italy, coordinating R&D Projects of the Agency. The Research Center, that counts 20 scientists, is quite active on plant biotechnology, molecular and genomic breeding, plant phenotyping by imaging, precision agriculture. His filed of interests range from plant pathology, particularly the resistance to plant viruses to oil biochemistry in oilseed crops to produce unusual fatty acids of industrial interest, to crop response to biotic and abiotic stresses. He pioneered in Italy the use of high throughput technologies for the study of plant phenotype, the so-called plant phenomics, that lays at the very base of precision agriculture applications. Dr. Cellini is coordinating several national and regional R&D projects.
	**Vincenzo Montesano** (CNR-IPSP) Researcher at the IPSP-CNR, SS Bari/URT of Metaponto (MT), since February 2022. Degree in Agricultural Sciences in 2002 at the University of Bari and PhD in Biology and Biotechnology at the University of Basilicata in 2010. From 2003 to 2020, as a research fellow and fixed-term researcher of the Institute of Biosciences and Bioresources of the CNR, he was involved in studies aimed at collecting plant bioresources of cultivated and spontaneous species, the management of germplasm collections in the field and conservation processes in bio-banks, to the evaluation of the genetic diversity existing within and among the species population with morphological (phenotyping), biochemical and genetic approaches. In 2013-2014 he was Contract Professor for teaching Botany in the Course of Studies in Primary Education Sciences of the Department of Human Sciences of the University of Basilicata and from 2009 Professor in various training activities. His skills and experience include the management of scientific and experimental tests in the field, evaluation of the quantitative-qualitative responses of herbaceous species to the application of agronomic inputs, eco-physiological analysis on crops and biometric and agronomic analysis of the components of plant production, the design and creation of databases of quantitative-qualitative data and their management using software for statistical processing (SAS, JMP, SPSS, R), teaching and research activities, drafting of international scientific publications, reports and elaboration of project proposals, refereeing of scientific articles in ISI international journals. Currently, his research is focused on studying the effects of environmental stresses on plants of agricultural interest. His research interests include the eco-physiological study of the relationship between plant and environment, which can be determined with direct physiological measurements and the use and development of optical sensing-based plant phenotyping techniques.
	**Adriano Conte** (CNR-IPSP) Graduated in “EcoBiology” at the University of Rome “La Sapienza” in 2015. He completed a PhD in “Science, Technology, and Biotechnology for Sustainability” with a specialization in “Forest Ecology and Environmental Technologies” at the University of Tuscia in Viterbo in 2019. During this time, he conducted research abroad as visiting researcher at the Lancaster Environmental Centre (LEC), University of Lancaster (UK). He worked as a Technician at the Forestry and Wood Research Centre (FL) of the Council for Agricultural Research and Economics (CREA) and as research fellow at the Institute for BioEconomy (IBE) of CNR. Since 2023, he works as Technologist at the Institute for Sustainable Plant Protection (IPSP), URT of Metaponto (MT). He focuses on studying agricultural and forest ecosystem responses to abiotic stresses. He specialized in modelling ecosystem services provided by urban and peri-urban

	forests and in monitoring greenhouse gas fluxes exchanged between forest ecosystems and the atmosphere using the Eddy Covariance technique.
	**Donatella Danzi** (CNR-IPSP) Graduated in Biotechnology at the University of Rome "La Sapienza" in 2009 and obtained her PhD in Plant Genetics and Biotechnology at the University of Bari in 2014. She is currently working as a researcher at the Institute for Sustainable Plant Protection of the National Research Council of Italy (CNR). From 2015 to 2020, as research fellow at the CNR Institute of Biosciences and Bioresources, she was involved in studies aimed at the phenotypic characterization of durum wheat germplasm, Tritordeum and barley lines, to identify sources of resilience to abiotic stresses, in particular water stress. Phenotypic characterization was carried out by crossing traditional phenotyping approaches, through normal descriptors, and High Throughput Shoot and Root Phenotyping approaches, through images acquired in the visible spectrum (RGB), infrared (IR) and ultraviolet (UV). All this is part of a Climate Smart Agriculture (CSA), whose ultimate goal is to optimize the use of water and nutritional resources to ensure sustainable development and food security, in a climate change scenario. Her research interest includes the valorization of plant genetic resources by managing experimental tests in the field and in a controlled environment in order to study the effects of abiotic stresses on plants of agricultural interest and identify sources of resilience, by use of High Throughput Phenotyping technologies. Part of her research is also focused on the characterization of lignocellulosic biomass of cereal crop in order to identify agricultural waste with good characteristics as feedstock for biofuels and biostimulator production.
	**Giulia Atzori** (CNR-IPSP) Giulia Atzori obtained her PhD in Agricultural and Environmental Sciences at the School of Agriculture of the University of Florence. She is currently Researcher in the Institute for Sustainable Plant Protection-National Research Council of Italy (CNR). She collaborated with the Institute of Environmental Sciences (CML) of Leiden University (The Netherlands) carrying out a research period at the SaltFarm Texel experimental site. Her research activity aims at studying the response of edible species to saline stress at the growth, physiological and at the biochemical level. The studied species are characterized by different degrees of salt tolerance, with a special focus on halophytes which have naturally adapted to saline environments developing a series of mechanisms that allow a tolerance to saline concentrations up to 50% sea water. Her research interests also include the investigation of the effects on crops of other abiotic stresses, among which water stress and increasing temperatures. She is keen at investigating the combinate effects of different stress factors in a framework which focuses on the double need of increasing food production and of modifying the current farming systems for achieving an enhanced tolerance to the effects of climate change. She is also participating in the Cost Action CA22144 - Sustainable use of salt-affected lands (SUSTAIN), participating as a member of the Management Committee and as Grant Awarding Coordinator. She is section editor for the journal "Advances in Horticultural Science".
	**Valentina Lazzazera** (CNR-IPSP) Valentina graduated in biotechnology for the quality and safety of human food with a thesis in the field of functional genomics of fruit plants at University of Bari "Aldo Moro". During her Ph.D. at the BOKU University in Austria, Valentina identified and characterized volatile organic compounds (VOCs) produced by plants and microorganisms to inhibit phytopathogens through gas chromatography-mass spectrometry (GC-MS) and by proton-transfer reaction time of flight (PTR-TOF-MS) techniques.

	As a post-doctoral researcher at the Laimburg Research Centre (South Tyrol, Italy), Valentina contributed to the development of methods for analysing VOCs and amino acids in South Tyrolean white wines using CG-TOF-MS and HPLC-QqQ-MS techniques, aiming to preserve their quality and typical characteristics. Valentina worked as a researcher at the Fondazione Edmund Mach (Trentino, Italy), where she characterized the role of VOCs produced by plants and microorganisms at both molecular and metabolomic levels to develop sustainable methods for plant disease control. She also worked as research assistant at the Crop Science Research Center of the Sant'Anna School of Advanced Studies (Pisa, Italy), where she contributed to the development of microbial bio stimulants on tomato plants subjected to drought stress. Valentina is currently a researcher at the National Research Council (CNR) – Institute for the Sustainable Plant Protection, in Sesto Fiorentino (Italy). Her primary interest lies in plant metabolomics and physiopathology, using GC-MS and PTR-TOF-MS techniques to study the role of VOCs in the communication between plants and microorganisms for the defence of agriculturally relevant plants.
	**Felicia Menicucci** (CNR-IPSP) Felicia Menicucci is a biologist currently working as researcher at the National Research Council (CNR) – Institute for the Sustainable Plant Protection, Sesto Fiorentino (FI). Since her PhD, she focused her studies on terpenes and essential oils as antimicrobial substances, testing them both on plant pathogens and in the field of cultural heritage conservation, particularly against microorganisms that degrade paper. Her main research interests focus on plant secondary metabolism in response to environmental stresses, using advanced technologies such as High-Performance Liquid Chromatography coupled to Mass Spectrometry (HPLC-MS) and Gas Chromatography-Mass Spectrometry (GC-MS). She is the author of several publications in peer-reviewed journals and has participated in numerous national and international conferences ranging from green chemistry to plant biology, agronomy and cultural heritage conservation.
	**Giovanni Marino** (CNR-IPSP) Researcher at the Institute for Sustainable Plant Protection-CNR, he has experience in plant phenotyping and eco-physiological study of the relationship between plant and environment for the characterization of the physiological response of plant species to changes in external conditions and the onset of stress factors, mainly abiotic. Interest in the mechanisms of response, resistance, and adaptation to environmental factors most influenced by climate change, such as water availability for the plant, atmospheric CO2 concentration, environmental temperature, and quality of light, indagated through direct physiological measurements and use and development of remote sensing techniques. He has been involved in national and international projects focused on the study of the effect of various environmental factors on photosynthetic efficiency, stomatal and mesophyll conductance and the synthesis and foliar emission of secondary metabolites.
	**Matthew Haworth** (CNR-IPSP) Matthew Haworth is a researcher in the Institute for Sustainable Plant Protection in the National Research Council of Italy (CNR – IPSP). He is primarily interested in stomatal morphological and physiological responses to the atmospheric concentration of carbon dioxide, water deficit and heat stress. His work involves the use of leaf gas exchange and chlorophyll fluorescence to quantify the diffusive and biochemical constraints to photosynthesis. These approaches can be utilised for phenotyping plant responses to abiotic stress. Matthew is also interested in the use of living plants to elucidate patterns in the leaf economics and palaeo-physiology of fossil plants.

