EU CAP NETWORK

EU CAP Network Workshop: Circular water management

Final Report

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Executive Summary

An EU CAP Network workshop 'Circular water management' took place in March 2024 in Seville, Spain, bringing together 83 stakeholders, including farmers and entrepreneurs. The primary goal was to share knowledge and encourage the adoption of solutions for reusing and recycling water in agricultural production. This involves capturing, storing/retaining, treating, and reusing water multiple times from sources close to the farm such as from fields, roofs, greenhouses, farm activities (e.g. livestock activity, primary processing), or small-scale nearby agri-food industries.

The workshop began with an overview of past achievements in agricultural water use efficiency, and emphasised why circular water management is the next step in addressing water-related challenges in the farming sector. Although the proposed solutions were primarily focused on the farm-scale, the workshop adopted an integrated approach considering the potential effects of water reuse on the overall basin water balance.

Four inspiring talks and 15 project posters were presented showcasing innovations based on both: i) "hard-type" technologies such as membranes for water filtration or solar panels to reduce soil evaporation from ponds and/or ii) "nature-based-solutions" such as constructed wetlands or the use of biochar. Some solutions were also integrated into decision support tools to assist practitioners in implementing the appropriate practices based on their inputs and constraints. Robust hydrological models were incorporated into GIS tools to identify the best sites for water collection and potential on-site treatment.

The circular approach was particularly effective when farms were located near agri-food industries, where treated water could be reused not only within the industry but also for irrigating nearby crops. Interestingly, in some cases, the solid waste from treatment operations could be repurposed, for instance, as feed for aquaculture species or to produce extracts used as plant biostimulants. Additionally, some innovative projects addressed management challenges by providing tools and applications to facilitate the administrative phases of implementing solutions on the ground. Governance, legislation, and financial aspects were frequently identified as either barriers or enablers for implementing these solutions.

The afternoon field visit provided participants with the opportunity to observe on-the-ground facilities for water management at an organic horticulture packing house. Here, washing water was reused multiple times after undergoing simple yet effective on-site treatments.

Throughout the workshop, stakeholder interaction was encouraged through engaging discussions in "Pro-Action Cafés" where challenges and solutions were identified. The workshop concluded with a lively "Fishbowl" session, during which participants explored research needs arising from practical experiences.

Among the new challenges discussed by practitioners, the need for long-term research on the impact of using different non-conventional water sources on the soil-plant ecosystem, as well as the potential effects on human nutrition and health, was highlighted. Such research will help society, consumers, and farmers gain greater confidence in the reuse of water for food production and in the circular water management approaches being considered. In fact, raising awareness and involving consumers in the process were also suggested as crucial next steps to promote more effective use of circular water management solutions within the farming sector.

Source: European Commission

1. Introduction

1.1. Background

The competitiveness and resilience of the farming sector depend heavily on the availability and quality of natural resources such as soil, nutrients, water, and biodiversity. **Water** is arguably the most critical input for crop production, and its management in agricultural systems has direct consequences on the surrounding environment and the overall water balance at basin level. Plant water status is a key determinant of biomass production, making the optimisation of soil water availability a primary goal for farmers.

On average, **irrigation** accounts for 24% of water abstractions in the EU, with significant regional and seasonal variations. In southern European countries, irrigation can account for up to 60-70% of abstracted water, while in some Northern European regions, this percentage can reach 30% during the summer. These variations highlight the challenges linked to the unsustainable management of water resources in agriculture, particularly regarding over-abstraction.

Natural resources are under increasing pressure from environmental variations linked to **climate change**, groundwater depletion, soil erosion, and desertification challenges, to which agriculture also contributes. There is growing evidence of the negative effects of climate change-induced shifts in precipitation and temperature on water availability for agriculture, with significant impacts on food production (IPCC 2023). As a highly water-dependent sector, agriculture will be severely affected by these changes, facing growing challenges with water scarcity. The productivity of both rain-fed and irrigated crop production in many regions is at risk, with potential consequences for food security and the economic sustainability of the farming sector.

In many areas, increasing irrigated land is not feasible due to current water resource limitations, as well as the technical difficulties and high costs associated with providing and installing the necessary water infrastructure, both on-farm and from the water source to the farm gate. Therefore, it is essential to explore more ***nature-based*** and **sustainable** solutions to enhance a farm's capacity to store more water in the soil, as well as to capture and treat water runoff and discharges from the surrounding environment. This includes water from farm fields, roofs, greenhouses, farm activities such as livestock operations and primary processing, and small-scale agri-food industries.

In this context, the EU CAP Network workshop 'Circular water management' was held in Seville, Spain, on 12-13 March 2024, bringing together 83 participants. Farmers, advisors, researchers, entrepreneurs, and other relevant stakeholders shared knowledge and practical experiences related to innovative projects and solutions for **circular water management**, with the aim of applying these practices throughout the European Union.

