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Strategic report on the long-term deployment of NBS

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Executive Summary

This strategic report analyses the long-term deployment of Nature-Based Solutions (NBS) for wastewater treatment and reuse in rural environments, focusing on Spain, France, and Portugal. The study is part of the SOLLAGUA project, which aims to promote sustainable water management through NBS.

Key Objectives

- Identify barriers to the adoption of NBS at local and regional levels.
- Propose corrective measures and strategies for effective implementation.
- Facilitate knowledge exchange and stakeholder engagement across regions.

Methodology

Regional Focus Groups (FGs) were established in Spain, France, and Portugal, involving water authorities, public services, municipalities, farmers, technology providers, NGOs, and academics. Workshops and surveys were conducted to gather insights on barriers and opportunities for NBS deployment.

SWOT Analysis of NBS

Strengths:

- Cost-effective construction, operation, and maintenance.
- Low energy requirements and minimal need for specialized personnel.
- Environmental benefits: pollutant removal, biodiversity conservation, climate change mitigation, and flood prevention.
- Production of valuable by-products for agriculture.

Weaknesses:

- Large land requirements and long retention times.
- Limited capacity for large volumes and certain pollutants.
- Efficiency affected by extreme weather and climate variability.
- Few local success stories to build trust.

Opportunities:

- Local adaptation and new water resources for agriculture, industry, and recreation.
- Creation of irrigation communities and rural economic development.
- Transition from conventional to green technologies.
- Strengthened cooperation among stakeholders and increased R&D investment.

Threats:

- Climate change impacts and competition with conventional technologies.
- Regulatory challenges and lack of awareness among policymakers.
- Limited information on water quality monitoring and control.

<u>Barriers to Adoption (Country Highlights)</u>

Spain:

- Policy: Lack of long-term strategies, support, and coherent policies.
- Economic: Coordination gaps between public/private funders, limited knowledge of returns.
- Technical: End-user trust, adaptation to standards.
- Environmental: Climate change impacts.
- Legal: Bureaucratic hurdles, outdated regulations.
- Socio-cultural: Lack of awareness and success stories.

France:

- Cost is the main barrier, especially for individual farmers.
- Water quality concerns and regulatory rigidity.
- Social acceptance and technical complexity.
- Environmental issues such as mosquito proliferation.

Portugal:

- Political: Bureaucratic licensing and legislative gaps.
- Economic: High costs for farmers, lack of affordable water.
- Social: Need for awareness and education.

- Technological: Lack of distribution networks and monitoring.

Recommendations

1. Foster transnational cooperation for knowledge exchange.
2. Systematically collect and disseminate both success and failure stories.
3. Improve administrative coordination across government levels.
4. Develop incentives and financing mechanisms for NBS.
5. Engage stakeholders early to build co-ownership and maximize benefits.
6. Enhance training and knowledge transfer for water sector professionals.
7. Strengthen technical, institutional, and financial capacities, and promote citizen participation.

Conclusions

NBS offer robust and efficient solutions for wastewater treatment in rural areas. Overcoming technical, regulatory, financial, and social barriers requires integrated strategies, incentives, capacity building, and broad stakeholder engagement. The report provides a roadmap for scaling up NBS deployment and ensuring sustainable water management across regions.

1. Introduction

Nature-based solutions (NBS) are sustainable environmental management strategies that rely on the use of natural ecosystems to address problems such as environmental degradation, climate change adaptation, and natural resource management. However, the adoption of these solutions can be limited by a number of factors that must be identified and addressed to ensure their effective implementation.

In this regard, it is important to analyse and understand the different obstacles that may exist in the adoption of NBS, such as lack of recognition of their effectiveness, resistance to change in traditional practices, lack of knowledge about their functioning or lack of economic resources for their implementation.

Identifying and understanding these limiting factors is essential to develop effective strategies for the promotion and adoption of NBS, thus contributing to environmental conservation and ecosystem sustainability.

In the case of the SOLLAGUA project, which aims to promote NBS for wastewater reuse in rural environments, the creation and deployment of regional Focus Groups (FG) has been proposed, with the objective of identifying at local and regional level the factors limiting the adoption of NBS and proposing a series of corrective measures (SWOT analysis) for these technologies, which are the subject of activity 3.1 of the project.

This report corresponds to deliverable 3. 1. 1 entitled "Strategic report on the long-term deployment of NBS".

2. Regional Focus Groups

As mentioned above, the objective of creating regional focus group (FG) is to identify at local and regional level the factors that limit the adoption of NBS, which may be regulatory, cost and access barriers, technical blockages, and mismatches, etc. According to the SOLLAGUA project, FG must be made up of water authorities, public water services, municipalities, irrigation and user communities, professional associations: farmers, technology, solution and knowledge providers, NGOs, etc.).

2.1. Spain

In the case of Spain, the FG was made up of the following actors:

- Public administration:

In this case we have selected the public administrations that grant concessions or authorisations to reuse treated water in the territory of Andalusia and Extremadura (assuming that the results can be extrapolated to the rest of the national territory):

- Guadalquivir Hydrographic Confederation:
- Guadiana Hydrographic Confederation:
- General Secretariat for Water – Andalusian Government:
- Water supply and sanitation companies:

  Public and private companies that manage wastewater treatment in the provinces of Seville, Huelva, and Badajoz (assuming that the results can be extrapolated to the rest of the national territory).:

  - ALJARAFESA (Aljarafe district within Seville province)
  - EMASESA (Metropolitan area of Seville.)
  - GIAHSA (Province of Huelva, 68 municipalities, organized into five areas: Andévalo, Condado, Costa, Cuenca Minera and Sierra)
  - ARECIAR (Commonwealth of 15 municipalities in the province of Seville)

- PROMEDIO (Commonwealth of 175 municipalities and the Provincial Council).
- AQUALIA (private water management company. Fourth company in Europe by population served)

All these entities are integrated into the Association of Water Supplies and Sanitation of Andalusia (ASA), so we will use this entity as a communication channel with them.

- End users (irrigation communities / associations):
- FERAGUA (Andalusian Association of Irrigation Communities)

All the selected entities are Partners or Associates of the project, so communication with them will be much more fluid from the outset since they are aware of the objectives of the SOLLAGUA project.

2.2. France

In the case of France, the FG was made up of the following actors, with regards to the 4 categories of LL attendees:

Public authorities

- Adour Garonne Water Agency (Agence de l'eau Adour Garonne)
- The Department of Ariège (Le Département de l'Ariège).
- Agriculture, Water and Environment Service - Department of Ariège (Service Agriculture, Eau et Environnement - Département de l'Ariège).
- Departmental Directorate of Ariège (Direction Départementale de l'Ariège).
- Ariège Chamber of Agriculture (Chambre d'Agriculture de l'Ariège).
- Ariège Pyrenees Regional Natural Park, (Parc naturel régional des Pyrénées Ariégeoises).

- Les eaux du Couserans as Water manager of the whole experimental territory
- Salat-Volp River Union (Syndicat de rivières Salat-Volp).
- Public union (SMDEA) for natural water management (Ariège subwater shed)

Citizens or stakeholders (farmers) or elected people as village major:

    - The commune of Soueix-Rogalle (La commune de Soueix-Rogalle).
    - Elected dean of the Couseran Communauté de Commune.
    - Elected major of the village “Sainte Croix.”
- Elected major of the village “Lacave.”
- Elected major of the village “Massat.”
    - The Lisière farm (La ferme de la Lisière).
    - Retired farmer and dean of the NGO Solidarité Paysans
    - ESAT Les jardins du terroir
- La table de Gaya, (Farm restaurant).
- En Vert de Terre (Vegetables, aromatics, flowers).
- Equestrian center Les crins en soi.
- Horse breeder.

Economic entities such as compagny for NBS building

    - Epur Aqua.
    - SOLLAGRO
    - Equestrian center Les crins en soi.

- Horse breeder.

Academics:

Toulouse University

CNRS

Lisboa University (Technico)

The following picture provides the profile of the French LL composition. IT shows a majority of public services and entities related to natural and anthropic water management. The second most frequent type of attendees are the citizens that groups the farmers, and the elected people in charge of village or groups of villages, or NGO.