	**Angelo Petrozza** (ALSIA-Agrobios) Head of the Agronomic Services Unit of Metapontum Agrobios. Coordinates all the agronomic activities of the projects, preparing the experimental plans and carrying out surveys and processing of the results obtained. He is responsible for the scientific and technological collaboration with Syngenta biological S.p.A. for experimental tests involving the evaluation of eco-physiological effects on plants following the use of bio stimulants through image analysis. Responsible for Metapontum's Plant Phenomics technological platform of ALSIA/Agrobios, carries out plant phenotyping activities by means of image analysis using Scanalyzer 3D System technology. Tooks care of the entire setup and start-up part of the Scanalyzer system 3D System is the only platform in Italy and one of the few in the world. In this context he produced studies and scientific works in the analysis of the phenotype of plants using high-throughput image analysis techniques, in the fields of plant nutrition, defence and resistance to abiotic stress. Head of the "Germplasm Bank" of Metapontum Agrobios. Catalogs and maintains the Germplasm Bank. Senior Researcher of the Metapontum Agrobios Testing Center for Good Experimentation practices to test residues and effectiveness. He carried out, as director of the study, experimental tests on crops of greater agricultural interest in Southern Italy. Experimental tests have been carried out and conducted with a high-quality standard, through the use of EPPO official guidelines.
	**Stephan Summerer** (ALSIA-Agrobios) Stephan Summerer obtained his PhD in Biochemistry at the Department of Biochemistry of the University of Calgary. He is currently a Senior Researcher at the Department of Research, Training, and Advances Services of ALSIA (Basilicata Agency for Development and Innovation in Agriculture). For the past 15 years he has worked as a bioinformatician for the PhenoLab platform at ALSIA, Metaponto. This work involves image analysis, data management, and statistical analysis of Phenomics experiments.
	**Alessandro Montaghi** (CNR-IRET) Alessandro Montaghi holds a degree in Computer Science and a degree in Forestry and Environmental Science from the University of Florence. He obtained a PhD in Remote Sensing on LiDAR applications in the environmental domain. His research activities continued at the Swedish University of Agricultural Sciences (SLU), where he developed remote sensing algorithms to study boreal forests. Later, he did research at Aarhus University, Denmark, where he developed a Machine-Learning framework to verify the quality and correctness of parcel declarations by farmers automatically, under the European Land Parcel Identification System (LPIS) project. As a winner of the Eyes High Postdoctoral Scholars program, he transferred to the University of Calgary in Alberta, Canada. His research has focused on the use of Unmanned Aerial Vehicles (UAVs) to acquire 3D information for planning and forestry purposes. Upon his return to Italy, he served as Director Technologist at CREA (Council for Agricultural Research and Economics), where he focused on developing cloud systems and IT platforms for precision agriculture. He is currently a Director Technologist at CNR (National Research Council), working on the development of the ITINERIS computing platform, the Italian Hub of Research Infrastructures in the environmental scientific domain. He is also a contract lecturer in Computer Science and Mathematics at the course of Forestry and Environmental Sciences at the Università degli Studi della Tuscia-Viterbo, Italy.

	**André Pierre Marie Fabbri** (CNR-IPSP) André P.M. Fabbri holds a degree in Applied Mathematics and a degree in Complex Systems. He obtained his PhD in Artificial Intelligence at University of Lyon under Prof. Salima Hassas. He worked after as a full-stack developer for public transportation software using state of the art programming and management method. His research interests are reinforcement learning and deep learning applied to life sciences. He is currently Researcher in the Institute for sustainable Plant Protection-National Research Council of Italy (CNR). He is setting up a FAIR platform for plant phenotyping data and further process using machine learning or deep learning methods applied to this challenging field.
	**Vito Renò** (CNR-STIIMA) Vito Renò received the Master Degree in Computer Engineering with honours from "Politecnico di Bari" in 2011, defending a thesis about computer vision and robust background modelling. He also received his PhD degree in Electrical and Information Engineering from the same University in 2017, defending the thesis "3D modelling, reconstruction and analysis of environments assisted by multi-sensorial data processing". He currently is a researcher at CNR-Istituto di Sistemi e Tecnologie Industriali Intelligenti per il Manifatturiero Avanzato and is involved in research activities in the fields of computer vision and pattern recognition. He is co-author of 80+ scientific papers and one international patent. Deeply curious and enthusiast about artificial intelligence, with a pinch of multi-disciplinary and synergic applications.
	**Donatella Caniani** (UNIBAS) Donatella Caniani is an Associate Professor in the field of Sanitary-Environmental Engineering, at the Department of Engineering, University of Basilicata, since 2018. Previously, she served as a Assistant professor from 2006 to 2018. In 2020, she achieved the National Scientific Qualification for the role of Full Professor in the same disciplinary field. She is the Vice-Rector of the University of Basilicata with a delegation for strategic planning. She earned her Ph.D. in "Methods and Technologies for Environmental Monitoring" in 2004. From 2004 to 2005, she was a visiting researcher at the Danish Hydraulic Institute in Copenhagen, Denmark, for six months. She serves as a reviewer for numerous international scientific journals and for the Italian Ministry of University and Research (MIUR). Since 2000, she has been conducting research in the field of Sanitary-Environmental Engineering. Her research activities are primarily focused on greenhouse gas emissions, energy consumption, and carbon neutrality of wastewater treatment plants, treatment and reuse of treated wastewater and organic fractions of municipal solid waste, application of innovative chemical-physical and biological methods for the remediation of contaminated water and soils, assessment of environmental risk and vulnerability to anthropogenic impacts on protected areas, protection of water resources and environmental modelling, development of innovative samplers for wastewater-based epidemiology, and life cycle analysis of products, processes, and projects aimed at assessing environmental sustainability. Prof. Caniani has been the Scientific Coordinator and participant in various research and technology transfer projects funded by the EU, the Italian Ministry of University and Research (MIUR), local authorities, and industry. She was recently the Principal Investigator for the UNIBAS Unit in the European ENI CBC MED DECOST project - Decentralised Composting in Small Towns, and she is currently involved in the PNRR TECH4YOU project - Technologies for climate change adaptation and quality of life improvement, Spoke 2 "Technological solutions for deep decarbonization of the energy system and reuse of waste and residues".

	Prof. Caniani has been a designated member of the Scientific Committee of the Environment Research Foundation of the Basilicata Region (FARBAS) since September 2023. She is the co-author of over 100 articles in international scientific journals and conference proceedings, 47 of which have been published in peer-reviewed journals and indexed volumes on Scopus and WoS.
	**Claudio Di Iaconi** (CNR-IRSA) Claudio Di Iaconi is a research director at Water Research Institute (IRSA) of National Research Council of Italy (CNR), Bari headquarter. Since 2020, he is also the head of Bari headquarter. Dr. Di Iaconi has completed his MS degree in Industrial Chemistry at the University "La Sapienza" of Rome in 1993. He has a vast experience in water-related environmental technologies and particularly in wastewater treatment and resource recovery, biomass and sludge treatment. Mr Di Iaconi developed several advanced processes for municipal and industrial wastewater and sludge treatment according to the circular economy model. He is the principal inventor of the patent (WO 2019/097463) “Plant and method for treating urban wastewater” applied at full scale. He was coordinator/principal investigator in more than 30 national and international research projects (e.g. Perbiof, Innovatech, Mediwat, Therbior, Biopos, Mangiafanghi, Trafande, Idroforsu, Ecotec, Bracco, Erica, etc). He received more than 2 million euros from private companies in the last 10 years for several research projects. He is a co-author of more than 200 scientific papers published in peer reviewed journals or presented to scientific conferences, book chapters on different subjects within the wastewater treatment field. He is serving as an editorial board member for several international peer reviewed journals. He was member of the international scientific committee in several conferences. He has received some national and international awards for having achieved innovative scientific results in the field of water-related environmental technologies.

3.5. The technical visits

Acquedotto Pugliese (www.aqp.it/en)

acquedotto pugliese l'acqua, bene comune	After 100 years, Acquedotto Pugliese continue to believe in this great vision. Acquedotto Pugliese was born from a dream: to bring water into the homes of the Apulian's. This idea seemed unattainable at first, but thanks to the work of many men and women, it has become the largest aqueduct in Europe. AQP is one of the largest integrated water service companies in Italy and provides its services throughout the entire Apulian territory, from Gargano to Santa Maria di Leuca, and in some communities of Campania, also ensuring the supply of water in sub-distribution to Acquedotto Lucano S.p.A., throughout Basilicata. We ensure the water supply of the managed territories through a system of aqueducts, plants, and hydraulic engineering works. In addition, we guarantee the protection of the environment through our purification, urban wastewater refinement and composting plants. Respect for and protection of the territory, energy efficiency and environmental protection, constant dialogue with communities and territories, customer satisfaction and attention to the enhancement of employees are part of the corporate identity and constitute the values at the basis of Acquedotto Pugliese's strategies. The sustainable management of a common good, such as water, the design and implementation of business activities to improve performance and reduce environmental impact have always been part of our vision. The headquarters of Acquedotto Pugliese is in Bari, in via Cognetti n.36, in one of the oldest buildings in the city. Designed by Cesare Vittorio Brunetti and furnished by Duilio Cambellotti at the beginning of the 20th century, the palace is also known as "the secular cathedral" of water, the place where water is depicted in every detail, in every decoration.

CNR-IPSP (www.ipsp.cnr.it/en/)

IPSP	The National Research Council of Italy (Consiglio Nazionale delle Ricerche, CNR) is the largest public research Institution in Italy, and one of the European leading research institutions. The CNR-Institute for Sustainable Plant Protection (IPSP) studies plant response to biotic and abiotic stress factors, to identify resistance mechanisms, adaptation processes and protection methods. Its activities target the protection of agricultural and forestry vegetation, the enhancement of natural antagonism, and the development of biocontrol methods for plant parasites and weeds. Additionally, the institute seeks to improve the quality and quantity of agri-food production, select and rehabilitate valuable plant germplasm, characterize and produce biomolecules for agro-industrial applications, and mitigate the impacts of global environmental change. All efforts are aligned with promoting sustainable and environmentally friendly growth. The CNR-IPSP encompasses a broad spectrum of expertise, including plant protection, plant phenotyping, plant development, eco-physiology, plant-microbe interactions, biodiversity, plant nutrition, genomics, biochemistry, plant physiology, and bioinformatics. For decades, CNR-IPSP has been at the forefront of studying plant responses to biotic and abiotic stress factors. One of its primary research focuses is on advancing plant phenomics through the enhancement of high-throughput phenotyping platforms. By applying innovative, non-destructive digital technologies, CNR-IPSP aims to develop improved germplasm with enhanced tolerance to both abiotic and biotic stresses. To achieve this, the institute has established environmentally controlled platforms (e.g., walk-in phytotron equipped with a XYZ robot that operates a multi-sensor platform to collect digital data from plants at predefined intervals and with a system of individual pots placed on scales to be used in greenhouse, where irrigation is automated with high accuracy and reliability and loss