Source: European Commission

1.2. Overall aim and specific objectives of the workshop

The primary focus of this workshop was on circular water management, specifically the **reuse and recycling of water in agricultural production**. This involves capturing, treating, and reusing water multiple times within farming processes or from nearby small-scale agri-food industries. To achieve this overall aim, the workshop participants, including **innovation actors, were tasked with the following objectives**:

- Share and Exchange Knowledge: Disseminate and exchange innovative approaches and practices from Operational Groups, EU Horizon and LIFE projects and other relevant initiatives focused on circular water management (reuse and recycling).
- Identify Tailored Methods: Determine methods and techniques for circular water management that are tailored to different types of farms, considering factors such as crops, animal production, size and capacity.
- Explore New Wastewater Resources: Identify new sources of wastewater from small agri-food industries (primary processing) that can be utilised individually or collectively.
- Highlight Socioeconomic Benefits: Emphasise the socioeconomic benefits of implementing circular water management systems, while identifying challenges, knowledge gaps, skill requirements, and research needs from a practical perspective.
- Promote Networking: Foster networking opportunities to encourage future collaboration.

The ultimate **specific objectives** to be achieved were:

- Promote Circular Water Management: Showcase innovative approaches to the reuse and recycling of water, including the management of agricultural runoff, advanced water recycling technologies, and novel wastewater treatment systems at the farm level.
- Explore Soil Management Techniques: Investigate soil management practices that support water circularity.
- Examine Rainwater Harvesting Methods: Evaluate methods and technologies for rainwater harvesting to reduce reliance on conventional freshwater sources.
- Foster Cooperation: Explore opportunities for collaboration between small agri-food industries (primary processing) and farmers to utilise wastewater effectively.
- Identify Barriers: Identify obstacles related to knowledge, skills and technologies that hinder the implementation of circular water use practices at the farm level.
- Encourage Dialogue: Facilitate the exchange of good practices among participants on collective water resource management and promote sustainable agricultural practices.

1.3. Participation

The workshop attracted a diverse group of attendees, representing 18 different nationalities and various professional backgrounds.

The tables below provide a detailed overview of the participants' nationalities and their professional affiliations.

Attendees by country:

Country	Participants
Austria	1
Belgium	9
Croatia	2
Denmark	1
Finland	4
France	4
Germany	5
Greece	10
Hungary	4
Italy	10
Malta	1
Netherlands	4
Portugal	5
Romania	1
Slovenia	2
Spain	17
United Kingdom	1
Ireland	2
Total: 83	

Attendees by professional background:

Professional background	Participants
Researcher	33
Farm manager / owner	9
Forester/forest manager	2
Advisor / Farm advisor	21
Civil Servant	5
Innovation support agent / innovation broker	7
IT expert / technology developer	2
Other	4

Source: European Commission

2. Part I. Welcome on board!

2.1. Introduction to the workshop and EU CAP Network

After an interactive registration event, where participants introduced themselves by contributing to an inspirational wall with information about their background, what they could offer, and their needs, the workshop was officially opened by **Elin Johnsson**, Policy Officer at the European Commission - DG Agriculture and Rural Development. Elin introduced the EU CAP Network and the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), emphasising the importance of enhancing the exchange of knowledge and bridging the innovation gap between research and agricultural practice through EIP-AGRI Operational Groups and their links with Horizon 2020/Europe activities.

Source: European Commission

Participants then had the opportunity to connect with each other by sharing a table with seven colleagues. Their expectations primarily centred on *"learning from others' experiences"* and *"better understanding the possibilities for circular water management under current regulations"*. A brainstorming session was initiated to explore the concept of circular water management under current regulations. Interestingly, initial thoughts included: *"saving water should be the first step*; *"responsibility in distribution and allocation"*; *"opportunity for nutrient recycling"*; and *"circular water management is at the core of the water-food-ecosystem nexus"*.

Source: European Commission

2.2. Setting the scene

Diego Intrigliolo, the workshop's coordinating expert, presented the framework for circular water management. He began by clarifying that crop biomass production is linked to evapotranspiration (i.e. water use). To explain the various water sources that sustain crop productivity, he used the **water colours** concept from the water footprint initiative. This framework was necessary to distinguish between:

i. Blue Water: Water used for irrigation, which is an external input derived from the surface or subterranean water sources.

ii. Green Water: Precipitation that lands on soil, where it is stored rather than running off or recharging groundwater.

iii. Grey Water: Water runoff from agricultural fields which, according to the Water Footprint Initiative, typically indicates freshwater pollution. In the context of this workshop, however, grey water refers to water reuse and the need for prior treatment within a circular water management approach.

The **working scales** were defined, which is a crucial aspect for assessing the effectiveness and potential impacts of different practices and solutions. While a whole basin-level approach is necessary for a holistic understanding and comprehensive management of agricultural water, the focus for this workshop was on the **farm level and its immediate surroundings**, particularly agri-food processing activities that are closely and directly related to farm operations. Based on this focus, the workshop considered three levels: water from the farm (including fields, roofs, greenhouses, etc.), water from farm activities (such as livestock operations and primary processing), and water from small-scale agri-food industries.

In the last decade, significant efforts and solutions have been effectively developed to improve irrigation **efficiency**, such as the use of sensors and models (refer to the outputs from a previous EIP-AGRI Workshop on Water and Agriculture). Advances in digitalisation and the use of remote sensing tools now enable the monitoring and mapping of entire fields, allowing for the assessment of variation within and across farms. These advancements have significantly increased water productivity at the farm level.