2.3. Portugal

In the case of Portugal, the FG was made up of the following actors:

- Lourinhã City Council
- Higher Institute of Agronomy – Higer Education School, with courses in agronomy and forestry
- SMASTorresVedras – water utility that manages water supply and wastewater treatment in 14 municipalities: Alcobaça, Alenquer, Arruda dos Vinhos, Azambuja, Bombarral, Cadaval, Caldas da Rainha, Lourinhã, Nazaré, Óbidos, Peniche, Rio Maior, Sobral de Monte Agraço and Torres Vedras.
- AIHO - Interprofessional Horticultural Association of the West – farmers association
- LOURAMBi - Environmental Association
- ETAPAS FRESCAS - Hortícolas, Unipessoal, LDA – farming company
- LOURICOOP - Cooperativa de Apoio e serviços do concelho da Lourinhã, CRL – farmers association.

- Intermunicipal Community of the West -association of municipalities in Portugal that promotes regional development, cooperation, and coordination among local governments in the Oeste region.
- Águas do Tejo Atlântico, SA - water utility that manages wastewater treatment in 23 municipalities:
- Biofrade – farming company
- CCDR-LVT (DAP) – public entity that supports regional development and territorial planning.

3. SWOT analysis

SWOT analysis is a strategic planning tool used to identify and assess the Strengths, Weaknesses, Opportunities, Threats and Weaknesses of an organization, project, or specific situation. This tool is very useful for decision making, as it provides a clear view of the current situation and helps to plan future actions.

The SWOT analysis is usually presented in a 2x2 matrix, which makes it easy to view and compare these factors. In the case of NBS for the treatment and reuse of wastewater in rural areas, the result of the SWOT analysis has been the following:

INTERNAL FACTORS	
STRENGTHS	WEAKNESSES
• Economical systems in terms of construction, operation, and maintenance. • They do not require advanced technologies or highly specialized personnel. • Energy efficiency since they consume little or no energy. • Use of natural processes that are respectful of the environment. • Treatment technologies with maximum reliability. • Efficient in the elimination of pathogens. • They produce fewer unpleasant odors.	• They require large surfaces. • Very high retention time. • Possibility of clogging. • Limited capacity to treat large volumes of wastewater. • Limited capacity to treat certain types of pollutants. • Variability in the quality of the effluent depending on climate. • Their efficiency can be affected by extreme climatic conditions. • Little implementation in the territory that shows their good functioning.

• Landscape integration and improvement of the aesthetics of the environment. • Guarantees in the supply of non-conventional water. • Reduction in the consumption of better-quality water. • Decrease in costs associated with the use of conventional fertilizers. • Generation of by-products with value for the agricultural sector. • Protection of the environment. • Mitigation against climate change. • Conservation of biodiversity. • Prevention of floods.	

EXTERNAL FACTORS	
OPPORTUNITIES	THREATS
• Appropriate technologies for implementation at a local scale, especially without wastewater network connection • New source of water resources for agricultural, industrial, environmental, and recreational use. • Improvement of soil and crop fertility (significant amount of	• Climate Change: Changes in weather patterns can affect the effectiveness of NBS. • Competition with Conventional Technologies: Traditional wastewater treatment technologies still dominate the market and can be seen as more reliable. • Regulations and Standards: NBS

nutrients, especially N and P). ● Creation of irrigation communities ● Employment and economic and social development in rural areas. ● Reconnection and understanding of the interdependence between the rural and urban world. ● Transition from grey technologies to increasingly green technologies. ● Strengthening understanding and cooperation among stakeholders (administration, operators, users, and researchers). ● Promoting the development of R&D&I in the NbS sector. ● New relationships between users and researchers to develop new technologies. ● Investments in green technology.	must comply with strict regulations that can vary between regions. ● Little knowledge of them among the competent administration.

STRENGTHS

- Economical systems in terms of construction, operation, and maintenance: NBS installation costs are low or moderate as no complex infrastructure is required, while operation and maintenance costs are low because they consume little or no energy and do not require specialized personnel.
- They do not require advanced technologies or highly specialized personnel: NBS use natural processes in water purification that mimic the natural service of water quality regulation that happen in the rivers banks and wetlands, so

they do not require constant maintenance or highly specialized personnel, but regular monitoring is needed.

- Energy efficiency: In general, NBS do not require an external energy supply since the oxygen supply necessary for water purification is done through natural processes. The only power need is due to the water pumps functioning for wastewater supply in the filter, and this need can be lower in case of gravitational providing.
- Use of environmentally friendly natural processes: The removal of contaminants from water, such as suspended solids, organic matter, nutrients (nitrogen and phosphorus), pathogens and trace elements (such as heavy metals), is done through various mechanisms such as sedimentation, filtration, precipitation, absorption, adsorption and biochemical processes, which are environmentally friendly natural processes. No additional chemicals are added in the wastewater to make the water treatment more efficient.
- Treatment technologies with maximum reliability: Some NBS are fully consolidated systems, as they guarantee the following parameters in the treated effluents: SEM < 15 mg/l, BOD5 < 15 mg/l, COD < 70 mg/l, and NTK < 10 mg/l.
- Some studies have shown that some NBS reduce the risk of toxicological impact on ecosystems by up to an average of 70%. Efficient in eliminating pathogens: NBS are low-speed systems that incorporate the interaction of various physical, chemical, and biotic processes that can treat pathogens and viruses with an efficiency greater than 90%. (e.g. Kipasika, H.J.; Buza, J.; Smith, W.A.; Njau, K. Removal capacity of faecal pathogens from wastewater by four wetland vegetation: Typha latifolia, Cyperus papyrus, Cyperus alternifolius and Phragmites australis. Afr. J. Microbiol. Res. 2016, 10, 654–661).
- They produce fewer unpleasant odours compared to other treatment methods: Most NBS have a higher density of plants per square metre, which

increases rhizomatic volume and improves the aerobic regime, thus reducing odour production.

- Landscape integration and improved aesthetics of the environment: Compared to other wastewater treatment systems, NBS offer an advantage such as excellent environmental integration, allowing infrastructures with a high visual impact to be replaced by elements with a lower landscape impact, as they create visually attractive and healthy landscapes.
- Guarantees for non-conventional water supply: NBS are an innovative and sustainable solution to guarantee non-conventional water supply, especially in areas with scarce water resources. This guarantee comes from the fact that populations supply water to these systems on a daily basis from domestic uses. In addition, water is generated with guarantees for public health, animal and crop health, and environmental protection.
- Reducing consumption of higher-quality water: Reusing reclaimed wastewater in agricultural irrigation, landscaping, industrial use, etc. reduces the need for higher-quality water. This practice not only conserves water resources but also minimizes the pressure on potable water sources.
- Reduced costs associated with the use of conventional fertilizers: In the case of agricultural use, water regenerated by NBS usually contains nutrients such as nitrogen and phosphorus, which can improve crop quality and increase crop productivity. This can reduce the need for chemical fertilizers, reducing costs and environmental impact.
- Generation of by-products with value for the agricultural sector: NBS that use plants such as reed and cattail can be harvested and used as biomass for energy production or as raw material for composting. Treatment processes in NBS can recover nutrients such as nitrogen and phosphorus, which can be reused in agriculture. Sludge resulting from water treatment can be treated and used as organic fertilizers, improving the quality of degraded soil and

promoting sustainable agriculture. These by-products not only contribute to environmental sustainability but also offer economic opportunities for local communities.

- Environmental protection: NBS contribute to environmental protection by removing pollutants, conserving, and regenerating water resources, creating habitats for a variety of flora and fauna, promoting local biodiversity, and capturing carbon, among others. In addition to their ecological benefits, NBS can improve the landscape and provide recreational spaces for local communities.
- Climate change mitigation: The low or zero energy consumption required for the exploitation of NBS, as well as their capacity to capture and store carbon dioxide, make these technologies contribute to the mitigation of climate change.
- Biodiversity conservation: NBS demonstrate the power of rewilding for biodiversity by providing habitats for diverse species in the biological community, promoting local biodiversity.
- Flood prevention: NBS can play a crucial role in flood management, as much of NBS has the capacity to absorb and retain large amounts of water during heavy rainfall, helping to reduce the risk of flooding in nearby areas. In addition, some NBS can act as rainwater retention and filtration systems, improving the quality of water released into receiving bodies.

WEAKNESSES

- They require large surfaces: NBS can require relatively large surfaces for wastewater treatment, especially compared to conventional treatment plants. This is because natural purification processes, such as filtration through soils and the action of plants and microorganisms, need space to be effective. This need for large surfaces can be a problem in densely populated areas.