	of weight of every pot is automatically recorded with high precision, allowing to compute transpiration dynamics and water use efficiency for every single plant) as well as field-based, high-throughput phenotyping platforms (fleets of drones, rovers, and gantry crane system) equipped with non-destructive sensors have been recently developed. These platforms are also used in precision agriculture and are complemented by: a) Portable equipment for "ground truth" validation (i.e., lean phenotyping tools such as gas exchange and fluorescence sensors) and b) Sensors for proximal and remote sensing (including novel optical sensors such as multi- and hyperspectral reflectance, infrared thermography, sun-induced fluorescence, and LiDAR). Ground-based technologies are essential as reference standards to assess the accuracy of biometric and vegetation indices derived from proximal and remote sensing data. These infrastructures are further enhanced by cutting-edge metabolomics and volatilomics equipment, creating high-quality, integrated platforms. These unique resources support the identification of biomolecules of agricultural or industrial interest and assist in selecting crop genotypes adapted to climate change and its mitigation These high-throughput phenotyping platforms are well-suited for the rapid, high-frequency screening of numerous crop varieties across a broad spatial scale, allowing for detailed analysis of structure, function, quality, and environmental interactions. This approach leverages crop genetic diversity to enhance plant productivity and drive innovations in plant breeding. However, the advanced automated data collection from these platforms generates vast amounts of data, presenting significant challenges in data management, including metadata collection and data annotation. To address this bottleneck, the CNR-IPSP plant phenotyping laboratory is developing a comprehensive computational system designed to handle the complexity of the data. This hybrid infrastructure will integrate local computing resources for preliminary analysis with an online cloud platform, enabling researchers to perform, share, and publish their findings, ranging from raw datasets to practical applications. The system's architecture is tailored to promote data harmonization and reuse, ensuring that the diversity of data collected can be managed effectively through versatile, shared data pipelines. The datasets generated by these platforms will serve as a foundation for machine learning approaches. Leveraging deep learning and artificial intelligence, researchers will be able to synthesize large, multivariate datasets, facilitating more accurate and rapid quantification of physiological traits across numerous replicate plants. To ensure transparency, reproducibility, and long-term usability of the data, the laboratory adheres to the FAIR principles (Findable, Accessible, Interoperable, and Reusable). These guidelines are essential for best practices in dataset curation, supporting the broader scientific community in accessing and reusing the data effectively.

Andriani SpA (www.andrianispa.com)

ANDRIANI Leading the Food Transition	Andriani SpA Benefit Corporation is a point of reference for healthy food innovation all over the world. The Andriani project began in 2009 with a specific idea: to innovate the sector for pasta production and sale, creating a product that was naturally gluten-free and healthy, with a unique flavour and a variety of new ingredients (rice, corn, quinoa, buckwheat, amaranth, lentils and peas). Innovation in products and processes has always characterised the Andriani Group's approach to management, and they have always aimed to combine sustainability with a competitive edge. The Andriani Group operates in the food sector, both as a co-packer for the most important global brands, and independently, with the production and distribution of products in the Felicia and Biori brands. The founding partners are brothers Michele and Francesco, the sons of Felice Andriani, who have inherited the know-how of over 40 years of experience in the milling industry, and in the design, creation, assembly and maintenance of the most important traditional pasta plants in the country. The technical partnership developed with the multinational company Buhler over decades has allowed them to build the first plant in the world that is entirely dedicated to the production of gluten-free pasta. In addition to its economic goals, Andriani pursues the goals for common good expressly included in its company by-laws following its transformation into a Benefit Corporation. As of 2021, Andriani is a Founding Member of the Global Compact Network Italy, further evidence of the company's mission and commitment to achieving the Sustainable Development Goals.

ApuliaKundi (www.apuliakundi.com)

ApuliaKundi	ApuliaKundi S.r.l. is an innovative SME based in Puglia, belonging to the Andriani S.p.A. Group; it deals with research in the field of microalgae and in particular produces Spirulina K BIO, 100% natural and pure from a circular economy path. ApuliaKundi studies and creates functional products and foods based on Spirulina K; it also provides innovation support services and accompaniment to innovative companies for the development of new economies such as algae farming; it carries out dissemination and awareness-raising activities on issues such as nutrition and environmental impact. In 2020, ApuliaKundi and Andriani S.p.A. Società Benefit and B Corp, have started a circular water management project in cooperation. The two companies have developed an innovative business initiative to produce Spirulina Algae from a circular economy while preserving the planet's natural resources such as water. Specifically, the plant recovers water from the pasta production process of the Andriani pasta factory, which, after various treatments, is used to produce spirulina algae. The algae produced is marketed as is by ApuliaKundi, transformed into spirulina-based snacks while another part returns to the pasta factory as an ingredient to produce spirulina pasta, thus closing the circular economy circle. Growing Spirulina does not cause pollution and contributes to the reduction of greenhouse gases. For every kg of dry Spirulina produced, in fact, approximately 2 kg of CO_2 are captured from the environment.

La Valle Verde Srl (www.lavalleverdesrl.it)

LaValleVerde srl	"Valle Verde Srl." is a company, which has been operating for 30 years in the Municipality of Gravina in Puglia (Bari). Its objective has always been to produce seeders dedicated to Conservation Agriculture. Numerous technical publications testify to their commitment to the experimentation and dissemination of the "sowing on no-till" technique. The experience gained in the field, resulting from a deep agronomic knowledge of Conservation Agriculture techniques, has allowed it to develop seeders dedicated to "sowing on no-till", a technique that is innovative and respectful of the environment. The choices that accompany the design and production of their products are made following the principle of: "building seeders that respond to the practical and technical needs of agricultural companies, whether large or medium-small."

3.6. Knowledge Self-Appraisal before the start of the 2nd Training Module

A simple survey (https://forms.gle/eS2bp52ec5zwreZLA) was delivered by email to the participants to understand their level of knowledge on Precision Agriculture and Innovations applied to farming practices before their participation to the Training of Trainers.

Such an evaluation allowed the collection of inputs to feed the outcome indicator linked to the Specific Objective 1 (SO1): "No. of national research institutions and corresponding staff members strengthened with capacity building and training activities."

Here below the Questions posed and the synthesis of results. The tool adopted to collect this information was Google Form.

The number of responses collected were 17, subdivided as follows:

- Egypt: 5
- Ethiopia: 5
- Kenya: 3
- Sudan: 4

The most relevant questions and answers are listed here below.

1 – How do you evaluate your know-how about precision Agriculture (PA)?

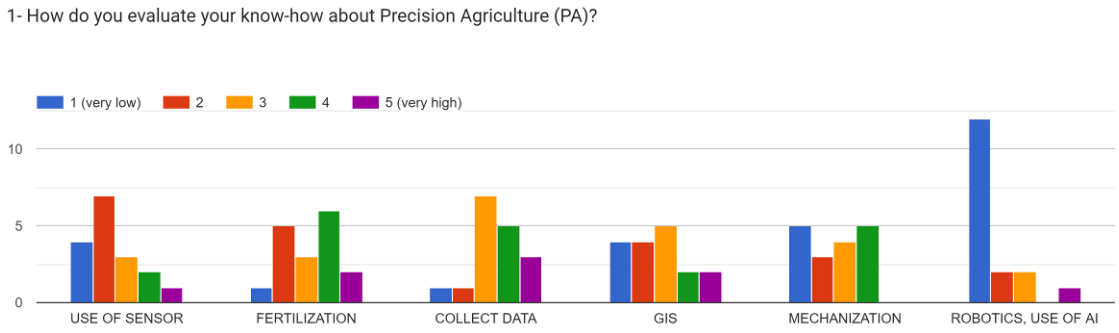


Figure 1 – Level of knowledge about PA (ranked from 1-very low to 5-very high) before the Training course.

The level of knowledge was significatively low for Robotics (82% of respondents evaluate their knowledge from 1 to 2) and quite higher for Fertilization and Collecting data (47% of respondents evaluate their knowledge for both from 4 to 5).

2 – PA can help farmers reducing inputs (level of agreement)

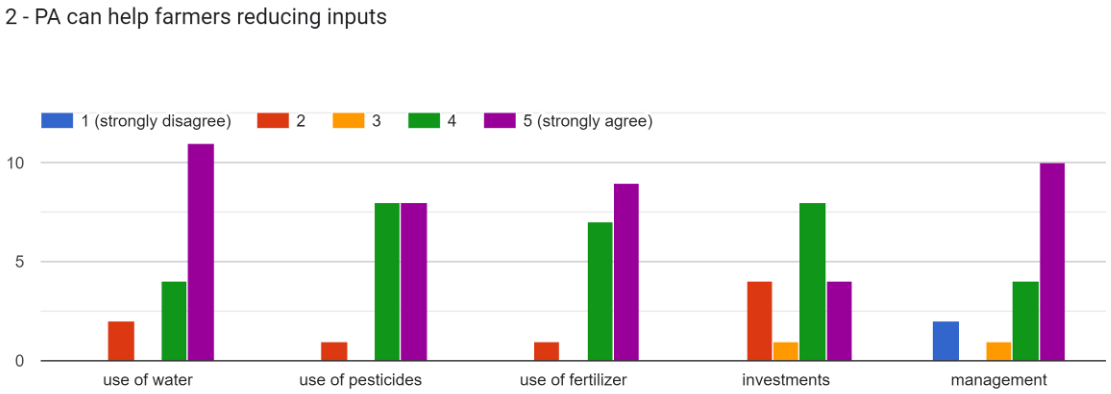


Figure 2 - Level of agreement (agree + strongly agree) about how PA reduce the inputs (use of water, pesticides, and fertilizers, level of investment and management) before the completion of the 2nd Module.

Most of the respondents consider that the implementation of PA can reduce inputs. Such perception is very high (94%) in the use of pesticides and fertilizers.

3 – PA can help farmers reducing Carbon Footprint (level of agreement)

Participants were asked to express their level of agreements about if the implementation of PA could reduce the carbon Footprint of farming activities (in term of the use of water, the fuel consumption, the reduction of soil erosion, and the use of less-efficient traditional farming methods).

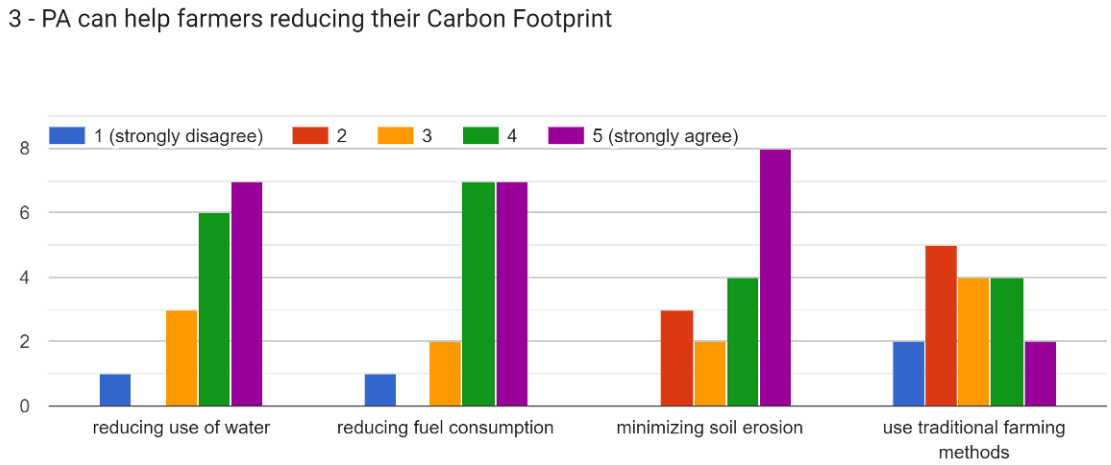


Figure 3 - Level of agreement (agree + strongly agree) about how PA reduce the Carbon Footprint (use of water, fuel consumption, soil erosion, use of traditional farming methods) before the completion of the 2nd Module.