The next step is then to explore "soft" measures to increase water availability through **soil management**, aiming to maximise the retention of rainfall for crop transpiration. Examples include soil mulching and the use of cover crops, which are on-site solutions that can be applied across the entire soil surface. Additionally, other techniques can be used to enhance soil water storage in specific areas of the farm by leveraging field topography (such as slopes and orientations), or taking advantage of discontinuous cropping systems where the soil is not fully covered by vegetation. The workshop also emphasised the integration of on-farm and off-farm solutions, such as cascade cropping, impeding and trapping water run-off, and the potential for underground water harvesting.

A final important remark was made regarding **integrated water management**, emphasising that while recycled water is essential and beneficial for enhancing water resources in agriculture, it is not "free" water when considering the entire basin, especially in inland areas. Water transpired by crops cannot be recycled, and exits the basin's water cycle. Therefore, while reusing water for irrigation is necessary for crop production and brings positive economic and social benefits to rural populations, improper management of this practice can increase pressure on water resources, potentially limiting the availability of alternative water ecosystem services.

Source: European Commission

Luis Sánchez Alvarez, from the European Commission DG AGRI, Research & Innovation Unit, introduced the general EU research and innovation funding ecosystem for sustainable water and soil management. He focused on key areas of research and innovation (R&I) in circular water management in agriculture supported by the EU. These include energy-efficient treatment technologies, minimising environmental risks, real-time monitoring of water quality parameters, cost-efficient water recovery from processing industries, and nature-based solutions for retaining, regulating, storing and treating water at the farm or agricultural watershed level.

Luis Sánchez Alvarez highlighted some of the remaining barriers for successful implementation of water reuse programmes. He then presented examples of ongoing EU projects and their results, which ranged from nature-based solutions, such as constructed wetlands, to newer irrigation equipment, and schemes adapted to using different water sources in various contexts. Current projects are developing a range of equipment including sensors, valves, sprays, and selective membranes designed to treat wastewater by retaining certain nutrients, which can be used as natural fertilisers.

The talk concluded with a discussion on the opportunities presented by open calls related to the workshop's subject, along with a detailed explanation of the Living Lab and Light House approach within the Mission Soil initiative, which aims to accelerate the adoption of innovative solutions and management practices to improve soil health.

Source: European Commission

Aniko Seregelyi, from the European Commission DG AGRI, Rural Areas & Networks Unit, highlighted the achievements of EIP-AGRI since it was launched in 2012, including 3,461 Operational Group projects, 358 of which are dedicated to water management according to the European Commission database. She also introduced the new public [database on the EU CAP Network website](), which includes both EIP-AGRI and Horizon projects. Additionally, previous EIP-AGRI activities related to water management, such as Focus Groups, workshops, and publications were presented.

Source: European Commission

As part of the workshop preparation, a **project portfolio analysis** report was developed, identifying several areas that require further attention and networking:

- Rainwater harvesting
- Surface water
- Groundwater
- Seawater desalination
- Treated wastewater processes from domestic or industrial use.

The report particularly highlighted the need for knowledge exchange and further research in areas such as:

- Direct field measurements and in situ observations (e.g. sensors, precipitation from weather stations)
- Simulation models (e.g. water flow models)
- Satellite imagery (e.g. water bodies detected from surface reflectance) and remote sensing
- Maps (e.g. processed data with water availability indices for risk assessment classification).

Moreover, questions arose regarding options for water storage, including:

- Reservoirs
- Recover basins
- Aquifers
- Soil water capacity

Most of these identified topics and research areas were thoroughly analysed and discussed during the workshop.

3. Part II. Inspiration from innovation journeys

The introductory session was followed by four brief oral presentations on inspiring innovation projects funded by various agencies. This was succeeded by an interactive session featuring 15 different project posters prepared by the workshop participants.

Source: European Commission

3.1. Inspiring talks

Eriona Canga, from Alchemia Nova, Austria, presented the Horizon 2020 project WATERAGRI which aims to re-introduce and enhance sustainable solutions for water retention and nutrient recycling. This is achieved by implementing several on-the-ground innovations, including:

- The efficient and precise application of irrigation and external nutrients by smart fertirrigation scheduling.
- Nature-based solutions, such as constructed wetlands, for the reuse of water and nutrients.
- Soil management practices to increase the soil water retention capacity (e.g. adding biochar).

The project's success is largely due to the development of a user-friendly decision support system. This tool allows advisors or farmers to input various parameters and receive the most appropriate solution based on their needs, inputs and constraints. The tool can also perform more advanced modelling when used by researchers, especially when more precise inputs, such as soil characteristics, are available.

Additionally, the project has developed an instructive game, AgriLemma, designed to help stakeholders better understand the new technologies being developed and demonstrated. As a result, stakeholders have been actively involved in the project activities.

They are, together, co-designing a policy-oriented report with the researchers, suggesting new policy recommendations to support the application of the project's innovations.

During the Q&A session, a key success factor was highlighted: that project efforts cover various solutions for recovering nutrients from water streams. Examples include the use of water retainers to enhance the soil's water-holding capacity, and biochar to retain nutrients or pesticides/herbicides such as glyphosate. Circularity is central to all innovations developed. For instance, when biochar is used to filter runoff water and becomes saturated, it can be repurposed to improve soil aeration or applied directly to soils as a fertiliser. Additionally, biochar and filters were also utilised in subsurface drains, where they were tested for nutrient recovery and to determine nutrient balance by analysing inflow and outflow. This has led to the development of more precise fertirrigation scheduling.