- Very high retention time: NBS is slower compared to other wastewater treatment methods because NBS relies on natural biological and chemical processes to remove contaminants. These processes, such as degradation of organic matter by microorganisms and uptake of nutrients by plants, require time to be effective. In addition, wastewater can have variations in contaminant load, and a high retention time provides a safety margin to ensure that even under high load conditions, NBS can treat water effectively.
- Possibility of clogging: Some NBS technologies that have filter beds can become clogged. This phenomenon occurs when the pores of the substrate, usually gravel or sand, become filled with solid particles, plant roots and biofilms, which reduces the filtration capacity and water flow, seriously affecting the efficiency and operation of these NBS. This difficulty is now on the way to be avoided by the new generation of worm-assisted planted filters that naturally prevent the clogging effect by the grazing of the organic matter deposits as main source of energy for these ecological engineers. This difficulty is now on the way to be solved by the new generation of worm-assisted planted filters that naturally prevent the clogging effect by the grazing of the organic matter deposits as the main source of energy for these ecological engineers
- Limited capacity to treat large volumes of wastewater: NBS are technologies especially used in rural areas or in communities where conventional wastewater treatment systems are not feasible due to costs or infrastructure limitations. In general, NBS are suitable for small and medium-sized populations, typically up to 20,000 population equivalents.
- Limited capacity to treat certain types of contaminants: Although NBS are very effective in removing many types of contaminants, they have limitations in removing some contaminants since natural processes cannot completely remove heavy metals, some persistent organic compounds, some emerging

microcontaminants, pathogenes and some antimicrobial resistance genes, etc...

- Effluent quality variability depending on climatic conditions: Effluent quality in NBS can vary considerably depending on climatic conditions. For example, heavy rainfall can dilute pollutants in the effluent, while droughts can concentrate them; higher temperatures can increase microbial activity, enhancing pollutant degradation, but can also increase evaporation, affecting nutrient concentration.
- Their efficiency can be affected by extreme weather conditions: Extreme weather conditions can have a significant impact on the operation of NBS. The effects of the following weather conditions are particularly noteworthy:
  - Prolonged droughts: Can reduce the water level in NBS, affecting treatment capacity and the health of vegetation and microorganisms that depend on the water.
  - Floods: Can overload the system, leading to lower efficiency in removing contaminants due to dilution and sediment carryover.
  - High temperatures: Can increase evaporation, concentrating contaminants in the remaining water that will directly affect the biological community of the system.
  - Intense frosts: Can negatively affect biological processes, especially nitrogen removal.
- Little implementation on the ground showing their success: Without visible success stories on the ground, it is difficult to build trust and support for new initiatives. Practical demonstration of the effectiveness of NBS in local contexts can be a keystone to overcoming this barrier, showing communities and decision-makers that these solutions work and have tangible benefits.

OPPORTUNITIES

- Technologies suitable for local implementation: NBS can be adapted to the specific conditions of each location, taking advantage of natural resources and the characteristics of the local environment, which reduces construction and maintenance costs, such as network building cost.
- New source of water resources for agricultural, industrial, environmental and recreational use: Wastewater regeneration using NBS is a key strategy to create new sources of water resources that can be used in various sectors such as agriculture, industry, environment and recreation, which allows for the release of higher quality water volumes for other more demanding uses, such as drinking water supply.
- Improved soil and crop fertility (significant amount of nutrients, especially N and P): Reclaimed water with NBS can significantly improve soil and crop fertility by providing essential nutrients such as nitrogen and phosphorus, reducing the use of chemical fertilizers, increasing the water retention and aeration capacity of the soil, and promoting microbial activity also indirectly contribute to it by facilitating and accelerating the process
- Creation of irrigation communities: NBS generate new sources of water resources, which leads to the creation of irrigation communities between farmers to efficiently and equitably manage and use these water resources for agricultural irrigation.
- Employment and economic and social development in rural areas: NBS generate opportunities for a nature-based economy, which values the natural and cultural capital of rural areas and allows for rural repopulation, especially among young people.
- Reconnection and understanding of the interdependence between the rural and urban worlds through ecosystem services (water, food, climate, etc.), also shifting the conversation towards the need to propose a new economic and

financial model that is fair, unifying, and sustainable, with compensatory mechanisms such as payment for ecosystem services.

- Transition from grey technologies to increasingly green technologies by:
  - Establishing policies and regulations that encourage the use of green technologies.
  - Promoting education and awareness about the importance of green technologies. Training programs and awareness-raising campaigns can help change the mindsets and practices of both companies and consumers.
  - Participating in international initiatives and agreements that promote the green transition. Global coordination can facilitate the exchange of knowledge and resources to address common environmental challenges.
- Strengthening understanding and cooperation of stakeholders (administration, operators, users, and researchers): Strengthening understanding and cooperation between stakeholders is crucial for the success of any technological project. This requires transparent communication, definition of common objectives, active participation, involvement of all stakeholders in the decision-making process, training and education for all stakeholders and the implementation of a system of continuous evaluation and feedback.
- Promote the development of R&D&I in the NBS sector by involving experts from different fields such as biology, environmental engineering, and chemistry to develop innovative and sustainable solutions.
- New relationships between users and researchers to develop new technologies: These relationships can be through scientific social networking platforms, communities of practice, organization of events and conferences, the development of collaborative projects and through publications and dissemination of scientific knowledge.

- Investments in green technology, through financial support for projects that use green technologies or NBS to purify water. In fact, some specific grant and financing programs are already being implemented for R&D&I projects in this sector.

THREATS

- Lack of information and traceability on water quality surveillance and control mechanisms, frequency, resources, and duties: Who will be in charge of that? When?
- Weather conditions: Changes in weather patterns can affect the effectiveness of NBS, especially sudden changes in weather conditions that can cause an imbalance or elimination of the biocenosis (biological community) of the system, leading to an imbalance in the functioning of the system that will require a considerable amount of time to recover.
- Competition with Conventional Technologies: Compared to NBS, traditional wastewater treatment technologies still dominate the market and can be seen as more reliable, well understood and offering consistent results.
- Regulations and Norms: Regulations may vary depending on the climatic, geographic, and socioeconomic conditions of each region, meaning that NBS must be designed and adapted specifically for each local context.
- Low awareness of NBS among policymakers: Lack of awareness and understanding of NBS among policymakers can be a major obstacle to their implementation. Without adequate information, policies and projects that foster NBS are less likely to be supported. Education and training of public administrators are essential to close this gap.

4. Identified adoption barriers and measures for NBS implementation

Each of the countries, Spain, France and Portugal, has adapted to its local context the methodology to follow to identify the adoption barriers, as well as the measures for the implementation of NBS.

4.1. Spain

<u>Workshop implementation</u>

In order to identify the adoption barriers as well as the measures for the implementation of NBS in the field of wastewater treatment and reuse in rural areas, a working day was held on September 18 at the headquarters of the Consortium for the Management of Environmental Services of Badajoz (PROMEDIO). This day was set up as a round table where the SOLLAGUA project was presented.

Figure 1- Picture of the participants in the Living Lab held in Badajoz, Spain.

The attendees participated in a questionnaire that aimed to identify at a local and regional level the factors that limit the adoption of NBS (regulatory, cost and access barriers, blockages, and technical mismatches, etc.) and to propose a series of corrective measures.

To ensure a good development of the questionnaire, the Mentimeter tool was used, which is an online tool that allows the creation of interactive presentations and surveys in real time. Through this tool, participants can answer questions and participate using their mobile phones, tablets or PCs, and the results are displayed on the screen instantly.

The questionnaire was prepared by the AMAYA technical team. Once prepared, it was sent to PROMEDIO and CTA, who reviewed it and uploaded it to the Mentimeter application. The survey was designed with the idea that it would be answered by technicians or those responsible for the focus group in Spain. However, this survey can also be answered by people from entities working in the wastewater treatment sector. The questions were grouped according to the following distribution:

- Knowledge about NBS for wastewater treatment and reuse.
- Barriers to the implementation of NBS for wastewater treatment and reuse.
- Measures that should be implemented to foster and promote NBS in wastewater treatment and reuse.

The questions and the answers from the participants were as follows:

Question 1: What is your level of knowledge about NBS for wastewater reuse?

Answer: Of the 22 participants, 11 consider their knowledge to be average, 7 consider it to be low and only 4 have a high level of knowledge.

Question 2: What projects do you know about the application of NBS for wastewater management in your area? Write the acronym and title if you know it?

Answer: 1 participant knows LIFE4ZOO and SOLLAGUA, 11 participants only know the SOLLAGUA project, and 9 participants do not know any project.

In relation to the previous question:

- What has driven the projects?

No response.

- What was the reason for undertaking these projects?