The level of agreement (before the Training) was very high especially on the reduction of fuel consumption (82%).

4 – Technologies used in PA

The level of agreement about the technologies adopted in PA, among several of them listed (GPS, GIS, satellite data/images, use of drones, autonomous-driven machinery, crop management software, plant genetics) was evaluated.

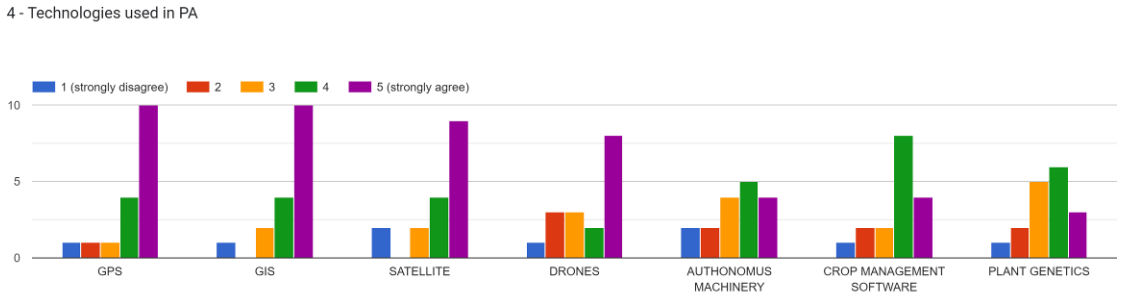


Figure 4 – Level of agreement about the technologies potentially used in PA (before the course).

The most part of participants (82%) agreed to indicate the use of GPS and GIS among the most relevant technologies to be mentioned under the umbrella of Precision Agriculture.

5 - List the main obstacles to spread the PA in your country

Here is a systematic grouping of the main problems limiting the implementation of precision agriculture (PA) in Eastern African Countries based on the trainees' answers:

1. **Knowledge and Awareness Barriers**

- Limited knowledge and awareness about precision agriculture techniques.
- Lack of training and technical know-how among farmers and practitioners.

2. **Socio-Cultural and Resistance Factors**

- Strong preference for traditional farming methods.
- Resistance to adopting new practices due to cultural and societal norms.

3. **Technology Access and Infrastructure**

- Limited access to necessary technology (GIS, GPS, sensors, etc.).
- Poor infrastructure and lack of data availability or accuracy.

4. **Economic Constraints**

- High costs of implementing PA technologies.
- Limited financial resources, particularly for smallholder farmers

5. **Policy and Regulatory Barriers**

- Insufficient government support or incentives for PA adoption
- Restrictive regulations (e.g., high-cost drone licenses).

6. **Environmental Challenges**

- Water scarcity, especially in rural areas reliant on traditional irrigation methods.
- Land and ownership fragmentation, making large-scale PA difficult to implement.

By grouping these issues, it's easier to identify where efforts could be concentrated (e.g., through enhanced education, financial and technical support, improved infrastructure, and better

coordination), the EAC can more effectively promote and implement the adoption of precision agriculture.

7 – What are the key benefits of PA?

From the responses provided, the following benefits can be synthetized:

Based on the content from the image, here's a restructured and summarized version of the key benefits of Precision Agriculture (PA), grouped into relevant categories:

1. **Increased Efficiency & Resource Optimization**

- Data Collection: Facilitates informed decisions by collecting real-time data, reducing the use of chemicals, and minimizing greenhouse gas emissions.
- Resource Efficiency: Efficient use of water, fertilizers, and pesticides by regulating inputs (e.g., irrigation, plant nutrients).
- Time, Effort & Cost Savings: Saves labour, time, and operational costs through automation and precise application of resources.
- Precision Input Management: Ensures the right inputs (water, nutrients) are applied at the right time, increasing productivity.
- Reduction of Waste: Minimizes resource wastage by optimizing inputs based on precise field data.
- High Efficiency: Promotes efficient use of sensors and modern technology to increase overall farm productivity.

2. **Enhanced Crop Yields & Productivity**

- Increased Yields: Optimizes the growth process to produce higher yields with minimal inputs.
- Productivity Improvement: Increases both production and productivity by improving resource management and reducing input costs.
- Meeting Food Demand: Helps meet the growing demand for food products through efficient and sustainable practices.
- Profit Maximization: Increases profitability by minimizing input costs and maximizing yields.

3. **Environmental Sustainability**

- Sustainable Practices: Reduces environmental impact by cutting down on chemical usage and adopting resource-efficient methods.
- Water Management: Enhances water management in large-scale irrigation schemes, promoting sustainability.
- Climate Resilience: By optimizing the use of resources, PA enhances resilience to climate variability and change.

4. **Farmer Empowerment & Capacity Building**

- Farmer Capacity Building: Enhances farmers' knowledge, skills, and sense of ownership, enabling them to better manage resources.
- Community Building: Fosters collaboration and knowledge sharing among farmers, researchers, and stakeholders.
- Education & Leadership: Provides opportunities for education, leadership skills, and capacity-building within farming communities.

5. **Enhanced Communication & Market Access**

- Knowledge Sharing: Promotes collaboration between farmers, researchers, and stakeholders, fostering better decision-making.
- Market Access & Fair Trade: Improves market access for farmers, promoting fair trade and contributing to their economic well-being.
- Improved Project & Time Management: Supports better planning, time management, and communication among farming stakeholders.

6. **Economic Benefits**

- Cost Reduction: Reduces the cost of production through resource optimization and increased efficiency.
- Profit Increase: Farmers achieve higher profit margins by reducing input costs and increasing crop yields.

8 – PA can help in reducing…

The respondents were asked to express one main effect among the following:

- The water used for irrigation, by delivering the right amount of water
- The greenhouse gas emissions by optimizing fertilizers application
- The need for tillage, increasing soil heath
- The risk of soil erosion and nutrient runoff

In the graph below the preferences expressed.

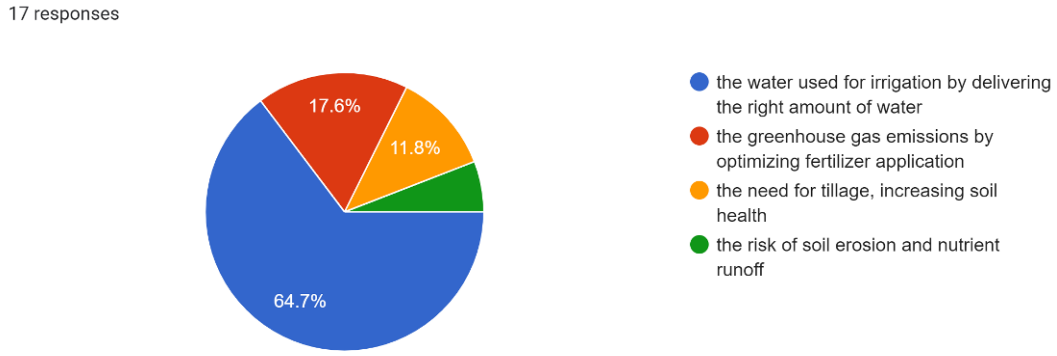


Figure 5 – The main effects of PA, according to the trainees' perceptions.

9 – Can you define PA with keywords?

In the word cloud here below, appear how the most voted keywords for PA (except for agriculture) are “Sustainability” and “Technology”.

Figure 6 – Word cloud of keywords for Precision Agriculture (before the training)

3.7. Knowledge Self-Appraisal after the completion of the 2nd Training Module

The Self-Assessment Evaluation form was sent by e-mail to participants, after the end of the Training to assess their knowledge about PA. The tool adopted to collect this information was Google Form (https://forms.gle/zA53FHKTFD5Vb2eXA).

The number of responses collected were 16, subdivided as follows:

- Egypt: 6
- Ethiopia: 5
- Kenya: 2
- Sudan: 3

Here below the Questions posed and the synthesis of results.

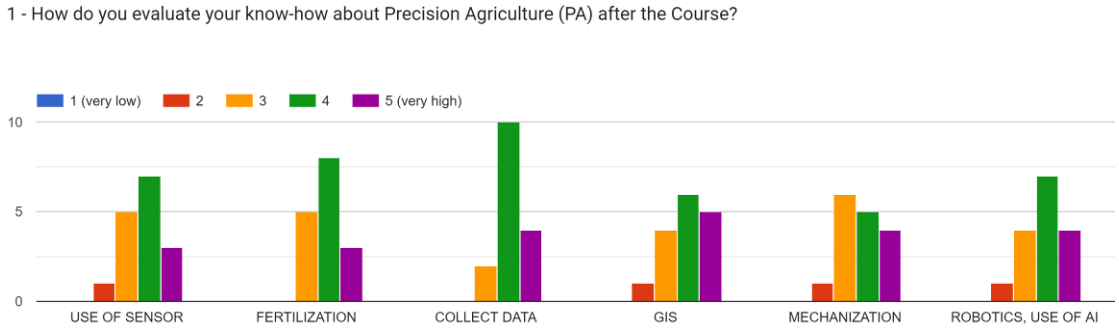


Figure 7 – Self-assessment of the knowledge level about PA after the end of the 2nd Module

As it is visible by comparing Figure 1 and Figure 7 the levels of Knowledge about the PA technologies increased (see figure here below).

The level ranked as 4-5 (high-very high) varied (as an average) from 28% before the training to 69% after the training. The levels of knowledge that increased more are those related to Robotics and use of Artificial Intelligence (63%).