Source: European Commission

Annette Dietmaier, representing the innovation project Smart-SWS from Germany, discussed the challenges in water management caused by frequent droughts and floods, which necessitate improved soil water storage capacity. To address these challenges, the project is searching for suitable locations to optimise aquifer recharge. To achieve this objective, they have implemented a protocol that begins with an on-ground and airborne sensor and monitoring campaign to thoroughly characterise the study area in terms of soil characteristics and topography. The collected data is then used to feed a GIS-based, open-data, multi-criteria analysis tool, coupled with a hydraulic model of infiltration and storage. This model also allows the hydrochemical monitoring of river water quality, all aimed at identifying:

- Potential sites for optimal water storage.
- Relevant ecosystem services and their changes to a pre-industrial state.

These results are being utilised by a spin-off company developed under the umbrella of a larger environmental consulting firm, reflecting the potential to further develop the proposed solutions into market opportunities.

During the Q&A session, additional details of the technical aspects were provided, particularly regarding the methods used for aquifer recharge. The optimal diameter of the infiltration ditch was found to be 6-7 meters, with its depth varying from 2 to 20 meters depending on the specific site. Participants were interested in understanding the overall strategy employed, and Annette explained that to efficiently capture floodwater before it infiltrates the aquifer, existing dams were used to store water from flooding events. All these on-the-ground developments were based on the outputs of the previously developed decision support tool.

Source: European Commission

Peter Bleyen, from the Experimental Poultry Centre in Belgium, presented the project Life ACLIMA Circular Use of Cleaning Water in Poultry Houses, which developed a system for reusing cleaning water from poultry houses, specifically broiler stables.

He explained that regular broilers are raised for 14 days, and when the stable is empty, it is cleaned with about 25,000 litres of water per cycle and per stable. ACLIMA is testing a water treatment system to purify this water for reuse and in the next cleaning cycle. This is achieved through a biological process using a bioreactor, where the purified water is stored in a tank and reused under autonomous operation. Analysis has been conducted to evaluate the water quality, ensuring it meets the standards and legal requirements for cleaning water. The results have demonstrated that the treated water indeed meets the same quality standards as drinking water. Additionally, the developed purification protocol minimises nutrient release into the environment, reduces water abstraction, and lowers overall energy costs.

During the Q&A session, it was mentioned that the membrane technology used could likely be applied to different types of wastewater, with reuse possible up to 5 or 6 times. However, it was noted that there is some loss (about 10-20%), due to evaporation, which should be considered. A similar type of approach to circular water use was also observed during the field visit, as detailed elsewhere in this report. Peter also suggested that biochar could potentially be used as a filter and purification system, especially when this valorised residue is available locally. However, there are concerns about whether the same efficiency in nitrogen and phosphorus removal could be achieved, which might depend on the type of biochar used. Further applied research is likely needed in this area, opening the door to new proposals for development.

Questions were also raised about the cost of installing and operating this circular system, which was initially supported by the local government under an innovation project. It was correctly noted that the current technology is based on a single-farm usage (one purification system per farm), but cost savings could be realised if the water treatment technology were shared among multiple farms. This would require collaboration between farmers and local authorities to design a common strategy at the local level.

Source: European Commission

Eleanna Pana, from the Hellenic Agricultural Organisation "DIMITRA" (Greece), presented the PRIMA project Prima Mara Mediterra, which aims to promote nature-based solutions for soil and water management by sharing relevant experiences and knowledge across the Mediterranean region. This multi-sectorial project focuses on safeguarding the livelihoods of rural communities and the environment using the Living Lab approach. The goal is to ensure that these solutions can be easily adopted by local end users and eventually transformed into tools, services and practices that effectively address key environmental and societal challenges in rural Mediterranean areas. Among the innovations successfully established based on the project outcomes are:

- The use of a wetland-aquaponic system for water and nutrient circulation.
- The widespread adoption of agroecological practices to reduce soil erosion and improve soil fertility and organic matter content.
- Mitigating the advancement of desertification in the Sahara region by planting trees in alignment with local biodiversity and appropriate planting distances, to ensure a long-term sustainable system.

The major success highlighted during the Q&A session was the mobilisation and engagement of local stakeholders, achieved throughout a co-creation process and their involvement from the beginning of the proposal submission phase.

Source: European Commission

3.2. Posters displaying innovations

A total of 15 posters were displayed and grouped into five sections within the meeting venue, where presenters explained their results and answered specific questions from participants. The posters were organised into three main thematic areas:

Improving collection and storage of run-off waters

In humid regions of Northern and Central Europe, such as Finland, it is important to retain snowmelt water. Therefore, surface runoff water is often collected in aquifers using an optimised aquifer recharge scheme. Conversely, in warmer countries such as Spain, reducing evaporation from dams and reservoirs is a key objective, which can be successfully achieved using self-righting modules, developed by the LIFE H2OLOCK project. Various types of natural water retention measures can be developed depending on the type of water to be stored:

i. Clay pits for rainwater,

ii. Sandy soils for the infiltration of treated wastewater, facilitating purification during infiltration.

Additionally, solutions for better and more efficient collection of water from roofs and drainages have been successfully applied in France.