The participants have presented the following reasons:

- Research: 15

- Demonstrative: 1

- They are viable for implementation as purification systems: 1

- What lessons can be drawn from these experiences?

The participants presented the following lessons:

Knowledge

- Much work to be done

- Emerging topic

- Difficult to bring to reality

- Application of alternative technologies

- Necessary but still in development

- Field with a long way to go

- Lack of regulation

- Costs and obstacles make them almost unaffordable

- Complexity of obtaining solutions applicable to exploitation

- Much to do

- Lack of implementation or involvement of local administrations

- Lack of practical experience

Question 3: What benefits do you think could come from implementing NBS for wastewater reuse?

Participants have provided the following:

- Cost reduction

- Reduction in consumption from other sources

- Greater knowledge and reduction in installation and operation costs

- Improvement of the water cycle

- Cost reduction compared to conventional technologies
- Reduction in consumption of drinking water where it is not necessary
- Awareness and education
- Possible reuse in small towns
- Promotion of reuse
- Reduce consumption from other sources
- Cost reduction
- An alternative source to water resources
- Possible only economically viable option
- Viable technical solutions for low volumes
- Improvement of quality for other uses
- Lower consumption of drinking water
- Reduce demands for drinking water
- Reduce consumption of drinking water

Question 4: What barriers does your community identify for the implementation of NBS?

Mark from 1 to 5 (1 being the most important and 5 the least)

Question 4a. How important, in your opinion, is your community in relation to the following political barriers for the implementation of NBS?

Concept	Average mark
Lack of long-term strategies.	4,1
Lack of support and incentives.	4,0
Coexistence of different policies.	3,9
Institutional fragmentation.	3,6
Lack of products and instruments	**3,4**

Question 4b. How important do you think your community is in relation to the following economic barriers to NBS implementation?

Concept	Average mark

Gap in coordination between public and private funders for NBS	4,0
Lack of knowledge about economic returns and impacts	4,0
Access to finance	**3,8**

Question 4c. How important do you think your community is in relation to the following technical barriers to NBS implementation?

Concept	Votes
End-user confidence.	3,8
Adaptation of technologies to current water quality standards	3,7
Greater surface area requirements for its implementation and start-up and operational time	3,1
Technical knowledge and skills	**2,9**

Question 4d. How important do you think your community is in relation to the following environmental barriers to NBS implementation?

Concept	Votes
Impact of climate change	3,6
Loss of biodiversity	**3,0**

Question 4e. How important do you think your community is in relation to the following legal barriers to NBS implementation?

Concept	Votes
Bureaucratic requirements and slow processes	4,8
Regulations lag behind technological advances	4,6
Complexity and fragmentation of the regulatory framework	4,2
Collaborative approaches	3,7
Synergy between different policies	**3,5**

Question 4f. How important do you think your community is in relation to the following socio-cultural barriers to NBS implementation?

Concept	Votes

Lack of examples of success stories	4,5
Lack of awareness and knowledge	4,3
Lack of awareness about NBS and its benefits	4,1
Depopulation of rural areas	3,8
Improving capacity development in NBS	3,7
Relationship between traditional practices and new solutions	**3,6**

Question 5. What specific measures do you think should be implemented to encourage and promote the use of nature-based solutions in wastewater reuse?

Mark from 1 to 5 (1 being the most important and 5 the least important)

Question 5a. How important are the following policy measures to encourage and promote the use of NBS in wastewater reuse?

Concept	Votes
Synergies with realistic policies	4,6
Strategic public-private interaction	4,2
Collaboration and management models	**3,7**

Question 5b. How important are the following economic measures to encourage and promote the use of NBS in wastewater reuse?

Concept	Votes
Incentives and financial aid/mechanisms	4,5
Improve knowledge, collaboration, and coordination among stakeholders	**3,7**

Question 5c. How important are the following technical measures to encourage and promote the use of NBS in wastewater reuse?

Concept	Votes
Greater knowledge of recent success stories related to the implementation and development of NBS	4,5
Improving awareness and capacity building on NBS	4,0
Promote R&D&I in the field	3,8
Intensification of extensive technologies	**3,1**

Question 5d. How important are the following environmental measures to encourage and promote the use of NBS in wastewater reuse?

Concept	Votes
Reducing pressure on conventional aquatic ecosystems	4,0
Improving biodiversity and ecological connectivity	**3,8**

Question 5e. How important are the following legal measures to encourage and promote the use of NBS in wastewater reuse?

Concept	Votes
Establishment of regulatory frameworks for the preservation and restoration of aquatic ecosystems	4,0
Greater knowledge about Regulation EU 2020/741 on water reuse and its implementation	4,0
Improving collaborative approaches	**3,5**

Question 5f. How important are the following socio-cultural measures to encourage and promote the use of NBS in wastewater reuse?

Concept	Votes
Examples of success stories	4,5
General awareness of the climate emergency and drought situation.	4,2
Knowledge about the benefits of NBS	4,1
Enhancing capacity building on NBS	3,6
Creation and promotion of training networks and platforms	3,3
Integration into the landscape	**3,3**

Interpretation of results

Level of knowledge

Although the survey participants are technicians in the water sector and most of them have very advanced knowledge about wastewater treatment and reuse, only 4 out of 22 participants consider their knowledge of NBS for wastewater reuse to be very high, and none of them know of any such project in operation, since 11 out of 22 participants only know the SOLLAGUA project, which is a research project, and 9 do not know of any project. In the last two decades, many scientific works related to NBS for wastewater treatment and reuse, especially artificial wetlands, have been disseminated worldwide.

This means that there is a high level of knowledge about the implementation and performance of NBS at the expert and scientific level. However, in Spain, the transfer to practice is insufficient and there is a low level of awareness and recognition of NBS at the institutional and administrative level. In addition, there is also a lack of knowledge of good examples of NBS in operation at the regional level.

Expected benefits

The third question in the questionnaire (What benefits do you think could be brought about by the implementation of NBS for wastewater reuse?) was an open-ended question. The participants considered that the implementation of NBS for wastewater reuse could benefit firstly by reducing the costs of generating wastewater (3), followed by reducing drinking water consumption (2), and by promoting wastewater reuse in small towns (2), and finally improving the quality of the water cycle.

These answers coincide to a certain extent with the results of the SWOT analysis, which considers that one of the strengths of NBS in wastewater treatment and reuse is the reduction in construction, operation and maintenance costs and the reduction in the consumption of better water quality that would be used for other purposes. While one of the opportunities generated by this type of technology has been technologies that are suitable for implementation at a local scale.

Identified barriers

In terms of identifying barriers to the implementation of NBS in wastewater treatment and reuse, at the policy level, according to survey participants, the most important barrier to incorporating the NBS approach in projects has been the lack of long-term strategies (4.1), followed by the lack of support and incentives (4.0) and the coexistence of different policies (3.9).

The lack of long-term strategies can be a significant obstacle to the effective implementation of NBS in wastewater treatment. Without a clear vision and well-defined plans, it is difficult to ensure the sustainability and long-lasting impact of these solutions.

Apart from long-term planning, it is also crucial to have adequate funding and collaboration between different stakeholders and awareness of decision-makers on the benefits of NBS. The coexistence of different policies and regulations can create complications.

When there is no clear alignment between local, regional, and national policies, it can lead to confusion and conflicts in the implementation of NBS projects. It is essential that policies are coherent and work together to support sustainable solutions. Furthermore, a lack of coordination between different levels of government and organisations can lead to duplication of efforts or, worse still, to NBS not being adopted effectively. This is why dialogue and collaboration between all parties involved is crucial.

At the legal level, voters ranked bureaucratic requirements and slow processes (4.8) as the top barrier, followed by regulations that lag behind technological advances (4.6) and then the complexity and fragmentation of the regulatory framework (4.2). Permitting, regulatory compliance, and coordination across entities can delay projects. Furthermore, outdated regulations can slow down NBS implementation by failing to adapt to new knowledge and technologies. When regulations are misaligned or difficult to understand, projects are delayed and sometimes even abandoned.

At the sociocultural level, the most important barrier considered by participants was the lack of examples of success stories (4,5), followed by the lack of awareness and knowledge (4,3) and the absence of awareness about NBS and its benefits (4,1). The lack of knowledge of examples of success stories is a barrier to its acceptance by the different groups responsible for its implementation, compared to widely known and proven traditional solutions. Also, the lack of information, or uncertainty regarding the processes and benefits of implementing NBS, is frequently mentioned in the literature as a critical barrier limiting the implementation of NBS by decision makers.