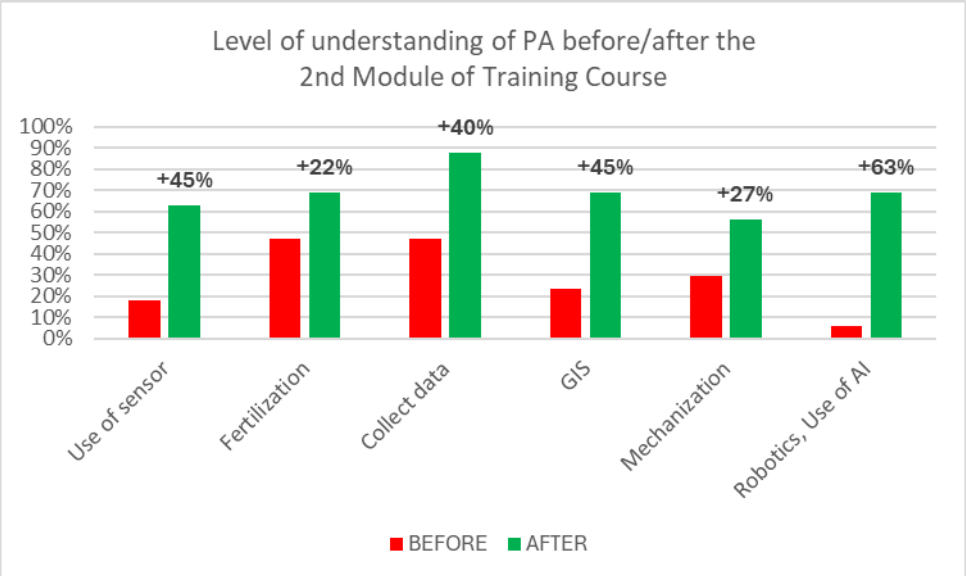


Figure 8 – Variation in the PA's level of understanding (before vs. after the completion of the 2nd module of the Training Course)

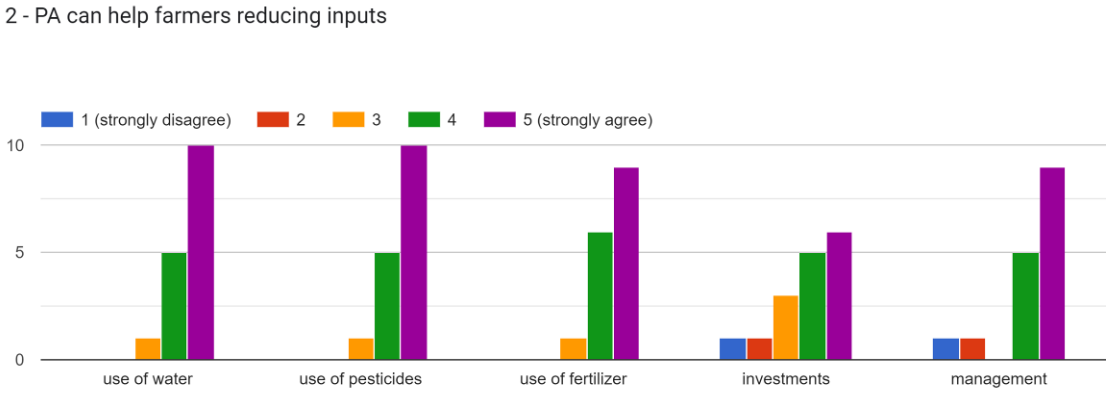


Figure 9 – Level of agreement (agree + strongly agree) about how PA reduces the inputs (use of water, pesticides, and fertilizers, level of investment and management) after the completion of the 2nd Module.

By comparing the level of agreement on how PAs can reduce inputs needs (water, pesticides, fertilizers, investments, and management), before (see Figure 2) and after (Figure 9) the course, this increases in the case of use of water (+6%), does not vary in the case of use of pesticides and fertilizers but slightly decrease in the case of investments and management inputs (from -2% to -7% respectively). Most participants consider the reduction of investments and management not so significant moving from traditional to precision agriculture.

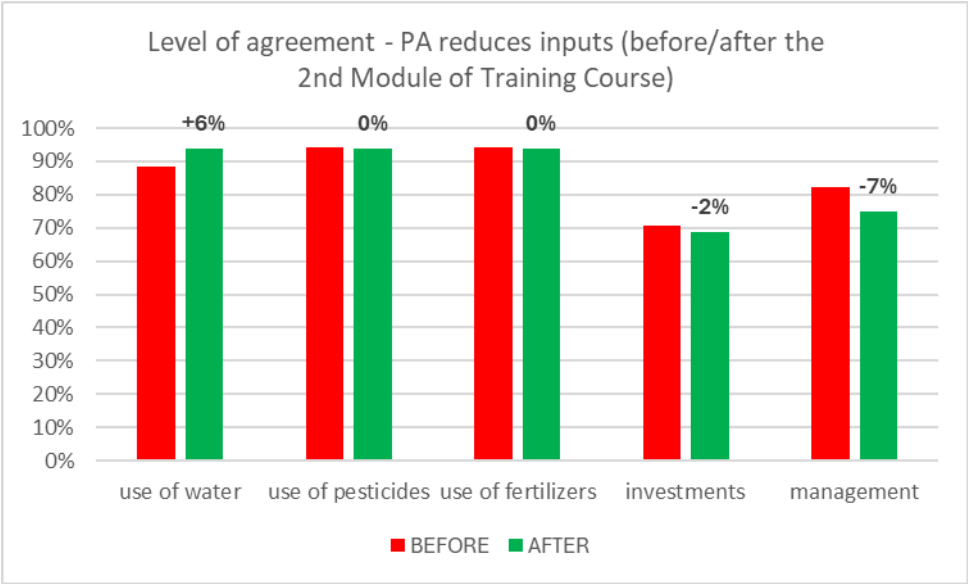


Figure 10 - Variation in the level of agreement (agree/strongly agree) on how PAs reduce the inputs needs (before vs. after the completion of the 2nd module of the Training Course)

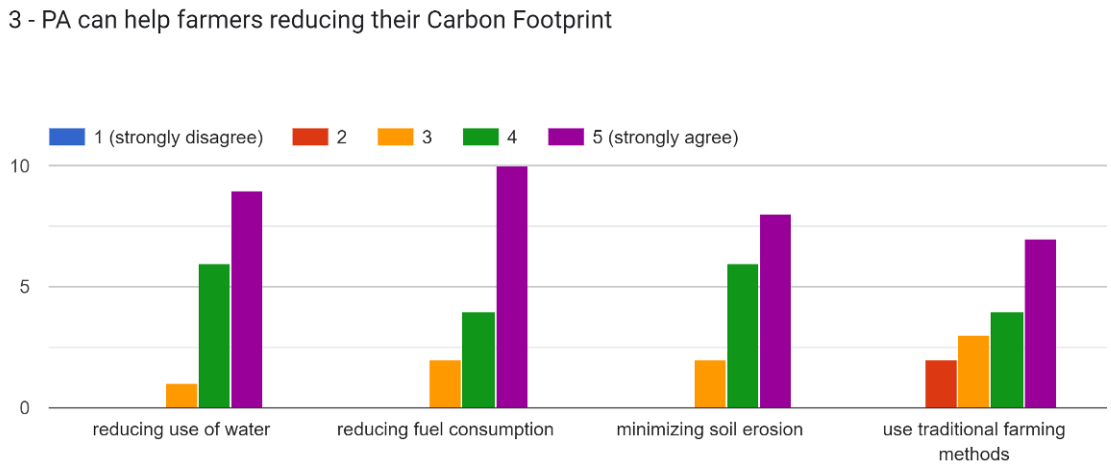


Figure 11 – Level of disagreement/agreement about how PA reduces the Carbon Footprint (use of water, fuel consumption, soil erosion, use of traditional farming methods)

By comparing the level of agreement on how PAs can reduce the Carbon Footprint (water, fuel consumption, minimizing soil erosion, reducing the adoption of less-efficient traditional farming practices), before (see Figure 3) and after the course (Figure 11), this increases in all the listed options (see Figure 12), but significantly more in comparing the Precision Agriculture with the traditional farming practices (+33%). The level of agreement ranked as 4-5 (high-very high) varied (as an average) from 66% before the training to 84% after the training.

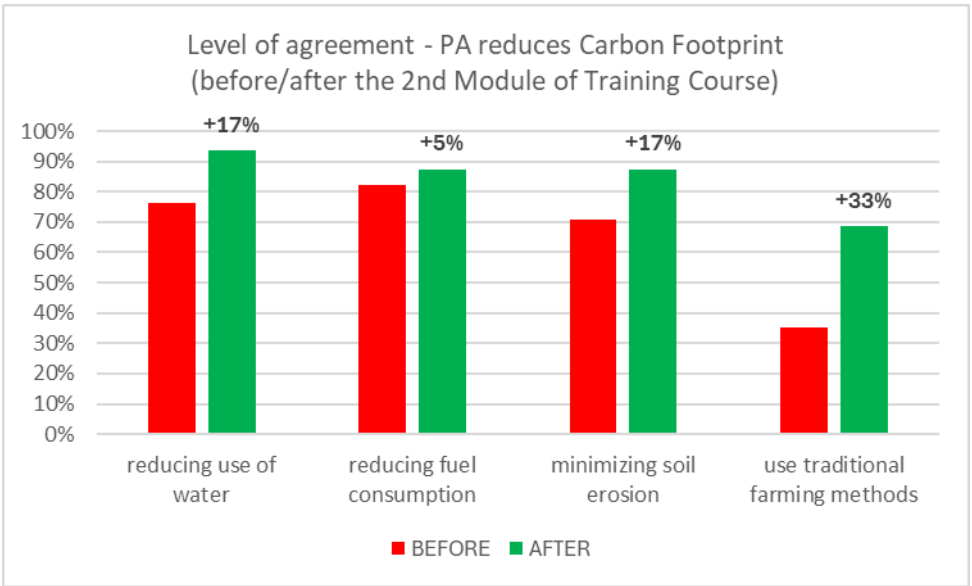


Figure 12 - Variation in the level of agreement (agree/strongly agree) on how PAs reduce the Carbon footprint (before vs. after the completion of the 2nd module of the Training Course)

After the training, the participants declared to have fully understood the concepts linked to innovations presented (see Figure 13)