Source: European Commission

Water reuse mainly at the farm level

This category encompasses activities related to both crop and animal systems. For example, water circularity efforts include reusing wastewater from aquaculture farms to grow micro-algae, which are then used as feed for fish. At the nursery level, leachate from pot plants was treated using constructed wetlands and sand filters to remove nitrates. The solutions presented also involved the return of treated water back into the system, necessitating specific equipment such as irrigation systems and intelligent management to apply the recycled water efficiently based on the type of crops or agroforestry systems. This reflects the key point raised at the beginning of the workshop about the need for efficient scheduling of reused water. Innovations showcased included a system developed in Belgium to economically support the installation and purchase of water circular systems. This system features an application to streamline payment requests, addressing the barrier to complex administrative work faced by end users when adopting new solutions.

Source: European Commission

Water reuse related to the agri-food-value chain

Water from various agri-food industries can be reused in several ways. For instance, water recovered from industrial slaughterhouses or wineries can be used to produce algae, which then serves as a biostimulant in vineyards. Purified water from pig slurry can be repurposed for cleaning activities. In Greece, nature-based solutions such as wetlands were employed to treat water from small milk processing units. Additionally, efforts to promote water circularity at the landscape level help companies and farms achieve their sustainability goals.

During the interactive poster session, several common aspects were emphasised in relation to:

- Transfer and adoption. The language used to communicate with potential end users needs to be simplified as much as possible. Young farmers, who are generally more willing to innovate, are easier to involve in the co-creation process. Pro-active growers can serve as pioneers and inspire local communities. It is also essential to understand the obstacles hindering the adoption of certain practices, which are often not purely technical. Additionally, since productivity and profitability are crucial for all farmers and growers, a thorough cost-benefit analysis must be conducted when demonstrating the feasibility of any new innovation.
- Innovation process. To facilitate the uptake of solutions, simple guidance should be provided on a strategic process for step-by-step incorporation of innovations. Interesting small concrete projects are often more effective than large research activities in encouraging end-user adoption. A streamlined process should be designed with easy-to-share measures, utilising attractive media tools such as videos and on-site field days to engage end users.
- Socio-economic. In some cases, subsidies may be necessary to support the initial implementation of certain practices, with the expectation that these practices become self-sustainable in the long term. Additionally, appropriate legislation can reinforce the use of specific practices.

Source: European Commission

3.3. Field visits

The field visit took place in the afternoon following the networking lunch. The participants were divided into two subgroups, each carrying out one of the two planned visits:

Source: European Commission

Experimental Centre of New Water Technologies (CENTA)

During this visit three innovative projects were presented:

- **Advances in the sustainability of olive grove irrigation with reclaimed water (REUTIVAR 2.0)**. This project is funded by the Operational Groups of the European Innovation Association (EIA) on agricultural productivity and sustainability. It focuses on using treated municipal wastewater for irrigating olive trees, emphasising the 'treat for purpose' concept by optimising wastewater treatment to suit the specific needs of olive groves. This aligns with the discussions during the plenary sessions earlier that day. Notably, in this project, some nutrients, particularly phosphorus, are intentionally not removed during water treatment due to the high phosphorus demand of olive trees. The circular water-energy management approach is further enhanced by utilising renewable energy for the production of products derived from the sludge of the wastewater treatment plant.
- **Non Conventional WAter Re-use in Agriculture in MEditerranean countries (MENAWARA)**. Funded by the Cross-Border Cooperation (CBC) initiative implemented under the EU's ENI CBC MED[1] programme, this project aims to provide additional water resources by recycling drainage and wastewater, minimising water losses, rationalising water use practices, and establishing governance models in line with national and international plans. The project also seeks to empower women in rural agriculture, adding a social dimension to its technical focus.
- **Nature-Based Solutions on existing infrastructures for resilient water management in the Mediterranean (NATMed)**. Funded by PRIMA, this project aims to implement and validate a set of nature-based-solutions (NBS), integrate them into existing grey or natural water infrastructures at specific phases of the water cycle, and optimise water provision, considering both quality and quantity as well as social aspects.

During these discussions, several key ideas emerged, such as the importance of coupling water treatment technologies with the water reuse system. Although this may seem like a simple and straightforward strategy, it is often not properly implemented. This is partly because the intended reuse of the treated water is not always clearly defined, leading to logistical and infrastructure challenges, especially when the treated water needs to be distributed to different types of users.

The field visit itself began from the highest point of the centre, where participants were given an overview of the facilities. They learned about the origin of the raw water, which comes from the nearby village "Carrión de los Céspedes". The wastewater treatment process was explained, starting from the pretreatment phase, followed by the pumping chamber and distribution-homogenisation tank.

The group was then guided to the lagoon area, where the process of conventional lagooning, including anaerobic-facultative and maturation ponds, as well as the high algal rate ponds, was detailed. The visits continued to the constructed wetlands area, where participants observed various facilities, including:

- **Primary treatment:** (Imhoff Tank).
- **Secondary treatments:** Three vertical flow subsurface wetlands.
- **Tertiary treatments:** A combination of vertical and horizontal subsurface wetlands, along with vertical subsurface wetlands integrated with surface wetlands.
- **Advanced water treatment innovations:** These included floating macrophytes operating under both aerobic and anaerobic conditions, as well as aerated vertical-horizontal wetlands.

The visit concluded in an area dedicated to water regeneration and reuse for agricultural irrigation. Here participants were shown the storage lagoon, the ultrasound treatment system used for the elimination of microalgae and reduction of E. coli, the filtration system (including both sand filter pressure and mesh filter), the water pumping station, and a traditional olive grove plot equipped with surface drip irrigation.