At the economic level, the most frequently selected barriers have been the gap in coordination between public and private funders for NBS (4.0) and the lack of knowledge about economic returns and impacts (4.0). These two barriers limit the financial resources to facilitate the implementation of NBS.

In general, the gap in coordination between public and private funders is since most of the co-benefits associated with NBS can only be realized in the long term, while private sector financing schemes tend to be short-term in nature.

Furthermore, the exclusive dependence on government and municipal resources to finance solutions puts great pressure on these institutions and highlights the critical need for further exploration of economic opportunities related to NBS to encourage private investment. In fact, it is essential to look for other types of incentives to further involve the private sector.

In addition, decision-makers must be made aware of the benefits of NBS in order to become more involved in prioritizing the financing of this type of technology.

At the technical level, the main barrier has been end-user trust and confidence in the produced water (3,8) followed by adaptation of technologies to current water quality standards (3,7).

Without end-user trust, NBS can face resistance due to the perception that traditional and high-tech solutions are safer or more reliable. Dissemination of operational cases, benefits and performance of these solutions is critical to building that trust. In addition, NBS must be adapted to current water quality standards to be effective and sustainable. This involves designing and implementing systems and treatment chains of several systems that not only improve water quality but also comply with current rules and regulations.

Concerning the **environmental level**, participants have considered the impact of climate change (3.6) to be more important as a barrier to implementing NBS than the loss of biodiversity (3.0). In fact, the impact of climate change can be a barrier, but also a major motivation to implement NBS. Extreme weather events and variability can make it difficult to implement and maintain NBS.

However, the need to adapt to and mitigate these effects also drives the search for more resilient and sustainable solutions, such as NBS. It is also worth noting that NBS can be considered as a tool for the improvement and conservation of biodiversity, including the renaturalization of the environment of its location and the creation of fresh temperature and cooling island during drought events.

Proposed solutions

In order to find solutions to encourage and promote the use of NBS in wastewater treatment and reuse, at the **policy level**, survey participants consider synergies with realistic policies (4,6) followed by strategic public-private interaction (4,2) as policy solutions to facilitate NBS implementation. Synergies with realistic and coherent policies are key to facilitate NBS implementation.

Integration of these policies can provide a supportive framework that favours the adoption and success of NBS. When there are alignment and collaboration between different government levels and sectors, NBS can be deployed more effectively and efficiently.

As for collaboration between public and private sectors, it can bring resources, knowledge, and technologies, which would otherwise not be available. This strategic interaction allows for sharing risks and benefits, optimizing solutions, and making NBS more viable and effective. This can also foster innovation and accelerate project implementation, by combining the agility of the private sector with the stability of the public sector.

At **legal level**, The establishment of regulatory frameworks for the preservation and restoration of aquatic ecosystems (4.0) and increased awareness of the EU Regulation 2020/741 on water reuse and its implementation (4.0) have been considered by participants as more important legal measures than improved collaborative approaches (3.5) to improve NBS implementation. Regulatory frameworks not only ensure that best practices are implemented but also provide stability and confidence to investors and communities. Regulation (EU) 2020/741 sets minimum requirements for water reuse, especially for agricultural irrigation. Knowing and understanding this regulation is essential to effectively implement NBS and comply with European regulations.

At **economic level**, to enable the implementation of NBS, participants have highlighted the importance of incentives and support as well as new financing mechanisms (4,7) since financial incentives and new support mechanisms are crucial for the implementation of NBS. Subsidies, tax incentives, sustainable development funds, and low-interest loans are tools that can make NBS more accessible and attractive for businesses and communities. Furthermore, these mechanisms can motivate investment in research and development, encourage the adoption of new technologies and practices, and ensure that NBS projects are economically viable in the long term. It is essential that both the public and private sectors work together to design and promote these incentives.

At **technical level**, the increased awareness of recent success stories related to the implementation and development of NBS (4,5) has gained more importance from the technicians who participated in the survey. Knowing recent success stories can inspire and guide future initiatives, showing how NBS can be implemented effectively, improving water quality and the environment.

At **environmental level**, the two environmental measures proposed in the questionnaire, namely reducing pressure on conventional aquatic ecosystems (4.0) and enhancing biodiversity and ecological connectivity (3.8), were of equal importance to respondents. NBSs alleviate the burden on traditional water infrastructure and enable and offer a sustainable and resilient way of managing water resources. NBSs not only improve water quality and biodiversity but also allow natural ecosystems to recover and remain healthy, as well as re-establish connectivity between different ecosystems, allowing species to move and adapt better.

The most important **socio-cultural measures** to encourage and promote the use of NBS chosen by the participants were firstly "Examples of success stories" (4,5), followed by "General awareness of the climate emergency and drought situation" (4,2) and "Knowledge of the benefits of NBS" (4,1).

The dissemination of NBS success stories can help to raise knowledge as well as awareness of society on the advantages of NBS, since it has been shown that the demonstration of previous successful examples improves public perception compared to standardised educational workshops/programs.

It is important to include existing examples both in Spain and in other countries. In this context, different online platforms, national and international conferences and networks, scientific journals, etc. can be used to ensure such dissemination.

The growing awareness of the climate crisis and droughts creates an enabling environment for the adoption of NBS. People and communities are more open to sustainable, resilient, and environmentally friendly solutions that address these urgent challenges.

Education and awareness-raising are key to mobilizing support and action towards greener and more sustainable practices. Knowing the benefits of NBS helps boost their implementation because it demonstrates their effectiveness and short- and long-term advantages.

4.2. France

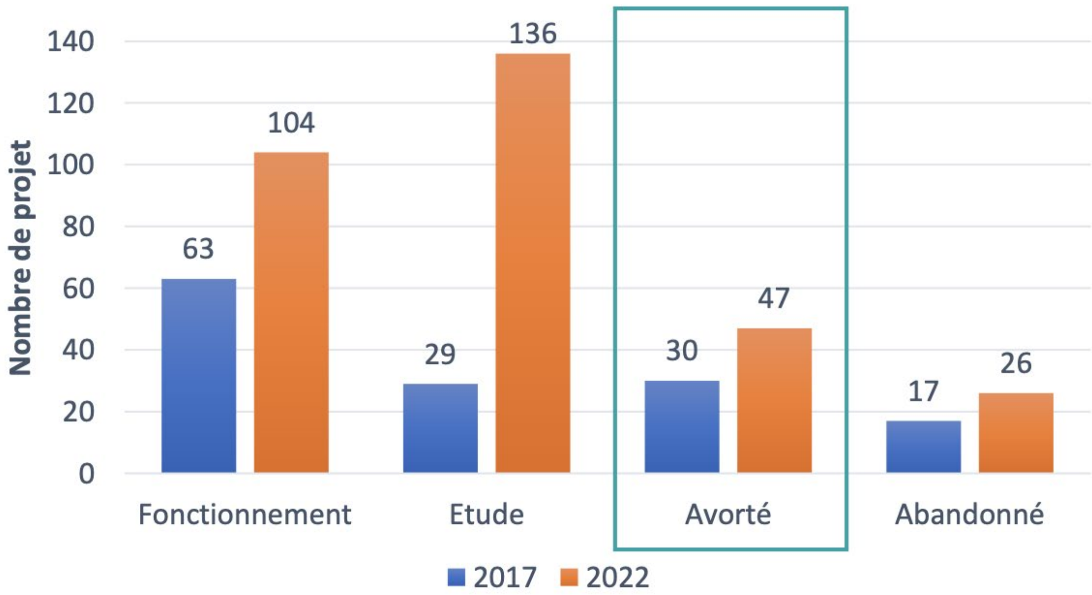
Introduction

A panorama of the REUTE project in France shows that the majority of new projects are coming from Haute Garonne and Rhone's Mediterranée Corse, which covers the South region Occitanie. The number of projects in the study state (etude) is much larger than the number of projects that are active, and this point is rising the difficulties of having a success story with a reuse project. The different barriers that appear during the administrative steps are the reasons why the project needs time to get though, although the number of studies and active project is largely increasing between 2017 and 2022 (Lombard-Latune et Bruyere 2024) (citation: Lombard-Latune et Bruyère 2024, Panorama de la réutilisation des eaux usées traitées en France en 2022: Etat des lieux de la REUT en France en 2022 et évolutions depuis 2017, Rapport EPNAC - 36p). Table 2 provides the number of projects in the 6 different water sheds of France. The Couseran territory is located in the Adour Garonne basin.