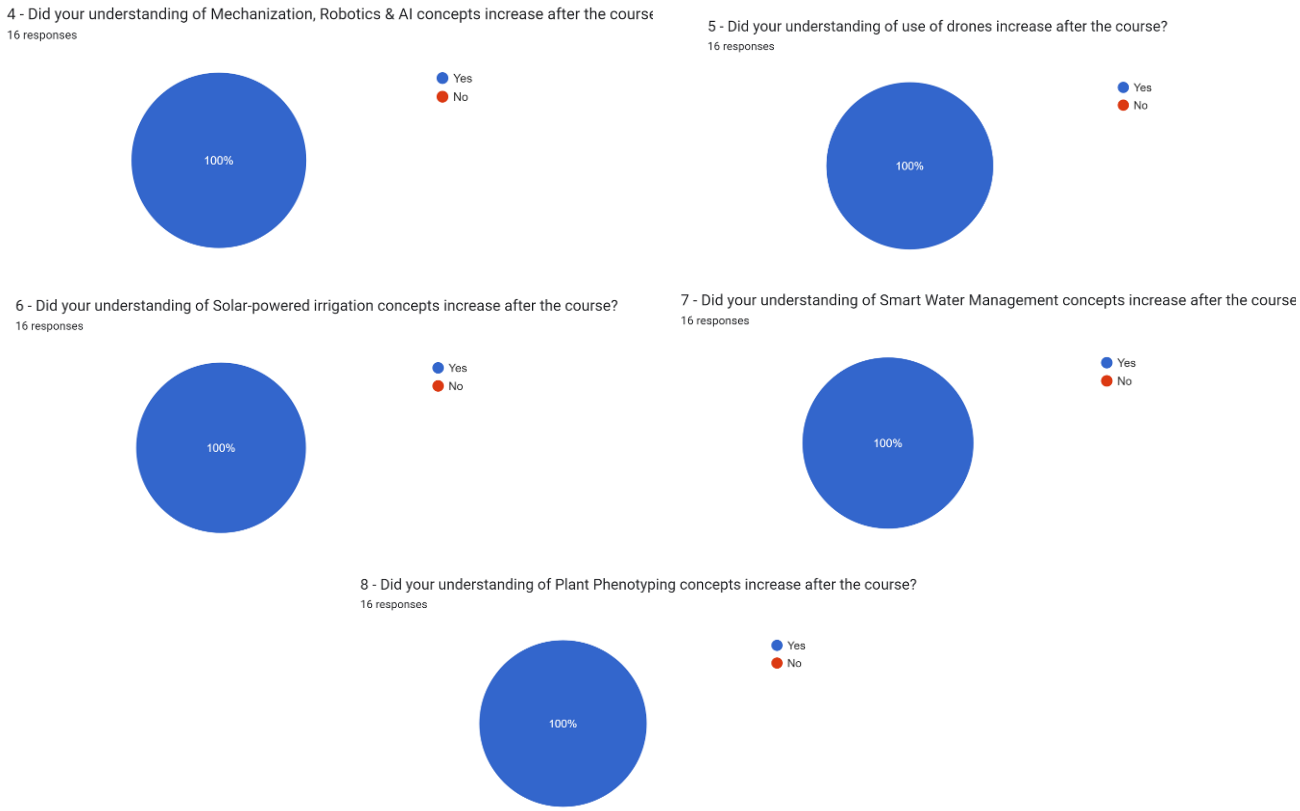


Figure 13 – Participants' understanding about the PAs (after the training)

After the end of the training, participants were asked to freely express their opinions about the ways PA can support Environmental and Socio-economic sustainability.

By grouping the opinions expressed by the trainees, the following categories emerged.

How can PA help with environmental sustainability?

1. **Efficient Resource Management**

- Water Conservation: Precision agriculture enables more accurate and efficient use of water, reducing waste. Techniques like optimized irrigation help reduce water usage, which is critical in areas prone to drought.
- Reduction of Chemical Use: By applying fertilizers, pesticides, and other inputs only where needed, PA minimizes chemical runoff and pollution, helping maintain soil health and protecting water quality.
- Energy Efficiency: PA technology, such as data-driven land management, helps reduce fuel consumption and energy use, thereby decreasing the agricultural sector's carbon footprint.
- Soil Health Maintenance: Reducing tillage helps preserve soil structure, mitigates erosion, and enhances soil carbon sequestration, contributing to long-term soil fertility and ecosystem health.

2. Reduction of Greenhouse Gas Emissions

- Optimized Input Use: PA reduces the need for excessive fertilizers and fuels, which lowers greenhouse gas emissions associated with their production and application.
- Enhanced Land Use Planning: By utilizing data to make more informed land-use decisions, PA prevents unnecessary expansion and deforestation, which helps to protect natural habitats and reduces carbon release.

3. Conservation of Biodiversity

- Minimization of Ecological Disturbance: Reducing chemical and pesticide use helps protect beneficial organisms and supports a more diverse ecosystem, ensuring that both crop production and the surrounding environment thrive.
- Sustainable Land Practices: PA allows farmers to identify areas better suited for conservation, leading to reduced habitat destruction and promoting the preservation of biodiversity.

4. Sustainable Food Production and Supply Chain Optimization

- Reduction in Food Waste: With PA technology, food production and distribution can be better managed to minimize waste throughout the supply chain, ensuring that resources are used effectively and sustainably.
- Promotion of Sustainable Farming Practices: Public demand for sustainably grown products encourages farmers to adopt PA practices that align with environmental goals, creating a positive feedback loop for sustainable agriculture.

5. Climate Adaptation and Resilience

- Adaptation to Climate Change: PA makes it easier to monitor environmental conditions and make rapid adjustments, which can help mitigate the impacts of climate change. For example, PA can aid in managing resources during extreme weather events like droughts.
- Reduced Vulnerability: By using real-time data to respond to changing weather patterns, PA enhances resilience against climate-related stresses, such as erratic rainfall and soil degradation.

6. Public and Policy Influence

- Consumer Demand for Sustainable Products: Awareness of environmental sustainability can drive consumer demand for products grown using sustainable practices, encouraging more farmers to adopt PA methods.
- Support for Environmental Policies: Positive public perception around sustainable farming can influence policymakers to implement regulations that support PA adoption, like subsidies for eco-friendly practices and restrictions on harmful agricultural methods.

How can PA help with socio-economic sustainability?

1. **Economic Efficiency and Profitability**

- Cost Savings: PA reduces the use of water, pesticides, fertilizers, and other costly inputs, which helps lower operating costs. Efficient use of resources also means fewer expenses on inputs, enabling higher profits.
- Increased Productivity: By optimizing crop yields with precise resource management, PA boosts productivity, leading to higher-quality yields and better profit margins for farmers.
- Labor Cost Reduction: Automation and efficient resource use help reduce manual labor costs, allowing farmers to allocate their resources to other areas, increasing overall profitability.

2. **Improved Income and Market Access for Farmers**

- Enhanced Farmer Income: By increasing efficiency and productivity, PA helps farmers improve their income. Additionally, higher-quality produce can often fetch better prices in the market.
- Access to Premium Markets: PA enables farmers to connect with markets that value sustainability, organic practices, and transparency. Technology also allows for traceability, making it easier to tap into markets focused on ethical sourcing and fair trade.
- Empowering Small Farmers: By providing access to technology and data-driven platforms, PA allows smallholder farmers to compete with larger operations, find new markets, and collectively bargain for better prices.

3. **Sustainable Resource Management**

- Optimized Input Use: PA allows for efficient use of natural resources, such as water and nitrogen, reducing waste and expenses. This aligns with economic sustainability by conserving resources and decreasing dependency on expensive inputs.
- Environmental and Economic Stability: Recycling practices, like those seen in other industries, can apply to PA by reusing certain materials or reducing pollution. This adds value to the resources and promotes a circular economy, which benefits both the environment and the economy.

4. **Job Creation and Socioeconomic Development**

- Job Creation through Technology: PA introduces technology-focused roles, such as data analysis and precision machinery operation, opening new opportunities for employment in rural areas.
- Sustainable Livelihoods for Rural Communities: By promoting higher incomes, reduced costs, and access to new markets, PA enhances the livelihood of rural communities, potentially reducing poverty and contributing to socioeconomic development.

5. **Enhanced Product Competitiveness**

- Higher-Quality Products: PA enables better control over crop production, which can result in higher-quality products that are more competitive in the market.
- Value-Added Products: By producing products that are sustainably grown and of higher quality, farmers can add value, making their products more attractive to consumers who prioritize sustainability.

6. **Consumer Influence and Market Trends**

- Shaping Consumer Behaviour: A positive public perception of sustainable practices can drive consumer demand for locally produced, ethically sourced, and environmentally friendly products. This, in turn, increases demand for products from PA-based operations, benefiting farmers and rural economies.
- Influence on Policy and Market Trends: As PA aligns with broader sustainability goals, it influences policymakers to support and fund these practices, further fostering socioeconomic growth and stability in agricultural communities.

Participants were also asked to express their opinion about the **factors that can influence the feasibility of PA** in their Countries. Based on the answers provided, here are the key factors that can influence the feasibility of PA techniques in the East African Countries (EAC):

1. **Economic and Financial Factors**

- High Initial Costs: The upfront investment in PA technologies, such as sensors, drones, and software, can be prohibitive, especially for smallholder farmers. Limited access to subsidies or financing options further impacts affordability.
- Farm Size and Economies of Scale: PA may be more cost-effective for larger farms, where the technology costs can be distributed across greater areas. Smaller or fragmented farms may find it challenging to justify the cost, making PA less feasible.
- Economic Viability: Ongoing costs, such as maintenance and upgrades, need to be balanced against the financial returns from implementing PA to ensure it remains economically viable.

2. **Access to Technology and Infrastructure**

- Availability of Technology: Farmers in remote or underdeveloped areas often have limited access to advanced PA tools, including sensors, drones, and other necessary equipment. Limited technology access makes it challenging to implement PA.
- Internet Connectivity: Reliable internet is essential for many PA techniques, especially those involving data analysis or remote monitoring. Regions with poor connectivity may struggle to adopt PA methods that rely on real-time data.
- Power Supply: Access to consistent power sources is needed for operating PA tools. Unreliable or costly power sources can limit feasibility, particularly in rural areas.

3. **Farmer Knowledge, Training, and Education**

- Technical Skills and Knowledge: PA requires a level of technical expertise for operating advanced machinery, interpreting data, and using software tools. Without adequate training, farmers may find it difficult to adopt PA practices effectively.
- Training and Support Systems: Access to education programs, workshops, and ongoing technical support is crucial. Collaboration with agricultural extension services and tech providers can help bridge the knowledge gap and enhance adoption.

4. **Social and Cultural Factors**

- Awareness and Acceptance: Farmers' awareness of the benefits and potential of PA, along with general acceptance of technology, can influence adoption rates. Cultural factors and resistance to change from traditional farming methods may affect feasibility.

- Age and Familiarity with Technology: Younger farmers may be more open to adopting digital tools like smartphones and data-driven systems, while older farmers may require additional training or assistance.

5. **Policy and Market Support**

- Government Policies and Incentives: Supportive government policies, such as subsidies, grants, or tax breaks for sustainable and innovative agricultural practices, can enhance the feasibility of PA. Regulatory support can also help create a favourable environment for adoption.
- Market Demand: Consumer demand for sustainably grown products, coupled with public awareness of environmentally friendly practices, can drive market acceptance and support the adoption of PA.