Source: European Commission

[1] European Neighborhood Instrument Cooperating across Borders in the Mediterranean.

Irrigation Community: CONTAGRI company

CONTAGRI is a Limited Company primarily focused on the production of vegetables such as potatoes, carrots, and broccoli, both in conventional and organic forms. The company faces significant challenges related to water management, particularly the scarcity of high-quality water, as they experience severe water droughts every 10 to 15 years. To address these challenges, CONTAGRI has implemented measures targeting both the supply and demand sides of the **agricultural water balance**.

Source: European Commission

- **Supply side:** CONTAGRI has adopted water recycling practices, including the reuse of water facility wash cycles. The company has installed **an on-site purification plant** that recycles and purifies the daily water usage allowing it to be reinjected again into the system for subsequent washing cycles. Additionally, there is a plan to utilise treated water from a nearby municipality for irrigation purposes. However, given the region's water stress, there is an ongoing debate about whether this recycled water should instead be used to reduce freshwater abstraction, thereby alleviating pressure on local aquifers
- **Demand side:** CONTAGRI's primary goal is to maximise the value of every drop of water available to them. This is achieved through **precision irrigation** using sensors to monitor soil water dynamics and optimise irrigation frequency and dosage. The company also employs agronomic practices to enhance water-use efficiency. For example, in their Boniato crop, they traditionally did not use plastic mulch. Last year, however, they applied mulching on approximately 10 hectares, resulting in a more than 50% reduction in external water application (blue water). While concerns were raised about the environmental impact of plastic mulch residues after cultivation, the company's technicians assured that the plastic is removed and sent to a recycling plant. CONTAGRI is also exploring the possibility of using biodegradable plastics made of vegetable residues in the future, acknowledging that research in this area is currently underway.

Source: European Commission

Looking into the future, the company recognises that, due to climate change, it will face even more severe water restrictions and increased demand resulting from higher evaporative losses. To address this challenge, it is urging the public administration to create sufficient infrastructure so that, when floods occur, the water can be retained and reused. This would require the construction of **storm tanks**, which is an expensive endeavour that should be undertaken in collaboration with the local water basin management board.

Source: European Commission

4. Part III. Pro action café – Challenges and solutions

The second day began with an interactive registration where participants were invited to share reflections from the previous day's field visits on an 'inspirational wall'. Participants were particularly impressed by the constructed wetlands and the purification system used in the vegetable packing house. It was stated that, for a swift transition from research solutions to practical applications, it is crucial to make things as simple and easy to operate as possible–much like what was observed in the horticulture packing facility visited the previous day.

The morning began with a "Pro-action café", where participants were divided into four groups based on their preferences. Each group engaged in discussions about the challenges and solutions related to the four previously identified main topics.

4.1. Systems to capture and/or treat runoff water from fields

As a general comment, it was highlighted that climate **change** is leading to more extreme events, including severe droughts and flooding from intensive rains. This underscores the need for systems to capture and manage runoff water effectively.

Challenges	Solutions
› **Efficiency** in **capturing** water run-off	› Maintain covered soil year-round (avoiding bare soil when possible) › Cultivate soil vertically along slopes (following contour lines) › Use terraces on steep slopes › Incorporate 'soil sponge' materials › Apply agroforestry solutions with clover and cover crops › Build wetland zones to control non-point source pollution
› **Forest sector** (this sector requires particular attention) › Drying of forest ecosystems	› Implement afforestation programs tailored to local conditions › Plant native species that are more resilient to water stress, considering functional biodiversity › Foster proper afforestation management practices such as tree spacing and using mycorrhiza colonised plant material
› **Water quality** aspects Ensuring water maintains desired standards	› Implement sensors in advanced systems, coupled with tools for data interpretation/harmonisation of data to provide outcomes and reliable results
› **Integrated management** within a biogeographical region, considering both surface and groundwater resources	› Utilise GIS and remote sensing tools to account for the water balance at the watershed level, taking into consideration various farming activities and ecosystem services
› **Governance**, policies and technology costs	› Establish a collaborative plan with other farmers to develop joint strategies › Establish an enabling legal and regulatory framework and develop policies and regulations to support the construction of storage and treatment facilities (e.g. CAP funding for investments) › Incorporate water conservation costs into product pricing
› **Technology transfer** to enhance groundwater infiltration. Raise awareness and facilitate knowledge transfer	› Develop a strong advisory system. Establish robust services with demonstration activities, field days at both the farm and watershed levels › Facilitate living labs with multi-stakeholder platforms. Create environments where various stakeholders can demonstrate and test innovations across the entire value-chain › Engage consumers and retailers. Involve consumers and retailers, and include farmers in identifying problems and finding solutions