Tableau 2 : Nombre de projets à l'étude ou en fonctionnement dans les différentes agences de l'eau. AG : Adour-Garonne ; AP : Artois-Picardie ; LB : Loire-Bretagne ; RM : Rhin-Meuse ; RMC : Rhône Méditerranée Corse ; SN : Seine-Normandie.

	Etude		Fonctionnement	
	2022	2017	2022	2017
AG	35	7	24	14
AP	1	0	1	0
LB	9	8	52	31
RM	2	0	0	0
RMC	73	13	20	12
SN	3	1	5	6

The number of aborted and abandoned projects is given at the national state in the figure XX. This graph shows that the number of projects that did not manage to reach the final step is still rising since 2017, so that even though information access about reuse is improving there are still main barriers to make the project become real. This also attest that the low increase of reuse projects over the territories is not only limited by the ambition to use REUSE water, but limitations are encountered during the building process of the project. Note that between 2017 and 2022, the number of aborted projects is larger than the number of new projects over the same period.



Outcome of the Living Lab meeting

With the aim of identifying the barriers to the adoption of NBS in the field of wastewater treatment and reuse in rural areas in France, a living lab was held on 15 November 2024 in Saint-Girons, Communauté de Communes Couserans Pyrénées. This event was set up as a round table where the SOLLAGUA project was presented.

Figure 2 - Picture of the attendees in the French Living Lab

The participants participated in a debate that aimed to identify at local and regional level the factors that limit the adoption of NBS (regulatory, cost and access barriers, blockages, and technical mismatches, etc.). During this debate, the following barriers were identified:

- Cost

Barriers	Number of answers
- Economic and energy cost - Cost of work to be carried out - Financial cost - Investment and operating costs / - Economic cost - Cost (vs the price of water) - Operating cost and new tax for the user - Investment and operating cost - Financing and profitability - Increase in cost for the user - Energy and carbon impact - Cost and volume - Economic brake - Cost	14

- Water quality

Barriers	Number of answers
- Who controls the quality? - Limit of general common knowledge on water quality - Water pollution by pharmaceutical chemical molecules - Sanitary - Quality of treated water - Contamination	6

- Regulation

Barriers	Number of answers
- Regulation - Compatibility with bio conversion - Control - The quality required for reuse is very restrictive - Standards and monitoring	5

- Social

Barriers	Number of answers
- Lack of sense of responsibility of everyone - Sociological obstacles - Acceptability of the project - Acceptability of REUT water	4

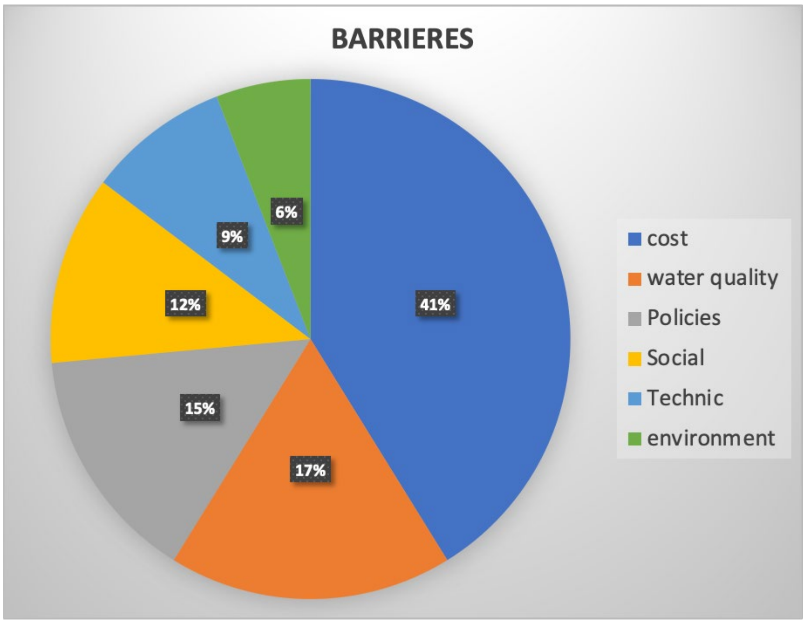
- Technical

Barriers	Number of answers
- Problem of networks to be set up in parallel with existing networks (buildings, housing, roads, etc.) - Distance between REUT and wastewater service - Technicality and complexity of implementation on site	3

- Environmental

Barriers	Number of answers
- Tiger mosquitoes - Low flow rates and decline in the context of climate change	2

Interpretation of results



During the debate related to the identification of barriers to implement NBS for wastewater treatment, 6 barriers have been identified, from the most important to the least: Cost, water quality, regulation, social, technical, and environmental.

Cost:

Cost has been identified as the main barrier. Although NBS can be cheaper than traditional water treatment systems in the long term, initial costs can be a significant obstacle when it is view from individual at the citizen level This initial investment is due, in the case of constructed wetlands, to site preparation, species selection and planting, and the installation of monitoring and control systems This cost barrier in the France territories come from the specificity of the Couseran with a large attending of farmers who came to the FG for REUSE opportunities at the individual scale. So that interpretation of this cost barrier should be scaling dependant: the initial investment is a barrier at the individual level because the source come from the farmers himself when the cost may be an opportunity at the public authority level in charge of water treatment. At this later level, not only the comparison between green and grey solution is built on practices that provide a realistic advantage to green solution, but the cost of the initial investment is coming from the government or the county. Furthermore, green projects often do not have access to the same sources of financing as conventional infrastructure projects. Financial institutions, governments, or companies may be reluctant to invest in NBS due to the perception that they are uncertain or experimentally riskier. In addition, the lack of a clear incentive or subsidy framework for NBS projects can make it difficult to obtain financial resources. It is worth noting that NBS require lower operational and maintenance costs compared to traditional infrastructures, which can make them more cost-effective in the long term. However, the financial and ecological benefits of these solutions are often not as visible or immediate, making it difficult to justify them in terms of cost-benefit. In addition, hidden costs, such as education and awareness-raising of local communities or the need for continuous monitoring, can be overlooked. In general, governments and wastewater treatment authorities often allocate budgets to solutions that appear to be more immediate and technically conventional, such as chemical or mechanical treatment plants. NBS, which may require a more long-term approach and be perceived as less urgent, are often displaced by these priorities.

Water quality:

Regardless of who controls water quality, which has been considered a barrier in this debate, NBS have shown that effluents from these technologies usually comply with the standards and guidelines that define the levels of contaminants allowed in treated water. Regarding the water quality barrier, although it has been identified during the debate as limiting knowledge about contamination by pharmaceutical products, research and case studies have been carried out showing that NBS can be highly effective for many types of wastewater, especially when properly designed and managed. They are often combined with conventional technologies to achieve a more robust and efficient solution, adapted to the specific needs of the local environment.

Regulation:

The third barrier that has been identified during the debate has been regulation. Standards and regulations are crucial to ensure that treatment solutions are safe, effective, and aligned with environmental and public health standards. However, in the case of NBS, there are several regulatory factors that can hinder their adoption. Of particular note is regulatory rigidity versus innovation. This means that although NBS may be a more economical and sustainable solution, a lack of regulatory flexibility can hinder their implementation.

Social:

Social acceptance is one of the major challenges when implementing NBS. Often, people are not familiar with these alternatives or may see them as ineffective or unhygienic compared to traditional systems. This is even more important when the NBS comes as a supplying system for reclaimed water from domestic source. Lack of information, lack of awareness of the long-term benefits and the perception that these solutions are less "technological" can contribute to such social resistance. One way to overcome this barrier is through education and awareness raising, showing successful examples and scientific evidence that these solutions are not only effective, but also more sustainable and environmentally friendly.

Technical:

The technicality and complexity of implementing NBS are very important barriers when it comes to implementing NBS for wastewater treatment. Although these solutions are very effective in the long term, they often require a multidisciplinary approach that includes knowledge of biology, ecology, engineering and environmental management, which can produce an imaginative feeling that their implementation are more complicated compared to conventional technologies such as chemical or mechanical treatment plants. In reality the implementation of NBS solution for the reuse is not more complex that hight technological ones. The demand of information about NBS is also fed by the difficulty to identfy the solutions that will be adapted to the specific need. There are multiple types of constructed wetlands with specific advantages with may lead to confusion to any citizen when it happens to choose the solution adapted to his water sources and needs. Deliverable 1.2 about the solutions tree of SOLLAGUA was made in purpose to drive the demander to a set of possible solutions. In addition, these NBS require an appropriate design that considers factors such as the type of ecosystem, local conditions, and long-term management. Also, because they are more flexible and less standard than traditional systems, it is sometimes difficult to guarantee their consistent performance.