6. **Environmental and Geographical Conditions**

- Land Characteristics and Scale: The size, type, and fragmentation of farmland can affect PA feasibility. Larger, contiguous plots are often more suited for PA, while smaller, fragmented plots may present challenges.
- Regional Limitations: Geographic factors, such as topography and soil type, can impact the effectiveness of certain PA techniques, making it crucial to adapt PA practices to suit specific regional conditions.

7. **Data Collection and Management**

- Access to Data Collection Tools: Successful PA implementation relies on effective data collection and management. Accessing accurate, simple, and user-friendly data collection tools is essential for farmers to make informed decisions.
- Data Analysis Capabilities: Skilled technicians to analyse data accurately and efficiently is needed. Without proper data interpretation, the benefits of PA may not be fully realized.

Finally, the participants were asked to express their opinions about what they consider as the **main obstacles in spreading the PA in EAC**. The answers were grouped into several categories:

1. **Economic Barriers**

- High Costs: The cost of acquiring PA technologies (sensors, drones, GPS systems) is prohibitively high for smallholder farmers.
- Financial Constraints: Limited access to affordable credit or loans prevents farmers from investing in PA technologies.
- Low-Profit Margins: Farmers often operate on narrow profit margins, making it difficult to justify the upfront investment in advanced agricultural solutions.
- Lack of Government Incentives: Limited governmental support, such as subsidies or grants, hampers the financial viability of adopting PA techniques.

2. **Technological Challenges**

- Limited Access to Technology: Many farmers lack access to necessary PA tools and technologies due to high costs or scarce availability.
- Technological Infrastructure Gaps: Insufficient internet connectivity in rural areas limits the use of digital tools essential for data sharing and analysis.
- Data Scarcity: There is often limited access to reliable data on weather patterns, soil health, and market conditions for effective PA implementation.

- Data Management Issues: Inadequate data collection systems hinder effective data management and analysis for decision-making in PA.

3. Knowledge and Training Deficiencies

- Lack of Knowledge and Awareness: Many farmers are unfamiliar with PA techniques and are unaware of their benefits, leading to slow adoption.
- Insufficient Training: Limited availability of training programs and trainers restricts farmers' ability to learn how to effectively use advanced agricultural technologies.
- Technical Skills Gap: A general lack of technical expertise necessary to operate PA tools and interpret data further complicates implementation.

4. Cultural and Social Resistance

- Cultural Resistance: Deeply ingrained traditional farming methods create resistance to adopting newer, sustainable practices.
- Rigidity to Change: Some local populations may be reluctant to changing their farming practices, preferring established methods over innovative techniques.

5. Policy and Regulatory Issues

- Weak Government Support: Inadequate policies and regulations that do not incentivize or support sustainable practices make it difficult for farmers to transition to PA.
- Lack of Collaboration: Limited collaboration among farmers, NGOs, and government agencies reduces opportunities for sharing knowledge and resources.

6. Environmental Challenges

- Water Scarcity and Mismanagement: Significant water shortages make the adoption of PA techniques more difficult and require careful water management.
- Dependence on Traditional Irrigation: Reliance on traditional irrigation methods may hinder the adoption of more efficient practices offered by PA.
- Climate Variability: Unpredictable climate conditions can complicate the effectiveness of PA, making farmers hesitant to invest in technologies that depend on stable environmental conditions.

7. Infrastructure Limitations

- Inadequate Infrastructure: Poor infrastructure in rural areas hampers the implementation of digital tools and technologies necessary for PA.
- Lack of Power Sources: Insufficient electricity and power sources can limit the operation of advanced agricultural technologies.

This grouping can help identify areas for intervention and support to promote the spread of precision agriculture in the EAC.

In the figure below, the causes and effects among the different areas are depicted.

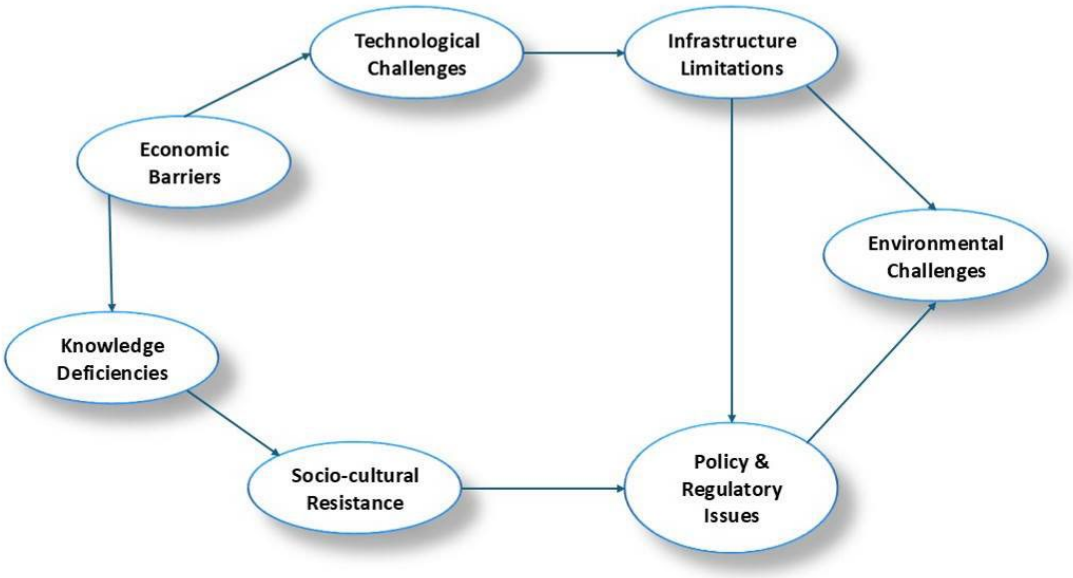


Figure 14 – Simplified Cause-Effect relationships of Obstacles to the spread of PA in EAC

3.8. Outcomes from the participants' evaluation of the 2nd Training Module

All participants were also invited to answer an online questionnaire, and provide their opinions on the quality of the program and overall organization of the 2-week training: https://forms.gle/YhKqaepaBtm3kpBt8. 13 out of 15 participants (12 in presence and 3 online) answered the survey, whereas the participants from Kenya and Sudan who attended the module online, were not connected in a stable manner during this period.

The trainees declared that their interest for the topics was very high (76.9%).

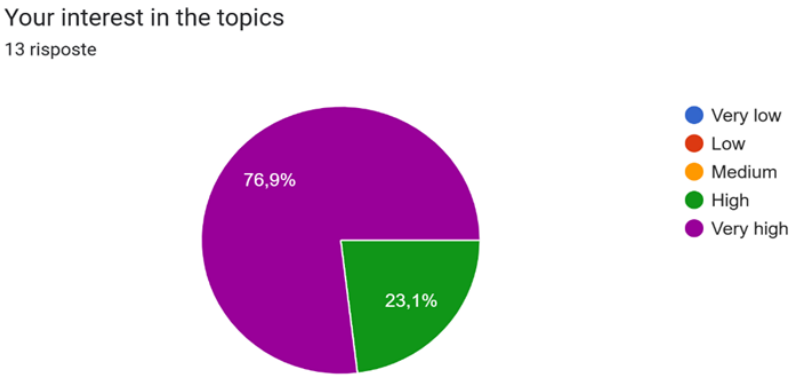


Figure 15 – Evaluation of the trainees' interest in the course topics.

The time devoted to each topic was evaluated as adequate (61.5%) or plenty (7.7%).

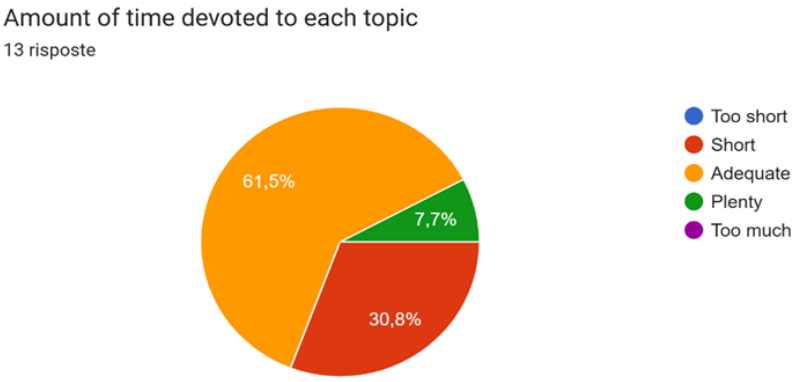


Figure 16 – Overall evaluation of the time devoted to each topic during the course.

69.2% of the participants declared that the topics examined during the 2nd Module have very high applicability in their work.

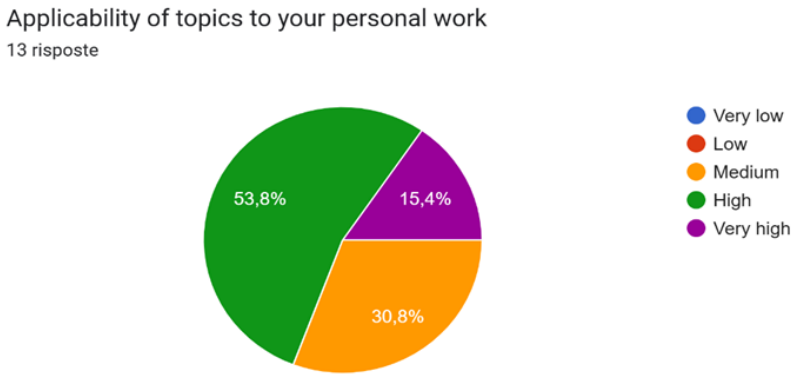


Figure 17 – Evaluation of the applicability of course's topics to the trainees' work

The quality of teaching was evaluated very high (53.8%) and high (46.2%)

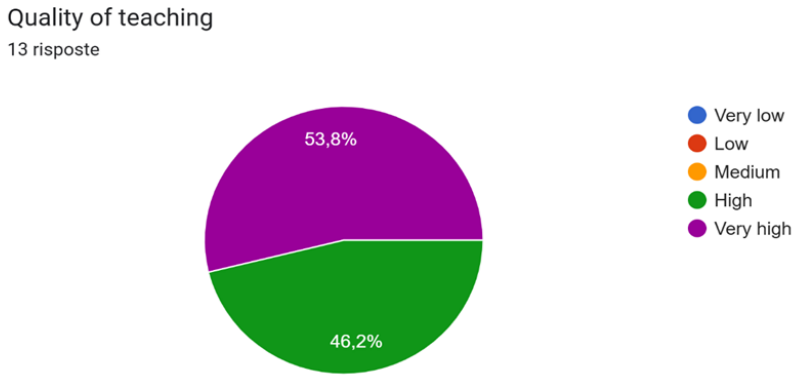


Figure 18 – Overall evaluation of the quality of teaching.