Source: European Commission

Source: European Commission

4.2. Solutions for water harvesting, reservoirs, ponds or aquifer recharge to store water runoff

Challenges	Solutions
› Dimensions required for storage and the necessary area/space › Understanding local geology › Recharge of aquifers during rainy periods	› Accept water storage within the 4% non-productive area designated by EU › Use of ditches and wells for artificial irrigation › Create ecological value in water ponds › Utilise unoccupied areas such as quarries › Integrate surface drainage systems
› **Technology solutions** to reduce water evaporation › Adaptation strategies for small farms › New collaborative irrigation systems based on ponds and water sharing approaches	› Implement solar panels to cover ponds and other types of reservoirs › Install small scale modular eco-tanks to minimise evaporation) › Apply systems to facilitate water infiltration in the root zone › Store water in drainage ditches equipped with weirs › Use small streams among fields to connect with ponds for water storage
› Preventing runoff as a primary measure to control erosion and improve **soil health** › Enhance soil care by increasing organic matter and improving water retention	› Implement agriculture practices for soil conservation (e.g. cover crops, direct sowing, minimum tillage) › Apply manure and compost precisely and in a climate smart manner, ensuring the proper carbon to nitrogen balance based to the soil characteristics
› Develop allocation mechanisms for post- aquifer recharge to increase **social acceptance** › Adapt water storage systems to align with crop needs. Preserve natural springs and wells	› Foster trust through social meetings › Enhance information discoverability. Train on storage implementation › Promote a multi-actor approach with collaboration among farmers, and between farmers and policymakers/government › Ensure involvement of citizens and consumers
› **Secure funding** support for small farms to store rainwater › Address cost-related constraints, especially for small farms and companies	› Ensure higher prices for products obtained using smart and eco-friendly technologies › Utilise subsidies from CAP eco-schemes › Create new legislation to support the development of novel infrastructure

4.3. Wastewater treatment systems, specifically designed for agricultural runoff

Challenges	Solutions
› **Collecting** runoff water: Identifying collection points and the necessary infrastructure › Adapted distribution systems: Designing systems that are well suited to the topography › Variability in the diffuse load: Managing changes in volumes and contaminants/ substances	› Use hydrogeological models: Apply hydrogeological models to the studied area › Explore treatment methods: Investigate water treatment methods used in other industries › Optimise cultivation practices: Begin by preventing contamination through water reuse and reduced inputs, adopting a holistic approach › Test simple filter systems on-site: Experiment with simple filtration systems, such as biochar and small membranes
› Technical solutions **tailored to the final use** of treated water › Defining the toxic thresholds for all potentially harmful substances for plants	› Monitor water quality: Continuously assess water quality to determine the appropriate treatment for each specific case › Conduct research on contaminants: Investigate the fate of the possible contaminants within the soil-plant continuum › Assess effects on product quality: Evaluate how water treatment impacts the quality of agricultural products
› **Water quality:** Address overall diversity and changing quality throughout the year › **System Versatility:** Develop systems capable of removing various substances and contaminants (e.g. pathogens, pesticides, micro plastics, salinity) › **Emerging contaminants:** Anticipate and address the potential appearance of new contaminants in the future	› Explore nature-based solutions and new technologies: Investigate options such as halophyte filters and biochar for treating water in a circular approach › Use scalable technology: Implement simpler technologies that can be adapted to various scales, as demonstrated in the workshop's posters and case studies › Adopt new membranes and materials: Incorporate advanced membranes and materials for enhanced water purification › Apply advanced analytical instruments: Use cutting-edge analytical tools for more precise water quality assessment
› **Public perception and technology transfer:** Many citizens, as well as farmers and landowners, are initially hesitant and lack trust in treated water	› Communicate and cooperate: Enhance public-private collaboration schemes › Address generational gaps: Overcome resistance to change among older farmers. Support advisors: Enable advisors to a) provide impartial advice on the best technologies, b) Assist farmers in effectively using these systems
› **Governance** of the solution › Legislation: The legal framework is not sufficiently stable › Competency issues: Diffuse responsibilities in water treatment lead to inconsistencies within the applicable legal framework	› Develop long-term and smarter legislation frameworks: Create policies that are tailored, up to date and aligned with technological developments › Ensure legal stability: Establish a more stable legal framework, avoiding changes to regulations during ongoing projects. Create specific legislation for agricultural reuse. Develop a framework specifically for agricultural water reuse, as current regulations often focus on urban or industrial water reclamation and are not well suited for farming purposes
› **Costs:** treatment systems are expensive, a cost-benefit analysis is needed › Cost comparison: Defining the cost of reclaimed water vs conventional water	› Develop Financial resources: Provide subsidies for farmers › Foster water pricing mechanisms: Implement effective pricing strategies › Identify and harmonise financial incentives: Create and align incentives for project implementation