Environmental:

Mosquitoes, especially tiger mosquitoes, are a major concern when implementing NBS, such as constructed wetlands or vegetated treatment systems, as these environments can provide suitable habitat for insect proliferation. This can lead to social rejection due to fear of diseases that mosquitoes can transmit.

4.3 Portugal.

On May 22, 2024, a workshop was organized at the Lourinhã Municipal Library (Figure 3). In this case, the objective of this workshop was focused on identifying the obstacles to the reuse of treated wastewater and the aspects that may influence the use and application of this treated water.

Figure 3 - Picture of the participates in the Living Lab in Portugal.

Lourinhã is a municipality where agriculture represents the third main economic activity of the municipality, with 1000 M€ produced annually. Due to this fact, water availability is very relevant for all actors of the production chain, with farmers being the most affected ones.

In face of this, both farmers and the municipality are eager to identify alternative water sources and identified wastewater as a potential one. As such, the workshop addressed the overall barriers to treated wastewater reuse, which are shared barriers to the implementation of NBS treatment systems.

The NBS technologies for wastewater treatment were further presented in a second meeting, on the 10th of December 20024, with five farmers and the municipality, to identify specific constraints.

During the workshop that included multiple stakeholders, the questions that generated the debate towards the reuse of treated wastewater were the following:

- What obstacles do you identify to the reuse of treated wastewater?
- What aspects can influence the use and application of treated wastewater reuse?

In this case, PEST analysis (also known as PESTEL or PESTLE analysis) was used. This is a strategic analysis tool used to evaluate the Political, Economic, Social and Technological factors that could affect a particular problem, organization, business, etc. The participants were asked to answer each question and place it in a PEST board, grouping the answer into the PEST categories.

The results of the PEST analysis were as follows:

Politics:

On a political level, according to Portuguese law, the use of river water, which is also the receiving environment for the final effluent from a water factory, is not considered reuse, unlike in Spain, where there is a distinction between direct and indirect reuse. The speakers highlighted the urgent need for a change in legislation and the time, and bureaucracy involved in licensing treated wastewater for agricultural use. In addition, they warned of legislation that does not facilitate the adaptability needed to implement these practices. To reuse water, it is necessary to obtain a license from the Portuguese Environment Agency (APA), a process associated with significant and time-consuming bureaucracy. Many sites that intend to reuse water face difficulties in allowing third parties to use it due to this bureaucracy. This process includes production and use licenses.

Another barrier mentioned was the insufficient monitoring of illegal discharges into rivers, which hinders the efficient management of water resources and the definition of priorities for access to ApR.

However, political opportunities were also identified that could be exploited to improve water reuse. Among the opportunities mentioned were the possibility of changing legislation to facilitate licensing and adaptability, as well as promoting the indirect use and storage of treated wastewater. Another suggestion was to align water reuse legislation with that of Spain, homogenizing standards at an Iberian level.

It was also proposed that provisions for the storage of treated wastewater be included in legislation, as well as the need for general awareness-raising about its importance and benefits.

At certain times and places, the water comes entirely from the Water Factories. Analyses of the river water are carried out for monitoring, and during the summer, disinfection is carried out to meet the bathing standards required in the discharge licenses of these Water Factories. Although there are guarantees about the quality of the treated water from the Waterworks, there are uncertainties about the quality of the river water and concerns about illegal discharges. Some producers avoid using river water because of doubts about its quality. There are also economic considerations involved: without disinfection, many participants said they would not use the water, but they recognize the farmers' need to guarantee their livelihoods. There is a prevailing understanding that the Water Factories are the least of the problems.

Economy:

There are various costs associated with using water, including technological costs, maintenance, treatment, monitoring, energy, distribution, infrastructure, bureaucracy, logistics and general management. For farmers, it is essential that the cost of water is affordable, as they do not have the financial capacity to bear high expenses. Obtaining a license to use water resources is not linked to the amount of water used, which means that there is no knowledge of the volume used by users.

On the other hand, participants highlighted the opportunity of community irrigation, which can reduce individual costs and promote efficient water use.

Social:

Promoting consumer awareness and education is key to improving the water management system, and awareness campaigns need to be carried out to ensure that all the players involved are properly informed and aware of their role.

One issue raised was the lack of knowledge on the part of people, who may often be unaware of the consequences of their actions when taking water from the river or carrying out illegal discharges. The system is complex and open, which makes it difficult to control all the variables that affect it.

There is a need to share knowledge and information, demystifying concepts such as that treated wastewater from the Waterworks is contaminated, and increasing confidence in reused water. It is essential to clarify and raise awareness in order to promote broad understanding and greater acceptance.

Technology:

In terms of technology, several obstacles were identified. Among them, they highlighted the lack of a treated wastewater distribution network, the need for continuous monitoring of the quality of water intended for reuse, and concern about its quality. Nevertheless, the importance of respecting ecological flows so as not to compromise ecosystems was mentioned, as well as the inherent risk of contamination by pollutants, including heavy metals, hormones, and antibiotics.

On the other hand, opportunities were identified that have the potential to be exploited. They highlighted the construction of reservoirs along rivers to store water and the use of bioremediation techniques to remove contaminants from water, making it safer to use.

Some stakeholders agreed that the technology exists and that there needs to be coordination between sectors, authorities, and society to put it to good use.

5. Recommendations

The analysis carried out in this document has served to better understand the barriers and solutions for implementing NBS in wastewater treatment and reuse in rural areas. Based on this analysis, the following recommendations can be made to improve the implementation of NBS for wastewater treatment and reuse.

1- Transnational cooperation is essential to promote the implementation of NBS for wastewater treatment. Through this cooperation, knowledge and experience can be exchanged even with countries outside the Sudoe area. For example, in the case of Denmark, in 2005 the environmental authorities issued a guide for the design and construction of artificial wetlands and legislation. Since the national guide has been published, about 100 wetlands are being built per year and there are censuses that record about 1,320 artificial wetlands for wastewater treatment.

2- To remedy the lack of knowledge of successful cases of NBS in wastewater reuse, it is important to systematically collect and disseminate success stories and failed experiences. It would be necessary to make a selection of success stories for dissemination, in order to identify which experiences are relevant according to the typology of the problems. Particularly important are examples referring to the cooperation and integration of actors and administrative coordination.

Likewise, while the dissemination of success stories can help to promote their adoption, the documentation of failed experiences can help to learn from mistakes in a constructive way. This would help to promote their visibility and replicability. Therefore, it is important to include existing examples in Spain and in other countries.

3- The distribution of powers between administrations (state, regional and local) and their interconnection means that no measure related to water is the exclusive responsibility of a single administration. This represents a challenge in administrative coordination that still needs to be worked on for the implementation and management of this type of measures.

4- The lack of adequate incentives to promote the implementation of NBS has been identified as a factor slowing down its adoption. The private sector does not find incentives, given the low profitability obtained and the long-term approach. This barrier is even more an obstacle when the reuse initiative comes from individual stakeholders at the scale of a farm. Incentives such as tax exemptions, simplification of approval processes, preferential financing or mandatory inclusion in land use and spatial planning at different scales would help accelerate the implementation of NBS. Well-targeted financing could serve to accelerate and increase the use of NBS. The administration has a key role to play in this. In addition, it is crucial to offer more financing opportunities through European collaboration to scale up NBS projects and ensure the expansion of their application.

5- Stakeholder engagement, especially from local communities, is key to the success of NBS, as they often rely on these actors to implement and manage interventions. Early engagement is particularly imperative to help develop a sense of co-ownership of NBS and shape them to maximise their potential benefits. Such cooperation and engagement can be difficult to achieve, especially as there is often a lack of knowledge and information available about NBS and what they can offer. The previous studies of comparison between engagements and successful projects numbers in France confirm that motivation for engagement exist but the following difficulties are the main limit to concretise the engagements. The difficulties that limit the stakeholder engagement may be related to economic, technical, and administrative issues to be solved.

6- Training and knowledge transfer are essential for the staff of the administration and companies in the water sector, in order to increase their knowledge of these solutions, as well as to instruct them in the techniques, tools and capabilities required for their implementation and maintenance. This will allow the identification of possible new profiles that need to be incorporated into the staff selection or public contracting processes.

7- Greater adoption of NBS depends on improved technical, institutional and financial capacities, but also on the participation of different actors, including lay citizens. Indeed, interaction between the different actors involved could promote further advances in knowledge, perspectives, and actionable discourses on NBS.