The quality of the training material was evaluated as very high (61.5%) and high (38.5%).

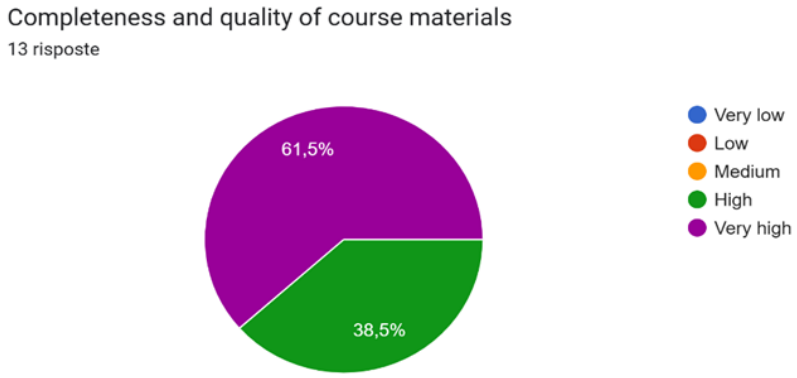


Figure 19 – Overall evaluation of the training material.

The course's activities (lectures, workshops, technical visits, …) allowed a good level of interaction among trainees and with the lecturers.

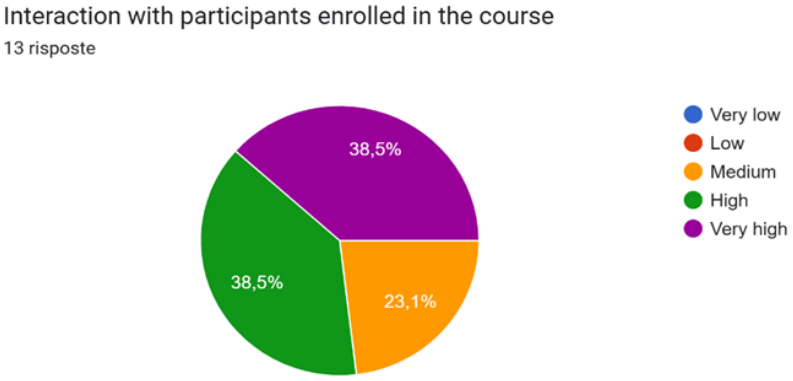


Figure 20 – Evaluation of the interaction's level among trainees.

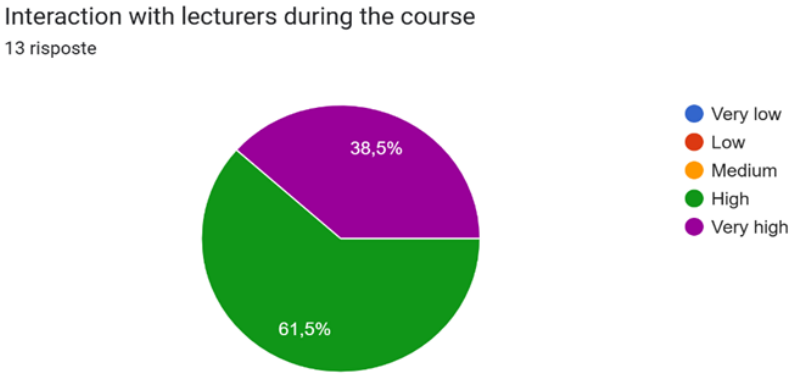


Figure 21 – Evaluation of the interaction level between trainees and lecturers.

In the figure below the different aspects of the course (program, methodology, organization) and the benefits achieved were evaluated. The trainees estimated as excellent the quality level of the training.

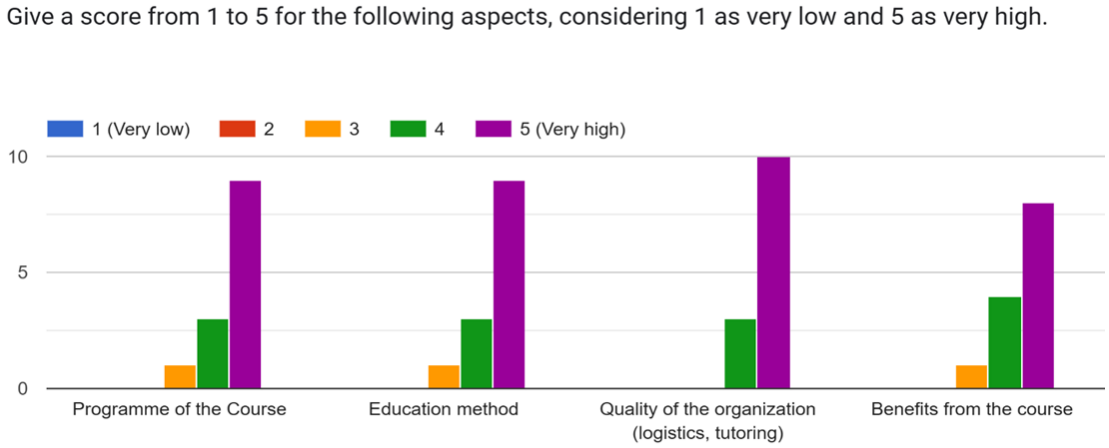


Figure 22 – Evaluation of different aspects of the training course

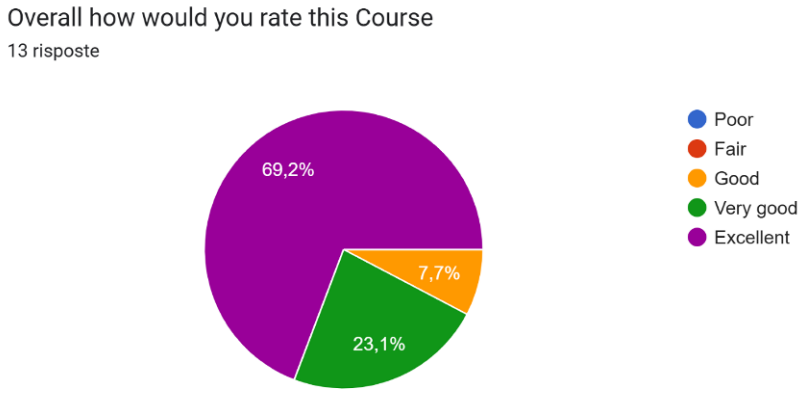


Figure 23 – Overall evaluation of the 2nd Module of the Training Course

Here is a summary of the suggested topics for addition to a course program:

1. **Technology Integration in Precision Agriculture**

- **Smartphone Applications and Websites:**
  - Development and utilization of mobile and web applications for crop monitoring, weather forecasts, and yield predictions.
- **Artificial Intelligence (AI) in Agriculture:**
  - AI applications for data analysis, crop monitoring, and predictive modeling.
  - Practical sessions on AI-powered tools in precision agriculture.

2. **Water Management and Irrigation Techniques**

- **Irrigation Scheduling:**
  - Strategies for optimizing irrigation schedules based on weather patterns and soil moisture levels.

- **Water Sources and Harvesting for Irrigation:**
  - Techniques for rainwater harvesting, groundwater utilization, and surface water storage.
- **Modern and Smart Water Distribution and Control Methods:**
  - Use of automated irrigation systems, drip irrigation, and other water-efficient technologies.
- **Crop Water Requirement and Soil Laboratories:**
  - Analyzing soil moisture and understanding specific crop water requirements.
  - Hands-on experience with soil testing and interpretation of soil data.

3. **Field Visits and Practical Exposure**

- **Visits to Farms Utilizing PA Technologies:**
  - Field trips to farms using drones, sensors, and other PA technologies for real-world learning.
- **Drone and AI Practical Sessions:**
  - Drone training for crop monitoring and data collection.
  - Hands-on projects involving AI tools for analyzing farm data.

4. **Financial Aspects of Precision Agriculture**

- **Financing for Small-Scale Farmers:**
  - Funding options for smallholders to adopt PA technologies.
  - Government grants, microloans, and partnerships with agricultural banks.

5. **Sustainable and Alternative Agriculture Approaches**

- **Sustainable Agriculture Practices:**
  - Incorporating sustainable techniques such as crop rotation, conservation tillage, and integrated pest management.
- **Biodynamic Agriculture:**
  - Understanding principles of biodynamic farming and its alignment with PA practices.

These suggestions cover a broad range of topics aimed at enhancing agricultural practices, sustainability, and climate resilience.

4. Conclusions

The course was evaluated very positively by the participants. Those who attended online had some problems following the technical visits smoothly.

Based on the suggestions provided by the trainees, here are some recommendations to improve the course:

- **Increase Duration:** Extend the course duration to allow for more in-depth learning and practical experience.
- **Visa Assistance**: Provide support to international participants with VISA application processes.
- **Emphasis on In-Person Learning**: Prioritize in-person over online formats, as hands-on experiences are more beneficial for this subject.
- **Practical Exposure**: i) Organize more field trips to farms and facilities, such as working wastewater treatment plants, to observe PA technologies in action. ii) Increase opportunities for practical application and hands-on activities.
- **Enhanced Interaction and Networking**: Allow more time for student interactions and discussions to promote collaboration and networking.
- **Curriculum Improvements**: i) Enrich the curriculum with advanced and interrelated topics in Precision Agriculture. ii) Encourage research projects that tackle real-world PA challenges, enhancing critical thinking and problem-solving skills.

By incorporating these suggestions, the course can offer a balanced mix of theoretical knowledge and practical skills, thereby enhancing the overall learning experience and effectiveness.

5. Annexes

5.1. Training & Capacity Building 2nd Module (09-13 September, Online / 16-20 September at CIHEAM Bari - Italy)

Training Materials:

- 1st week: https://cloud.watdev.eu/index.php/s/2DE6myMTGxspLtK
- 2nd week: https://cloud.watdev.eu/index.php/s/fsEEiix79i5R4jn

Training programme (weekly): https://cloud.watdev.eu/index.php/s/nE7HozqSjTGt7SC

Daily attendance register: https://cloud.watdev.eu/index.php/s/xrTBPRZzRWYGe9R

2nd Module photo gallery: https://cloud.watdev.eu/index.php/s/6zjJsxznzjb2Eeb