4.4. Use treated water from agri-food industries on a small scale

Challenges	Solutions
› **Water treatment technologies: improve methods** for removing specific compounds (e.g. polyphenols) › Technology optimisation: Adapt and optimise technologies for small scale applications	› Utilise smart monitoring of pollutants › Adopt a “Fit for purpose” approach › Develop standards with feedback from various sectors › Apply scaling methods and assess costs
› Lack of holistic approach and **stakeholder cooperation** › Creating symbiosis due to current lack of cooperation › Risk of dependency on other stakeholders	› Enhance capacity building › Implement education-training to raise stakeholder awareness and achieve acceptance › Foster dialogue among stakeholders (authorities, industry, citizens, environmental agencies) › Establish a knowledge platform for feasibility studies and cost-benefit analysis › Provide clearer information for consumers › Foster green social bonds for micro-producers
› **Acceptance** of nature-base-solutions for wastewater treatment › Social acceptance of sustainability practices	› Foster a life-cycle approach: Analyse economic, social and environmental constraints › Define risk assessment: Establish a quantitative & standardised methodology to ensure no risk in water reuse › Prioritise water recovery: Focus on recovering valuable compounds (e.g. polyphenols, nutrients) rather than just treating water
› Reduction of **treatment costs** for farmers › Energy consumption reduction › Costs of infrastructure and distribution systems › Economic feasibility › Potential economic challenges when scaling down solutions. › CAPEX & OPEX per cubic meter of treated water reused	› Study economic feasibility › Implement frugal innovations › Engage the food-chain/customers in financing › Foster cooperative clustering (like water co-operatives) › Increase public investment and funding › Implement renewable energy › Utilise robust Technical Economic Assessment TEA –€/m3, for feasibility › Support the circular economy › Promote green tax credits › Apply ESG certification for micro producers
› Biological and chemical limits established by **EU and local legislation** › Regulation of water reuse › Restrictions imposed by Public administration › Water security and consumer acceptance	› Create realistic legislation › Reduce administrative bureaucracy › Bolster confidence in scientific results › Implement insurance for farmers and industry › Secure long-term operational rights (legal framework)

5. Part IV. What's next?

5.1. Fishing research needs from the practice bowl

A highly interactive final session employed the "fishbowl" method to identify future **research needs from practical perspectives**. This bottom-up approach allowed practitioners to articulate their on-the-ground research requirements. Participants were arranged in a large semi-circle around an inner circle with seven chairs. Only those in the inner circle could speak, and one chair was kept empty for others wishing to contribute.

Source: European Commission

The discussion, which lasted about one hour, was dynamic and engaging, generating numerous insightful ideas. The coordinating expert of the workshop then provided an integrated summary of the discussion, which is detailed in the following paragraph.

Source: European Commission

5.2. Research needs from practice

Several examples of circular water management were presented and visited during the workshop, demonstrating their effectiveness in addressing water scarcity and leveraging flooding events, which are increasing due to climate change. The workshop concluded with a clear need to enhance and promote water reuse for agricultural purposes while considering alternative water users and potential ecosystem services. Seven key research needs were identified to address the challenges discussed by participants:

1. The challenge: **Increase the productivity of rain-fed crops.**

   Possible solutions: Implement agronomic practices to enhance green water storage in the soil, such as using composts and agroforestry systems.

   Geographical area: Throughout Europe with a focus on semi-arid environments.

   Sector: Field crops, rain-fed orchards and vineyards.

2. The challenge: **Establishing priority uses for the non-conventional water sources to avoid overexploitation of water resources.**

   Possible solutions:
   1) Quantify water consumption within farming systems, specifically analysing the proportions of total evapotranspired water sourced from "blue", "green" and "grey" water.
   2) Implement accounting mechanisms to establish limits on water allocation among sectors based on socio-economic, environmental, efficiency and productivity aspects.

   Geographical area: Throughout Europe.

   Sector: All sectors.

3. The challenge: **Predict the long-term effects of using different water sources.**

   Possible solutions:
   1) Conduct long-term experiments and integrate experimental research with model simulations to derive robust trends, which should be validated with field data.
   2) Utilise big data and artificial intelligence tools, along with open-access databases to enhance long-term predictions.

   Geographical area: Throughout Europe.

   Sector: All sectors.

4. The challenge: **Understanding the impacts of different water types (non-conventional waters) on soils.**

   Possible solutions:
   Conduct long-term experiments to assess the effects of non-conventional waters on the physical, chemical and biological status of soils, with a particular focus on soil microbiota.

   Geographical area: Throughout Europe.

   Sector: All sectors.

5. **The challenge: Achieving social acceptance among consumers and farmers for using treated wastewater in agriculture.**

   Possible solutions:
   1) Investigate the fate of potential contaminants (including emergent contaminants) from treated wastewater or runoff within the soil-plant-atmosphere continuum.
   2) Conduct risk-assessment studies to evaluate the potential effects of non-conventional water sources on the environment and human health, specifically concerning food production and consumption.

   Geographical area: Throughout Europe.

   Sector: Farming areas using non-conventional waters.

6. **The challenge: Integrating circular water management into the entire agri-food-value chain.**

   Possible solutions:
   1) Designing new commercialisation mechanisms (e.g. Water credits) to assign environmental value to primary products.
   2) Incorporate research on social science and behaviour change to influence consumers, farmers and companies to adopt new practices.

   Geographical area: Throughout Europe.

   Sector: The agri-food value chain.

Source: European Commission

7. **The challenge: Knowledge transfer and uptake by end users.**

   Possible solutions:
   1) Develop new mechanisms to involve farmers in the innovation process through a comprehensive co-creation approach tailored to the specific needs of each target group.
   2) Conduct detailed innovation activities, including comprehensive cost-benefit analyses and life cycle assessments.

   Geographical area: Throughout Europe.

   Sector: All sectors.

5.3. Thanks and see you soon!

The workshop concluded with thanks to all participants for their active involvement, with hopes of meeting again at future events. Special appreciation was extended to Isabel Martin and Macarena Ureña from the Andalusia Environmental and Water Agency for organising the field trips. A final networking lunch provided an excellent opportunity for participants to exchange ideas. Positive reactions and feedback continued to pour in over the following days, with many participants sharing encouraging posts on social media.

Source: European Commission

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