6. Conclusions

NBS have proven to be efficient and robust treatment systems that can be implemented in small communities and rural settings, and their widespread adoption could therefore be the solution to promote the development of wastewater treatment in rural areas. To overcome the existing technical and non-technical barriers to implement NBS in wastewater treatment and reuse, different instruments and approaches need to be introduced, such as regulation, economic and fiscal incentives, capacity building, dissemination, and awareness raising.

Annex: Workshops meetings and agendas

Spain

Agenda

09h00 - 09h30	Reception of participants and identification of their typology	30 min
09h30 - 09h45	Opening of the working days	15 min
09h45 - 10h00	Presentation of the SOLLAGUA Project. Objectives and results.	15 min
10h00 - 11h30	Discussion panel on the need for reused water.	90 min
11h30 - 11h50	Coffee break	20 min
11:50 - 15:20	Roundtable discussion on barriers to the use of reused water and NBS	30 min
15h20 - 15h30	Closing of the working day.	10 min

Participants

ENTITY	NAME
Universidad de Extremadura. Facultad de Ciencias	María Martín
	Ana Rey Barroso
	Pedro Modesto Álvarez
Universidad de Extremadura, Escuela de Ingenieros Industriales.	Marcos Garrido
	Miguel Ángel Jaramillo
Giahsa (empresa pública de gestión de la Mancomunidad de Aguas Costa de Huelva)	Modesto Pereira Villaseñor
	Francesc Berenguer Pla
Ambling Ingenieria y Servicio S. L.	Fernando Teva
DAM (Depuration De Aguas Del Mediterranean)	Federico López
Ayuntamiento de Valverde de Burguillos	Carlos Delgado
Junta de Extremadura	Manuel Setrakian
MAs Medio (Diputación de Cáceres)	Jorge Benito Cortijo
	Ana Guadalupe Valiente Revilla
DRACE GEOCISA, S.A.	Miguel Fernández
AEOPAS (Asociación Española de Operadores Públicos de Abastecimiento y Saneamiento)	Antonio Ramirez
INYGESINYGES CONSULTORES S.L.	Eliseo Ruiz
Espina y Delfín	José María Nigeria
AMAYA (Agencia de Medio Ambiente y Agua de Andalucía)	Juan Ramon Pidre Bocardo
	Khalid Fahd Draissi
	Fernando Villafruela
	Alberto Alco lea
Confederation Hidrográfica del Gualdalquivir	Juan Ramis Ciruela
ASA (Asociación de Abatements de Agua y Saneamento's de Andalucía)	Lidia Capitán Zamora
	Manuel Silva Aragón
	Carlos Garcia Delgado
Fundación Solidarist Universidad de Barcelona	Pau Cantos Perea
Junta de Extremadura. Gestión Forestal, Caza y Pesca	Cesar Fallola Sánchez-Herrera

	Paula Moreno Rendón
Promedio. Grupo investigación INTRAGUA	Maria Isabel Fernández
Promedio	Pedro Tomás Martín de la Vega Manzano
	Francisca Tena Medina

France

Agenda

14h00 - 14h10	Welcome speech, Bernard Lanary, Vice-President in charge of Couserans Waters	10 min
14:10 - 14:20	Introduction, Jean-Philippe Subra, Director of Couserans Waters	10 min
14h20 - 14h30	Presentation of the SOLLAGUA project, Magali Gerino, Scientific Coordinator of SOLLAGUA	10 min
14h30 - 15h30	Round table and exchange of ideas	60 min
15h30 - 16h00	Coffee break	30 min
16:00 - 16:30	Thinking groups (positive aspects, opportunities, concerns, obstacles)	30 min
16h30 - 17h30	report of the exchanges	60 min
17h00 - 17h30	conclusions of the round tables of our Spanish and Portuguese partners	

Participants

ENTITY	NAME
Le Département de l'Ariège	Richard BAPTISTE
Parc naturel régional des Pyrénées Ariégeoises, Coordinator du pôle Biodiversité, agriculture et territories	Yannick BARASCUD
La ferme de la Lisière	Lennan BATE
Agence de l'eau Adour Garonne	Pierre CONQUET
Epur Aqua (PME = small and medium business)	Dan-Tam COSTA
Direction Départementale de l'Ariège	Carole DHUMIERES
Syndicat de rivières Salat-Volp	Gilles Domenic Directeur
Service Agriculture, Eau et Environnement - Département de l'Ariège	Anne GAUTHIER
La table de Gaya, ferme restaurant	Kyria ET Manu (2 personness)
Vice-president en charge des eaux du Couserans	Bernard LAMARY
Chambre d'Agriculture de l'Ariège	Elise LLOBET
Leever de chevaux	Simon ET Mathis Lumped (2 personnes)
Agence de l'eau Adour Garonne	Matthieu MAGDELAINE
Direction Départementale de l'Ariège, Inspect rice de l'environnement, référente assainissement	Agathe MORAT DEVAUX
En Vert de Terre (pépiniériste: Légumes, aromatiques, fleurs)	Coline ROSSET
Agence de l'eau Adour Garonne	Ariette SOURZAC
Directeur des Eaux du Couserans	Jean-Philippe SUBRA
Syndicat public	Mathieu SUGNER
Centre équestre Les crins en soi	Florence Pouvreau
Eleveuse	Christiane BONTE
Agence de l'eau Adour Garonne	Aurélia BESNARD
Maire	Kathy WERSINGER
Cheffe de projets européens	Alida Lefter
Coordinatrice scientifique Sollagua	Magali Gerino

Portugal

Agenda

14h00 - 14h30	Welcoming the participants	30 min
14:30 - 14:40	Presentation of the SOLLAGUA project. Introduction to the Living Lab concept.	10 min
14h40 - 14h50	Activity 1- Introducing the participants	10 min
14h50 - 15h10	Activity 2 - What are the challenges of water scarcity associated with climate change affecting rural communities?	20 min
15h10 - 15h30	Activity 3 - What measures do you think could be implemented to address these challenges?	20 min
15:30 - 15:45	Pause	15 min
15h45 - 16h05	Activity 4 - What obstacles do you identify to the reuse of treated wastewater - PEST analysis?	20 min
16h05 - 16h25	Activity 5 - What aspects can influence the use and application of treated wastewater reuse - PEST analysis?	20 min
16h25 - 16h30	Final remarks	5 min

Participants

ENTITY	NAME
Lourinhã City Council	João Serra
Higher Institute of Agronomy	Inês Areosa
SMASTorresVedras	Ana Cláudia Nunes
SMASTorresVedras	Margarida Frade
AIHO - Interprofessional Horticultural Association of the West	Sérgio Ferreira
AIHO - Interprofessional Horticultural Association of the West	Sofia Baltazar
LOURAMBi - Environmental Association	Sara Margarida
LOURAMBi - Environmental Association	Tiago Navais
ETAPAS FRESCAS - Hortícolas, Unipessoal, LDA	Luís Manuel Antunes
LOURICOOP - Cooperativa de Apoio e serviços do concelho da Lourinhã, CRL	Sérgio Ferreira
Intermunicipal Community of the West	André Lopes
Águas do Tejo Atlântico, SA	Cláudia Tomás
Águas do Tejo Atlântico, SA	Andrea Faria
Águas do Tejo Atlântico, SA	Sara Duarte
CM Lourinhã	Ana Tabarra Santos
CM Lourinhã	Rafael Silva
CM Lourinhã	Pedro Pestana
	Sara Gomes
Biofrade	António Gomes
CCDR-LVT (DAP)	Paulo Monteiro

Interreg Sudoe | Co-funded by the European Union | SOLLAGUA

PROJECT INFORMATION

Project title

Nature-based solutions (NBS) and living labs for rural water reuse.

Start - end date

01/01/2024 - 31/12/2026 (36 months)

Programme

Interreg VI-B SUDOE

Project type

Priority 1: Preserving natural capital and strengthening climate adaptation in the SUDOE area.
Specific objective 2.5: Promoting access to water and sustainable water management.

ERDF funding

€1,389,232.10

Coordinator

Université de Toulouse

Project review

SOLLAGUA, funded by the Interreg SUDOE Programme, is a three-year project that aims to promote nature-based solutions (NBS) for water reuse across the SUDOE region, which faces major challenges linked to water scarcity due to its semi-arid climate, the impacts of climate change and a growing population. The initiative seeks to address these shared challenges by implementing sustainable water-management strategies in three rural communities in France, Portugal, and Spain.

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